M&S JOURNAL

S P R I N G 2 0 I I

The Data Issue

An Emerging DoD M&S Enterprise Data Strategy

Almost Accidental Database Standards

Discovery and Reuse of Modeling and Simulation Assets

Discovery and Reuse of Order of Battle Data Across the M&S Enterprise

The Environmental Data Cube Support System: Realistic Environmental Data, Products, and Services in Support of the DoD Modeling and Simulation Enterprise

ABOUT THE COVER

THIS MONTH'S COVER depicts the "City Planning" analogy for Modeling and Simulation (M&S). The tall buildings prominent on the skyline represent the seven Department of Defense (DoD) Communities that are enabled by M&S. Other buildings distributed throughout the city (and by extension, across the country and around the world) represent the military Services, including the Joint Staff, which have global M&S missions. This modern, thriving, and ordered-yet-unconstrained metropolis represents the M&S Enterprise Data theme of this issue of the M&S Journal.

A functional city plan provides the broad rules and boundaries within which organizations, businesses, and citizens can work and live productively without impeding corporate productivity and individual freedoms. The flow of timely, accurate data is a benefit to both the city and its corporate and individual citizens. In fact, authoritative data made available on smaller, more useful and cost-effective devices is an essential part of our daily lives. The same is true for Modeling and Simulation.

The Undersecretary of Defense for Acquisition, Technology, and Logistics is chartered to provide the leadership, guidance, technical framework, as well as the common data, services, and tools that promote interoperability and reuse of M&S resources across the Department. Implementing a DoD M&S Enterprise Data Strategy that accomplishes those mandates is analogous to planning for the sustainable growth of a city.

To be effective, the DoD M&S Enterprise must provide not only technical solutions, but also governance in the form of policies, standards, and a common architectural framework, that encourage and enable interoperability and reuse, and guide Department investments to support the operational needs of the Components and Communities enabled by M&S without intruding on their individual missions and Title 10 responsibilities.

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Guest Editorial

Mr. Joseph C. Bonnet, III
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Message from Mr. Bonnet

Those who have worked closely with me in the M&S community know that I like to say," It's all about the data." We should have unfettered access to authoritative data and strive to develop common tools through a common framework or environment, that support multiple Communities and Military Services enabled by Modeling & Simulation (M&S). In order to comply with the Net Centric Data Strategy, authoritative data should be available, synthesized and formatted to enable visibility, accessibility, understanding, trust, and responsiveness to user needs. We have yet to meet these objectives.

Several years ago, through a Training Initial Capabilities Document (ICD), data was identified as a Joint Requirements Oversight Council (JROC) item of interest illustrating that M&S data has been and continues to be a huge problem for the Department. Likewise, ready access to authoritative data and the judicious use of M&S are imperative to developing our nation's top priority war plans, complete with branches and sequels to ensure we are prepared for all contingencies.

Unfortunately, ready access to reliable authoritative data remains a problem. This problem extends from data input (what data exists and where to go get it); through data usage (pedigree, standards, formats, granularity, etc.); to data output (limited visibility of the repositories for reuse which hinders availability and promotes stovepipes). Currently, each Community and Service enabled by M&S independently develops their M&S data within their spheres of responsibility causing the Department to pay for databases when an application is built, proving to be both costly and inefficient. The Communities and Services enabled by M&S should seek to leverage the same authoritative data and tools to help make informed Doctrine, Organization, Training, Material, Leadership and education, Personnel and Facilities (DOTMLPF) decisions that are enforced within the Department. We might get different results as models are expected to provide different answers, but efficiencies will be gained if the authoritative data is the same. From that standpoint, we can have a discussion on the issues because we are working from a common data baseline.

The Department needs an enduring M&S Enterprise Data approach that enables integration with other operational communities and with the broader Department of Defense (DoD) net-centric environment. Over the past few years a M&S Steering Committee (SC) stakeholder team has led several M&S High Level Tasks (HLT) addressing M&S data. We accomplished much, but the efforts were tactical approaches to the M&S data problem and lacked the enterprise reach that enables authoritative M&S data to be available across the Communities and Services enabled by M&S.

In March 2010, the M&S SC stakeholders, with help from the Modeling & Simulation Coordination Office (M&S CO) and the Joint Training Integration and Evaluation Center (JTIEC), formed a development team to address the data problem. Data is a complex issue which is not going to be solved within a two year funded project but by an effective strategy that builds an incremental capability for the Department. Our vision is a multi-year strategy, through a 5-year investment plan, to incrementally develop an enterprise approach for M&S data. This is an effective

strategy that initiates what we believe will become an enduring M&S data capability. Using this approach we developed an HLT called Rapid Data Generation (RDG), funded by the M&S CO Program Element.

Three major components comprise the RDG HLT:

- An Enterprise Business Plan (BP) that defines a five year incremental capability development and investment strategy aligning current and planned initiatives, processes and decision points, progressing towards a sustainable Department level enterprise solution and supporting the accomplishment of the DoD M&S goals and objectives. The business plan will address stakeholders, governance and policy, funding strategies, life cycle sustainment, metrics and risk assessment and mitigation.
- An Enterprise Business Framework that establishes a core M&S enterprise level of governance and policy to achieve an effective rapid data generation solution across Communities and Services enabled by M&S. The Enterprise Business Framework documents the processes, policies and artifacts necessary to establish and maintain a Data Management Working Group (DMWG) under the M&S Community of Interest (COI) and coordinate M&S data requirements and policies with other COIs such as Global Force Management Data Initiative, Geospatial, Logistics, Command & Control, to name just a few.
- An M&S Common Data Production Environment (CDPE) that builds an incremental technical capability that includes data repositories and data services (tools) to provide simulation-ready data to multiple Communities and Services. These data services will integrate and fuse data from a number of authoritative data sources using selected commercial and DoD data standards to rapidly integrate/correlate data from disparate sources and to exchange and translate data into simulation-ready formats. The CDPE infrastructure will be built using service oriented architecture, CDPE data services and business rules with sufficient flexibility and agility to rapidly add services as they become available.

All of us understand that the data problem is a complicated issue and will not be solved overnight, but the bottom-line is make data available, make it authoritative and make it work! There is no doubt we can succeed.

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Mr. Bonnet has over 34 years of professional experience in National Security. He is a member of the Senior Executive Service and in March 2008 took the position of Vice Director, Operational Plans and Joint Force Development Directorate, Joint Staff, J-7. He was responsible for overseeing and managing the Directorate's four divisions: Joint Operational War Plans, Joint Experimentation, Transformation and Concepts, Joint Exercise and Training, and Joint Education and Doctrine; and its Military Secretariat. He joined the Operational Plans and Joint Force Development Directorate, Joint Staff, J-7, in July 2004.

Mr. Bonnet served as the Deputy Director, for Joint Force Development and Integration, Joint Staff J-7. Immediately prior to that, he served as the Chief, Joint Experimentation, Transformation and Concepts Division, Joint Staff, J-7. His current tenure with the Joint Staff began in 2001 in the Force Structure, Resources and Assessment Directorate, Joint Staff, J-8 as an on-site contractor for Northrop-Grumman. In 2002, Mr. Bonnet entered the Civil Service, as the Deputy, Warfighting Concepts and Architectures Integration Division, Joint Staff, J-8.

Mr. Bonnet retired from the US Army with over 23 years of service. During his career, he held a number of combat arms command and staff assignments within the United States and overseas, including two Battalion Commands. He served two Joint tours while on active duty: with the Joint Staff, J-3, and with the North Atlantic Treaty Organization in Germany and Bosnia.

Mr. Bonnet is a 1974 graduate from the United States Military Academy and has a master's degree in Personnel Management from Troy State University.

An Emerging DoD M&S Enterprise Data Strategy

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 over arching enterprise-level data strategy for M&S that is aligned with the DoD's Net-Centric Data Strategy and that provide 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 road map 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.

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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 over arching 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 an 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.

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 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 for M&S enterprise data 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

M&S 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.	M&S DATA GOALS 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, and 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

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 over arching 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 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.

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 3 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.

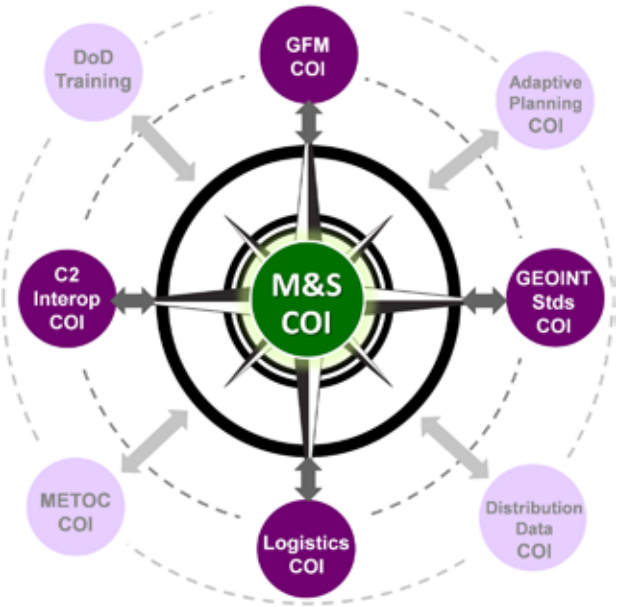

Figure 3. Collaboration among COIs

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

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.

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 4 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

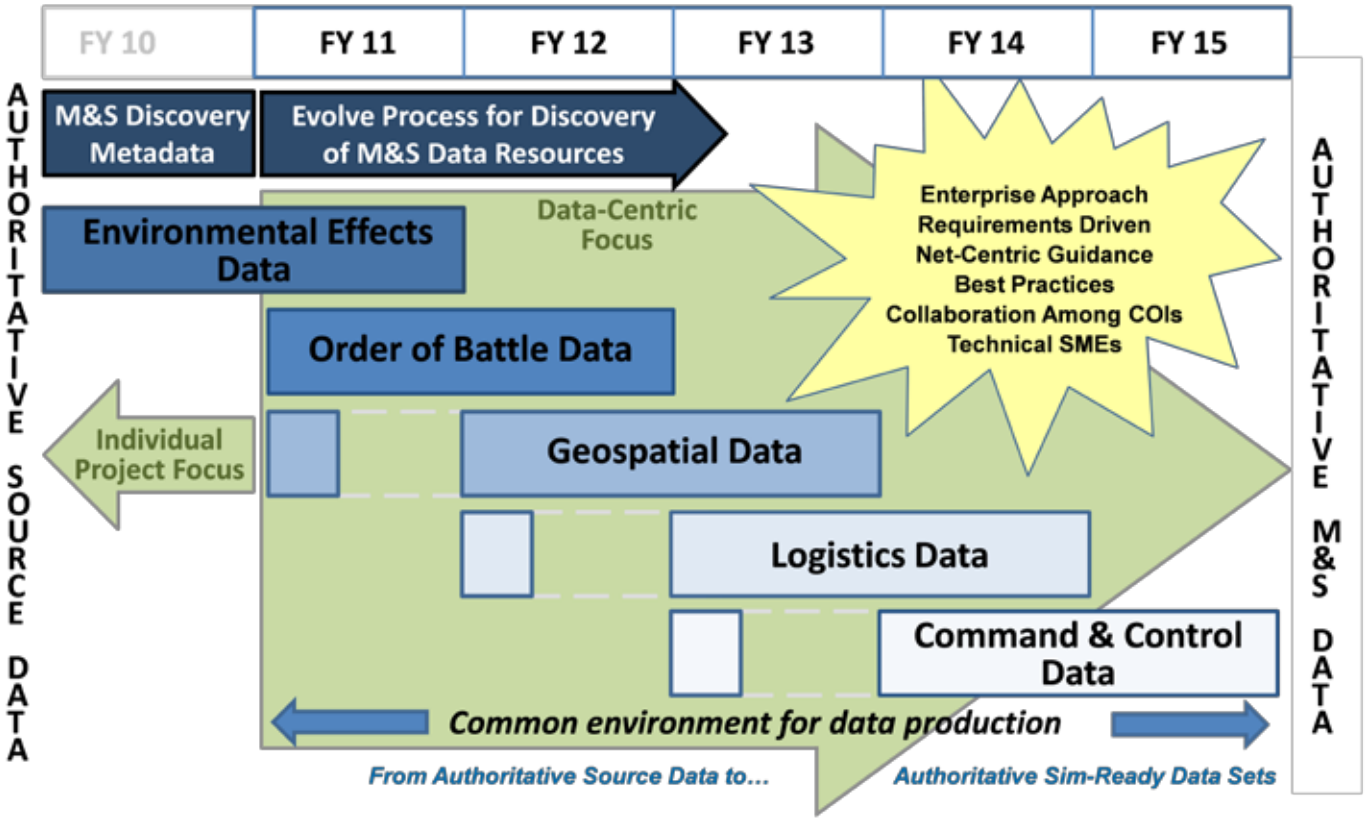

Figure 4. Conceptual Timeline for an M&S Enterprise Data Strategy

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 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.

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 over arching 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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Almost Accidental Database Standards

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Spatial Data, Environmental Datasets, Dataset Reuse, Dataset Interchange.

FOREWARD

The DoD Modeling and Simulation (M&S) community is spread broadly across DoD organizations and missions, to include logistics, studies and analysis, planning, training, operations, command and control, intelligence, and acquisition. Data that drives M&S functions can include any term that can influence or describe appearance, behavior, or time. This paper focuses on a very small subset of M&S data that provides virtual DoD simulation with a physical environment model to support training and rehearsal. This paper uses the term "database" to describe the hills, rivers, roads, trees, buildings, vehicles, and other features that populate virtual training environments used for visual and sensor simulation.

ABSTRACT

After decades of redundantly building simulator digital databases across programs and services, an opportunity has arisen to decrease this redundancy and reuse/exchange database investments. Several database initiatives have almost simultaneously begun within the military services. Although differing considerably in scope, these initiatives share a common theme of simulation programs sharing spatial database files at the in-process level (prior to transformation to run-time) in commonly used, open formats already adopted by industry. This paper describes the need and rationale for these initiatives, the forces that caused them to emerge almost simultaneously, and some of the similarities and differences between them. This paper also lists the common formats and why they were chosen, the anticipated value and limitations from using them, the remaining challenges associated with adoption across programs and services, and the need for continued coordination between them. This paper also includes brief discussions on the effects that sharing database files across programs may have on rapid database generation for combat mission rehearsal, the need for sufficient correlation during networked simulation events, and includes recommendations for DoD M&S engineers and managers.

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INTRODUCTION

DoD crew training M&S programs have been using digital databases for visual and sensor simulation for over 30 years. Because of computational limits in early computer image generators and a lack of real world source materials,

databases were sometimes synthetic and fictitious, with database content intentionally designed to support specific training tasks and only generally resembling the real world. Real world, geo-specific databases became more common as computer image generators became more capable and real world source materials became more available. By the early 1980s, real airfields, mountains, and buildings became modeled into databases (although quite primitively by today's standards) by more and more programs, often duplicating modeling efforts.

In a tri-service survey of flight simulation programs conducted in 1992 [1], it was found that of the 29 programs responding, a total of 329 airfields were required to be modeled within just the Continental United States (CONUS), and 145 of those airfields (44%) were required by more than one program. One airfield was required by nine programs. The average cost of modeling a high-fidelity airfield was in perhaps the $50-100K range. If that survey were to be re-conducted today, redundancy would be even more apparent, as the number of programs with digital database requirements has increased significantly and the number of airfields within the CONUS has not. Redundant database requirements, cost, and modeling effort have been known conditions in the simulation community for a long time.

Redundant database modeling effort is perhaps one of the more troubling aspects of this situation. Database modeling skills are hard to come by in our community. Neither government nor industry management have historically considered those skills to be essential. They are. When two skilled database modelers are tasked to work with the same source data to achieve the same practical result for customers in two separate programs, this represents an abuse of a rare, valuable, and often unappreciated skill set.

Why Couldn't We Share?

Obviously, differences between program database requirements (ie. ground armor versus aircraft fighter simulators) require different scene content and dictate different databases; however, there are many other reasons that have made sharing database investments or achieving database commonality between programs very difficult.

One reason was due to differences in format. For example, two different image generator vendors might start with the same source material to build a database of the same geographic area, but would reduce the source material into proprietary formats by the database modeler. Each image generator vendor developed database modeling processes internally, and with minimal consistency between database modeling toolsets' appearance and function. Once the database modeling process was complete, the proprietary in-process files were further reduced into a proprietary run-time format for scene generation.

Differences in database content caused by significant differences in image generator design made it difficult to share databases. Austere graphics processing limits forced image generator vendors to continuously create and intensely promote novel innovations in database architectures to increase the apparent scene content of databases. These competitive innovations could cause different image generators to create considerably different scenes of the same geographic area even though they use the same source materials.

Differences in database content were also attributed to modeling. Assuming identical content requirements, two databases of the same geographic area built for two different programs, might appear quite differently because of subjective decisions made by two sets of database modelers (compounded by two sets of subject matter experts) regarding which real world features to include and to exclude from the sparse (by today's standards) database.

Another reason was a lack of coordination between programs. Two programs within the same service would often not know what each other's database requirements or database holdings, even if managed within the same acquisition organization and shared the same vendor. At times programs were not aware of redundant requirements until informed by their common vendor. Cross talk between service programs was even rarer.

That was then. This is now. Say…do you feel a breeze?

The Winds of Change

The PC-based video game community with its enormous market and profit potential is founded upon many of the early developments within the DoD digital image generation community, but has eclipsed it both in terms of capability and cost. Increased processing capacity can now be purchased at several orders of magnitude of less cost… all "accidental" to DoD.

Modern image generators use massive amounts of geo-specific photo-texture (imagery), both for orthographic views of the terrain and for models and features. Imagery often requires considerable manipulation using complex algorithms. The Geographic Information System (GIS) community has spawned a sophisticated technology base that is expert in both imagery and feature manipulation. To remain competitive, image generator vendors have often found it cheaper to purchase mature imagery manipulation and feature modeling tools from second party (often GIS-based) vendors, rather than recreating these tools internally. This has caused image generator vendors to often use the same tools and the same in-process file formats common to the GIS community. In-process formats have become common across DoD image generator vendors.

Image generator vendors select from the same set of PC-based commodity graphics processors when populating their hardware and from the same small set of operating environments. The package is then wrapped within competitive vendors' proprietary run-time software and fiercely marketed. The market is intensely competitive, but with marketing hyperbole set aside, differences between each vendor's database architecture are becoming fewer and fewer than before. The discriminator tends to be not so much their database content and constructs, but rather how they are rendered.

Graphics processing capacities have radically improved. Although there are still processing limits (and will be until Star Trek's Holodeck becomes operational), the amount of scene content achievable today far surpasses that of just ten years ago that there can be no comparison. There is less reason to exclude features from the database because of processing limits. Common (or at least more similar) database content has become more achievable.

Same Formats – Different Scope

Program management across the services has been aware of the inefficiencies caused by database redundancy between programs and has initiated several database standardization initiatives within the last several years… and (most importantly) they've been talking to each other. The Navy, Air Force, Special Operations, and the Army have projects that vary widely in scope, but each includes a potential to share database investments across programs by requiring each program to export in-process dataset files in commonly used formats for reuse by other programs. These initiatives reference the same family of formats commonly used by industry.

The Navy Portable Source Initiative (NPSI) family of formats is nearly identical to those selected by the United States Special Operations Command Common Data Base Specification (USSOCOM CDB) program. The Air Force Common Dataset (AFCD) standard initiative uses the Navy formats with minor adaptations. The Army Synthetic Environment Core (SE Core) program has adopted similar formats. The opportunity to reuse database investments across programs and services appears on the horizon.

The charter and scope of these initiatives (beyond the exchange of datasets) varies widely. The Air Force initiative is basically a list of formats "borrowed" from the Navy; after all, plagiarism can be the sincerest form of flattery. The Navy initiative includes not just a list of formats, but also rules and guidelines for database modeling and production. The USSOCOM initiative includes even more explicit rules for database modeling as well as interfaces between the database and the image generator(s). The Army initiative includes development of database production centers to satisfy many Army M&S program database requirements.

Common In-Process Formats

The adoption of common in-process dataset formats by industry is not due to any dictate or proactive movement by the government. It has occurred almost accidentally because of market and technology forces beyond government control. The government now has the opportunity for programs and their vendors to export files in formats they already possess for purposes of reuse by other programs…at no or minimal additional cost.

The common in-process formats vary, depending upon data types:

1. For terrain, the use of Digital Terrain Elevation Data (DTED) or GeoTIFF formats.
2. For vector features, the use of ESRI Shape format.
3. For overhead imagery and textures on models, the use of GeoTIFF format, RGB or RGBa, or lossless JPEG 2000 format.
4. For static and dynamic models, the use of Presagis OpenFlight format.

Use of the National Geospatial-Intelligence Agency's (NGA's) World Geodetic Standard (WGS)-84 datum, the WGS-84 reference ellipsoid, and a geodetic Lat/Long coordinate system are preferred for all data types. WGS-84 has become

universally accepted within the GIS community as the preferred method to consolidate nearly a hundred different datums and several projections into one over arching definition of where objects exist on the earth. It also serves as the geopositioning reference for the Global Positioning System. NGA and its predecessor organizations have done a terrific job developing, maintaining, and promoting the use of WGS-84, to include its several appendices. See http://earth-info.nga.mil/GandG/publications/tr8350.2/wgs84fin.pdf.

Compliance to export in-process dataset files in these common formats should require no or minimal additional effort on the vendor's part, since they already process data in those formats.

The sharing of in-process dataset files in common formats was not achievable ten years ago, but it is now.

Criterion for Inclusion

The criterion is that they must be commonly used as in-process formats by industry. Other formats could be used for the various data types, but they do not currently meet the criterion for inclusion. Because of the dynamic and innovative technology base, it is anticipated that the list of formats will change with time, as vendors adopt more improved formats.

Changes to this list can only occur with industry adoption of new formats. It truly is industry's list, and not the government's. Periodic meetings and reviews are required to keep this list current and relevant.

Results of Prototyping and Testing

Both the Navy and the Air Force initiatives were preceded by the development of common dataset prototypes and then testing their value on a variety of different vendors' image generators. The test results were nearly identical. If two programs possess the same database area and content requirements, up to a 95% cost (and schedule) improvement was attainable through the sharing of common in-process format files. The results of these tests are well documented in papers and presentations at the annual IMAGE Conference and annual Interservice/Industry Training Simulation and Education Conference (I/ITSEC) [see recommended reading].

Numerous practical examples of sharing common format datasets have occurred on a near weekly basis between and among service programs. It's working!

Common In-Process Format Impact on Networked Correlation

More DoD simulation programs are expressing a requirement for networked simulation across programs, to better achieve force-on-force simulation training to more closely resemble the complex nature of real world combat. In the real world, there is only one environment. In a simulated world, each entity's environment must be sufficiently correlated with that of the other entities' so that the outcome of a simulated event is parallel to a real world event. Networking between simulation entities dictates sufficiently correlated environments. Exact correlation function requires identical performance, may require a dictated design (which can limit competition and stifle innovation), and may not always be required. Standards that require ultraprecision can serve as a two-edged sword that can hurt as much as help.

Depending upon the degree of interaction and the mission profiles of simulated entities, significant constraints and rules regarding database generation and rendering may be required…or may not. Although beginning with the same set of common source files does not guarantee sufficient correlation, any initiative to help share common datasets between programs will help mitigate the risk of insufficient correlation during networked operation because they start with the same stuff.

Anecdotal (but expert) opinion from the Navy and Air Force prototype tests indicate a high perceptual similarity between run-time databases built from the same common in-process format files.

Common In-Process Format Impact on Rapid Database Generation

More DOD simulation programs are expressing a requirement for the rehearsal of combat missions, which requires very rapid database generation and may require near run-time insertion of recently available imagery and object sets into the simulated environment. Although beginning with a set of common source files does not guarantee sufficient timeliness of database generation or update, it does save considerable production and update time since the initial dataset does not have to be recreated from scratch.

Common In-Process Format Limitations

Use of common in-process formats will not result in 100% cost or schedule savings, nor will it result in perfect correlation for several reasons.

The program that produces the shared dataset may have had different database fidelity requirements or different image generator capabilities than the program that uses or consumes the shared dataset. For example, perhaps the imagery in the shared dataset provided by the producer program is too old to meet the consumer program's requirements. They will still need to expend work and effort to improve upon the imagery portion of the shared dataset to meet its program requirements. The consumer program would then include these improvements in the dataset they produce for use by subsequent programs. As another example, a highly detailed urban database built to support close-in ground armor scene content requirements might overload a fast-moving flight simulator with a requirement to present scene content out to a hundred or more miles.

These are in-process datasets, not run-time databases. Exchange of these datasets between programs will not result in a plug-and-play database. Work and effort will still be required to place the datasets into vendor-specific data structures and transformation to run-time. Because of differences between competitive image generator vendor designs, the results will not be exactly identical scenes. As previously mentioned, exactly identical scenes may not be required to achieve sufficient correlation.

Shape and OpenFlight formats include a large number of explicitly defined data types that are universally understood. Both formats also allow the use of extensions to hold data types that might be unique or peculiar to a particular application or vendor. In this case, all of the value and content of the shared feature or model may not transfer from the producer to the consumer program. There will be some value transfer but not probably all, depending upon the data type and the frequency of the use of extensions. The addition of a specification that tells industry how to build databases can help minimize this loss of value, but with the possible risk of constraining our innovative vendor base.

Databases used for sensor simulation (radar, infra-red, night vision goggle, etc.) is an application that requires a considerable amount of data type extensions to both Shape and OpenFlight files. This is a known weakness of those formats. Efforts by the NPSI program to develop standard sensor extensions in XML files and to reference them in their database specifications [see recommended reading]. This will allow more reuse value in shared datasets and further improve correlation. The Navy has the lead on this initiative and the other services will no doubt consider adoption.

The fact that use of common in-process datasets cannot (and in some cases should not) achieve 100% cost or schedule savings or perfect correlation is insufficient reason to not use them to achieve the greatest savings or correlation attainable. Prior to common in-process datasets, our community only had the option of continuing with zero percent reuse/savings and repurchasing the same digital dirt again, and again, and again.

Challenges of Implementation

Government acquisition processes have long frowned upon the inclusion of government standards or specifications in contracts, and have favored the use of industry standards and specifications instead. This is because compliance to government standards exposes the government acquisition process to liability if a defaulting vendor can show defects or omissions in the government standards and the vendor were to file a claim. If data export in commonly used in-process file formats is to be contractually required, they must be clearly described as being the result of industry's selection, and not the government's. This can be tedious and difficult. Top-level support from senior management in acquisition may be required to help expedite this.

Individual program customers may view compliance as being a cost driver, or as an undue influence on their database requirements. These misperceptions must be immediately corrected, since neither is true. Most vendors should already comply with the format requirement, since they are already using the common formats. The only additional effort would be in copying existing files for transmittal to the government for reuse. Each individual program remains in total control of their database content and extent. Compliance to these formats does not add, delete, or modify a single feature, attribute, or polygon in their databases nor does it measurably add to their database delivery schedule. The understanding that customer collaboration will not impact cost/schedule/performance is an absolute necessity and must be assured.

Some types of source data, such as commercial imagery, may include licensing costs borne by the producing program. These costs may increase if the license were to be extended to other customer programs that reuse the imagery. This same concern may extend to the use of certain database services from second party contractors who manipulate and enhance imagery and/or other database components. The producing program should not be required to pay for these extended costs, but should negotiate with the imagery/service provider the costs of an extended license beforehand, should a customer program desire to reuse it. The customer program would then have to pay for the negotiated costs of an extended license, if they decided to reuse it. Extended data rights should be required whenever possible by programs, but if there is an additional cost involved, the producing program should not be required to pay for it.

Although not specifically a limitation of the selected formats, the producer program cannot be held liable or responsible for omissions or errors in the shared dataset. The consumer program will receive the datasets "as-is" and will still be responsible for ensuring that their database meets their program requirements. Also, the cost and schedule advantages cannot occur until producer programs have provided a sufficient "library" of accumulated datasets for consumer programs to choose from.

Security and Classification Issues

Some types of database source material (especially imagery) may be classified. These cannot be shared with other programs unless those programs possess a sufficient security level and a need-to-know. This shall always be true.

In the past, unclassified materials may have had insufficient resolution or recency to conduct training/mission rehearsal missions and classified materials were required. This situation is becoming less of an issue with unclassified sub-meter commercial imagery available from several commercial vendors now, and imaging satellite launch plans from several vendors indicate that even finer resolutions and extended wavelengths will become available over the next several years. Also, the National Geospatial-Intelligence Agency has a well-funded program to purchase commercial imagery and make it available for free to any government program.

If the source materials have no security classification, a particular database existing in a particular area of the world may be interpreted as showing "will or intent" and therefore become classified. This has been especially true for those programs with a combat mission rehearsal requirement. This is becoming less of a concern since global (although quite coarse) databases are now available from several vendors and higher resolution databases can now be built using unclassified source data that consume tens or hundreds of terabytes of storage and cover millions of square miles. In the not-too-distant future databases built with unclassified source materials may remain unclassified, even if they are used for mission rehearsal. If the database is the whole world (or a large chunk of it), the mission rehearsal scenario may be classified, but the database need not be. This quite reasonable interpretation could free up a huge source of shareable datasets that were previously unavailable to most programs and could provide immense value to our warfighters.

Continued Service Coordination

Some of the similar service initiatives started with little knowledge of each other, but luckily the government database community is small enough to ensure that the initiatives soon became aware of each other's activities. Even though the scope of the initiatives varies widely, the use of the same basic family of common in-process formats for data exchange appeared to be in everyone's best interest.

For the past five years, representatives from each of the service initiatives have met and exchanged update briefings twice a year, with industry in attendance. These meetings have been occurring at the IMAGE Conference in the summer and at I/ITSEC in late fall. Frequent exchange is necessary across the programs to ensure that we communicate information of what's available or being built, continue to produce datasets in formats that are reusable, and share information on database research and development initiatives to promote collaboration and leveraging of each other's investments and knowledge. Continued coordination between the services is necessary to achieve the best common good.

At the 2010 I/ITSEC meeting and with SOCOM sponsorship, the representatives agreed to make the current ad hoc/informal exchange of datasets more formal with the adoption of data exchange agreements. This is an excellent idea and should be pursued.

The various service initiatives are supported by documentation (standards and specifications) that vary widely in terms of content and detail because of their significant differences in scope. It would be useful if the part of the initiatives that are common between them (in-process formats) could be broken out as a stand-alone document or as an appendix, perhaps to the data exchange agreement. That way it would be much easier to adopt common changes when agreed to by the services. The document should not focus on how to build datasets, but rather on how to exchange them.

Each of the service initiatives includes their own dataset archive and distribution facility. Considerable dataset sharing has already occurred, most often as the result of person-to-person queries. A method to establish connectivity between the facilities and employment of common data naming and metadata conventions would considerably assist the data discovery process and provide virtual pointers to where desired datasets reside. Coordination and cooperation on this matter could assist customer programs by providing an easy to use common cross-index.

It could also be very useful to have each service agree to common language in contracts and requests for proposals that defines the requirement to export in-process files in common formats. Consistency in contract descriptions would make it much easier for our shared industry base to better understand just what is expected of them and help them more confidently prepare proposals.

Sharing and Coordinating Requirements

Sharing common format in-process datasets is only one part of a solution to minimize database redundancy. Another part is sharing and coordinating database requirements before the databases are built and the sharable datasets become available.

Multiple programs may have an urgent, time-critical requirement for a database of the same geographic area, and database development redundancy may be necessary and reasonable to satisfy their requirements. Other database requirements are not that time-critical.

Some programs may have stable and well-known database requirements, such as a pilot training simulator program needing just pilot training airfields in the CONUS. Other programs could require databases in any area of the world. The initiation of global database requirements are limited to funds available, and may be additionally constrained by the need for a variety of environment types for training, forward locations where the weapon system may be stationed, or where the media or conventional wisdom indicate the next global crisis might occur.

If the office responsible for setting Program A's database area requirements was aware of reusable datasets available, their decision regarding location and area of coverage could be altered to result in more training capability for the same cost. If Program B was three months away from having reusable datasets, Program A wouldn't know about it unless Program B's requirements and schedule available. Many other examples of potential efficiencies achievable through the coordination of database requirements and schedule could be made.

A key point is that each program would still be responsible for setting its own requirements. That would not change. With the coordination of database requirements and schedule, each program would have more information at their disposal to make smarter decisions with a better return on investment and provide more value to our warfighters.

Recommendations

Periodic meetings between service initiative representatives should continue.

Adoption of more formal data exchange agreements between service initiatives should be completed.

Service initiatives should document their list of common in-process formats separately or as an appendix to the data exchange agreements to provide easier adoption of common format changes.

Periodic meetings and reviews with industry should continue to occur to ensure that the in-process formats used for sharing datasets are common across our vendors and provide best value to our warfighters.

Both industry and government offices should support efforts to define improved methods of sharing sensor data types, such as NPSI development of sensor and metadata XML extensions.

The services' distributed archive and distribution capabilities should work toward a common method of organizing and querying their archives to promote improved data discovery across services.

Top-level support and endorsement of these initiatives by acquisition management can expedite their application to programs and should be pursued.

Customer acceptance of having their program export data to support someone else's program with no impact on their cost/schedule/performance is an absolute necessity and must be assured.

Methods or conditions should be found to allow otherwise unclassified datasets used for combat mission rehearsal to be shared with other programs without compromising or disclosing "will or intent."

The services should work toward the sharing of information that describes not just common dataset holdings, but also information describing database requirements and schedules prior to database generation, test, and acceptance.

The services should work toward the use of common language in contracts and requests for proposals that define the requirement to export in-process files in common formats.

Through the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics and the Modeling & Simulation Coordination Office, a new initiative called Rapid Database Generation is emerging to explore ways of identifying, coordinating, and managing the torrent of data that supports the very diversified DoD M&S community. Experiences described in this paper could be used as a model or exemplar for broader application.

SUMMARY

Although this paper makes the concept of dataset sharing through common in-process formats appear accidental and almost serendipitous, it has taken a lot of hard work, perseverance, and dedication by a number of very talented folks. Our innovative technology base and the highly dynamic market sector are very hard to predict. The "accidental" conditions that make the concept feasible now could just as easily disappear. Action is necessary to maintain this initiative. The services are faced with a marvelous opportunity to right a long standing wrong within our DoD M&S virtual training community. The dedicated folks who have pursued this concept this far have a bit more pushing ahead of them, but the end goal of providing better bang-per-buck to our warfighters appears achievable.

RECOMMENDED READING

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Discovery and Reuse of Modeling and Simulation Assets

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DoD, M&S, XML, NCES, discovery, metadata, standards, reuse, repository.

ABSTRACT

The ability to discover existing modeling and simulation (M&S) assets is a critical need for enabling effective reuse and for reducing the duplication of capabilities. Such visibility and accessibility is a key to optimizing the investment of the estimated billions of dollars spent on M&S within the Department of Defense (DoD).

This paper updates the status of work presented at the SISO 2009 Spring SIW (09S-SIW-076). The DoD M&S Community of Interest (COI) Discovery Metadata Specification (MSC-DMS) version 1.2.1, which provides a common mechanism to catalog a wide variety of M&S resources as metacards, is now publicly available through the DoD Metadata Registry. A formal process has been established to coordinate the MSC-DMS and the closely related specification used by the DoD M&S Catalog.

The M&S Catalog provides a common portal with connection to various M&S related repository Sources, with Initial Operational Capability expected in early 2010. In addition, the M&S Catalog will be federated with the DoD Enterprise Catalog, and publish-and-subscribe mechanisms using DoD Net-Centric Enterprise Services (NCES) will be developed. Tools will be developed and technical assistance provided to help Sources map their existing data structures to the MSC-DMS, to generate conformant XML-formatted metadata, and to submit the metadata to the M&S Catalog (or any other authorized subscriber). Potential Sources of M&S metadata are encouraged to contact the authors.

Disclaimer: The views presented in this paper are those of the authors and do not necessarily represent the views of the Department of Defense or its Components.

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NETWARS/JCSS community, having led the development of models for both EHF Milstar and UHF DAMA satellite communications. More recently, he has supported the Navy M&S Office (NMSO) and now serves as technical lead for the DoD M&S Catalog project. He has a Bachelor of Arts degree in Mathematics from Reed College, a Master of Arts degree in Mathematics from the University of Oregon, and a Ph.D. from the Medical University of South Carolina in Biometry (systems science track). He taught mathematics, computer programming, and physics at the college level for 25 years. His hobbies include alpine skiing and barbershop harmony.

CURTIS BLAIS is a research associate in the Naval Postgraduate School Modeling, Virtual Environments, and Simulation (MOVES) Institute. He has over 35 years experience in M&S research, development, and education. Mr. Blais provides technical consultation in web-based technologies for development and employment of the M&S Catalog and is coordinating the generation and transfer of metadata describing 3D models maintained in the MOVES Scenario Authoring and Visualization for Advanced Graphical Environments (SAVAGE) repository. He is an active member of the SISO Product Development Groups for the Coalition Battle Management Language, Military Scenario Definition Language, and Simulation Reference Markup Language. Mr. Blais holds Bachelor of Science and Master of Science degrees in Mathematics from the University of Notre Dame.

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INTRODUCTION

This is the third installment of a technical paper within the Simulation Interoperability Standards Organization (SISO) regarding the M&S Community of Interest (COI) Discovery Metadata Specification (MSC-DMS). The first paper, presented in the Fall of 2008, was simply an introduction; a primer describing how the specification was developed, what it offered including what types of resources could be cataloged and what available metatags could be used to describe those resources [1].

The second paper, presented in the Spring of 2009, focused on maximizing discovery; it introduced the M&S Catalog, which provides a common portal with connection to various M&S related repository Sources [2]. This second paper highlighted what could be exploited from the MSC-DMS by search engines such as the one provided by the M&S Catalog.

This third paper focuses on the practical application of the specification and use of the M&S Catalog. Like the second paper, the MSC-DMS and M&S Catalog are featured as a dynamic duo. We highlight what the MSC-DMS and M&S Catalog both presently offer to the community, and examine how they can be used in a practical way for both developers in creating metacards that describe their resource (similar to a soup can label describing a food product) and users who are looking to discover such resources.

Net-Centric M&S Discovery Efforts

The Modeling and Simulation Coordination Office (M&S CO), chartered by the Office for the Secretary of Defense (OSD), has supported the development of the MSC-DMS. The first version of the MSC-DMS appeared on the street almost two years ago. In those two years it has been updated twice and uploaded to the DoD Metadata Registry [3]. In addition, a supporting document, identified as the MSC-DMS Implementation Guide [5], has recently been developed that describes how to document and catalog M&S resources with the necessary Discovery Metadata. The goal of both the MCS-DMS specification [4] and guide is to help support the net-centric goals of data visibility of M&S assets across the DoD.

Also in the past two years a growing number of people have begun to utilize the MSC-DMS as a template for creating metacards to catalog resources. A majority of these users are involved in connecting their resource repositories with the M&S Catalog effort, which was birthed just over a year ago. Users of the M&S Catalog and MSC-DMS include the Army, Navy, Air Force, and the DoD MSIS, as well as the joint analysis community, among others.

Twice now we've used the term metacard. Perhaps you are wondering what a metacard is. A metacard holds key information, typically in Extensible Markup Language (XML) format, that describes a resource including its purpose and application, and other information including points of contact, creation date, and, if available, usage experience. We say XML, because that's how it is supported by the MSC-DMS, and also by its close relative, the DoD Discovery Metadata Specification (DDMS) [6], which provides the basis for all community-focused discovery metadata initiatives within DoD.

In support of the different versions of the MSC-DMS that have evolved and to maintain mapping with the DDMS, several transformation files based on the Extensible Stylesheet Language Transformations (XSLT) [7] have been developed as well. These XSLT files help transform MSC-DMS metacards to support different specified formats. In particular, they help maintain compatibility with different versions of the MSC-DMS as they have been introduced, and also cross-compatibility with the DDMS thereby supporting the DoD Core Enterprise Services such as DoD Federated Search and Enterprise Catalog (see side note).

The bottom line is that in the last two years tools have been put-in-play to begin to better build, connect, and share M&S resources. These tools include the MSC-DMS, supporting guides, examples, transformations, the M&S Catalog, and the connection of repositories to the M&S Catalog. With all these things in place organizations are poised to help improve M&S reuse and discovery – but only if the capabilities are used and used properly. Furthermore, these capabilities stand to better serve the DoD M&S community only if feedback continues to be received that identifies how to improve these tools.

Note: The purpose of DoD Federated Search is to provide a capability to the community of users (including but not limited to M&S users), which allows the discovery of information from disparate data sources with "one query" request. Such a Federated Search request works with the Enterprise Catalog, which uses standard, vendor-neutral specifications to leverage existing Community of Interest (COI) information repositories such as the M&S Catalog.

The Enterprise Catalog makes connection with a network of resources to support the Federated Search goal. Understanding that each COI has different needs with regard to how and what should be reflected in its metadata (e.g., the MSC-DMS for DoD M&S resources) but knowing that a core lingua franca (e.g., DDMS) is needed for the federated search clarifies why transformation mappings, such as described above, are needed. For more information on these Core Enterprise Services visit https://metadata.dod/mil/mdr.

Discovering M&S Assets

Discovery is defined as "the ability to locate data assets through a consistent and flexible search."[6] The DoD Net-Centric Data Strategy (dated May 9, 2003) [8] defines goals and approaches for users and systems to discover and access a wide range of data assets throughout the DoD Enterprise.

From the MSC-DMS perspective, the types of M&S resource that should be cataloged with the same set of metacards include the following:

1. M&S software (implements a complete model or simulation)
2. Adjunct tools (e.g., data loggers)
3. Federations of simulations
4. M&S software components (reusable building block with known inputs, and expected output but implementation details may be hidden; may be compileable source module or linkable byte code, such as an active X component)
5. M&S services (models and simulations implemented as web services)
6. M&S data (data in M&S-usable format and data produced by M&S)
7. M&S data models (structural metadata for M&S data)
8. Interface specifications
9. M&S software design documents

Records currently in the M&S Catalog are "legacy" in the sense that they existed in various Source repositories before being translated to comply with the MSC-DMS schema. Different Sources categorized their records in different ways. For example, one Source has nothing but simulations, each of which was originally tagged as *live, virtual, constructive,* or some combination thereof. Another Source focused on the implementation of models, so its resource types included *algorithmic, Monte Carlo, deterministic,* and the like. Yet another Source had some records tagged but others with no resource type indicated at all. Translations of these records into the MSC-DMS schema have also varied. Many still have the original tag even if it doesn't match the MSC-DMS enumeration above. Others have tried to match (typically with *Software, Data, or Data Model*), while some others appear in the M&S Catalog as N/A.

The overall collection of elements that the MSC-DMS provides for in a metacard is illustrated in Figure 1.

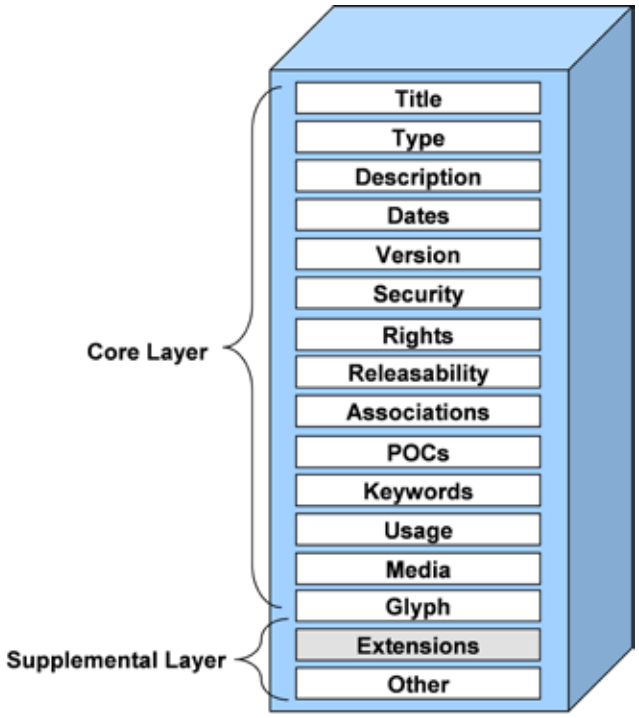

Figure 1. MSC-DMS Structure for the Resource Metadata Set

The M&S Implementation Guide explains how to document and capture these metacard elements. It also provides a basic XML tutorial to help the reader understand the syntax. Some of the XML syntax is used within this paper, and the reader is encouraged to refer to the Implementation Guide or other XML related references if such syntax is not clear.

The M&S Catalog team has identified that there are subcomponents of the MSC-DMS that also may need to be cataloged and discovered. These include subject matter experts (SMEs), which can be captured using the POC type provided by the MSC-DMS. POCs include individuals (identified as Person) and Organizations. The overall structure of POC elements is illustrated in Figure 2.

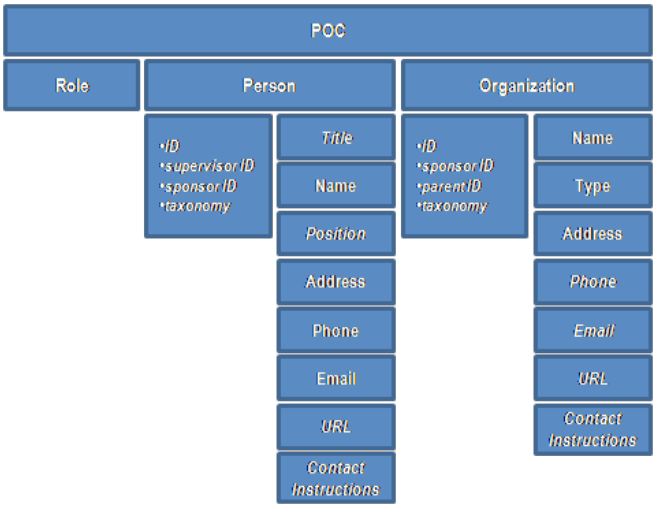

Figure 2. MSC-DMS POC Structure for Persons and Organizations

Although support for SMEs as stand-alone records (similar to a "Yellow Pages" directory) has long been seen as desirable, such stand-alone records are not yet used by the M&S Catalog. Currently, a SME would be listed as a POC for some particular resource with a role of *technical POC*. At least in principle, this structure can be made to work for some useful queries. Most obviously, it can support "who is a SME for resource XYZ?" – simply returning all POCs of *type technical POC* belonging to records for resource XYZ. This basic query will be within the scope of the M&S Catalog user interface planned for 2010. It can, in principle, be extended to find the most experienced SMEs for the resource XYZ: for each SME returned for resource XYZ, perform a sub-query to identify all the resources for which that SME is listed as a *technical POC*. The SMEs with the longest (or most relevant) list of supported resources would likely be the most experienced. This two-level query will probably be outside the scope of the ordinary M&S Catalog user interface, but it may be possible to generate some custom reports. This will be investigated.

How the M&S Catalog Works

In 2009, the M&S Catalog project developed a functioning search engine capable of basic "targeted search" that took advantage of the high-level fields of the MSC-DMS. It is possible to search for particular values in *Title, Description, Dates, Version, Rights, Releasability, Security, Associations, POCs, Keywords, Usages, Media, or Extensions*. Although it is possible to search for a POC named "Smith", looking for "John Smith" will not return the expected result because the first name and last name are stored in separate fields, and the target string "John Smith" does not exist by itself. The M&S Catalog team intends to improve upon this in the coming year.

In 2010, the M&S Catalog project will take advantage of the lessons learned using the in-house government off-the-shelf (GOTS) query interface tool to acquire and configure a COTS search engine to better meet the requirements defined in 2009 by an extensive series of interviews with leaders of the various DoD M&S COIs. One of these requirements is "faceted search", in which the search engine will provide the user with a succession of search options. One well-known example of this is seen in many store-front websites that offer filters based on object type, brand name, capacity, price, and the like. The M&S Catalog expects also to offer *dynamic* faceted search, in which options are presented based on the underlying data.

A specific example of this that the M&S Catalog team intends to implement will be based on the *Keywords* structure of the MSC-DMS. This allows for ordered pairs consisting of *taxonomy* and *value*. For example, some records may have pairs indicating different kinds of Warfare Area such as (Warfare Area, Anti-Air Defense) or (Warfare Area, Anti-Surface). In this case, the search engine would allow the user to select *Warfare Area* as a possible filter, and would offer *Anti-Air Defense and Anti-Surface* as two possible values for that filter.

Making such searches possible requires some advance preparation. For instance, the M&S Catalog team has recently reviewed the data it manages to identify which aspects are possessed by all records, and which are possessed by some. The former, which would include required fields like *title*, would be available at the outset of a search, like *brand* and *price* in a storefront. Aspects held by only some records, like particular taxonomy/value pairs, would be candidates for dynamic facets after a search has begun.

Of course, all of this assumes that the M&S Catalog has metadata records to be searched. A key priority in 2010 is to sign up more Sources and Sources of different kinds of data supporting experimentation, training, analysis, and testing -- all the different DoD communities enabled by M&S.

When a Source does sign up for the M&S Catalog, it submits its metacards describing its resources in the form of XML files that comply (or nearly so) with the MSC-DMS schema. These files can contain one record each or can contain an aggregate of multiple records. They are submitted by each Source using either e-mail or an upload web-service hosted by the M&S Catalog. Each submission is scanned for compliance with the schema and feedback (acknowledgment or error message) is returned to the submitting Source for each individual record, as illustrated in Figure 3.

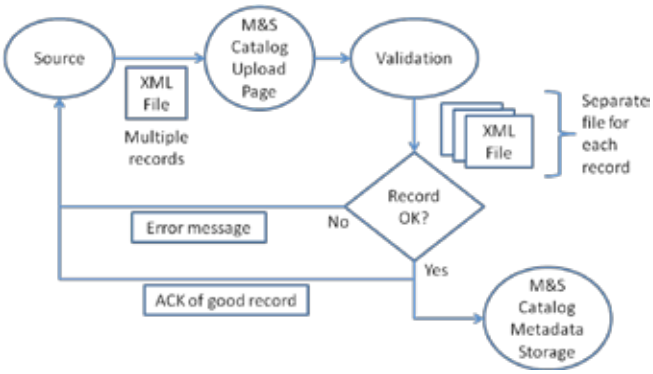

Figure 3. M&S Catalog Upload Work Flow Process

Each Source identified in this illustration represents a resource repository. The Source shares with the M&S Catalog a record of the resources it maintains. The M&S Catalog takes that information, validates it, and then provides a clearinghouse listing of what resources are available from these other Sources to users. The M&S Catalog maintains discovery metadata, and the data that the M&S Catalog provides to users are the metadata elements defined in the MSC-DMS [5].

One quality characteristic of the M&S Catalog is the robustness built into the upload work flow process, which helps received data not be misapplied. For example, suppose a contractor in the Air Force submits a "block update" intended to replace the entire collection for their particular Source, however he accidently chooses a Navy Source from a pull-down list. To protect against this sort of error, two mechanisms have been implemented. First, a designated POC's e-mail address is associated with each

Source, and the acknowledgments/error messages are sent to that e-mail address. Positive confirmation will be required from that POC before the records are pushed into the M&S Catalog. Thus, if the Air Force person accidentally designated a Navy Source for the submission, the Navy POC would receive notice of the submission and be able to protest. Second, the M&S Catalog backs-up the entire data collection each week with each submission saved separately. If some erroneous changes are made, reversion to the last-known good state can be made, and only the changes known to be valid can be reapplied, leaving out the bad ones.

The Source provides metadata corresponding to the MSC-DMS data elements, using as many of the MSC-DMS elements as applicable to the resource being described. At a minimum the metacard data provided by each Source must include:

- Resource ID
- Title
- Description
- POC

Certain other fields are highly recommended but not absolutely required for Source submission by the M&S Catalog. To be compliant with the MSC-DMS schema, the following fields should also be present:

- Type
- Dates
- Version
- Releasability
- Keyword

Very important is the fact that the M&S Catalog explicitly wants to stay as closely aligned with the MSC-DMS as possible. It hasn't been perfect because the M&S Catalog has been on the "cutting edge" supporting Sources with legacy metadata and assimilating into something that fits as closely as it can with the MSC-DMS. But the vision and the process are to keep them going in the same direction.

Generating and using IDs within MSC-DMS

There are several components of the MSC-DMS that utilize unique identifier (ID) tags to support cross referencing. They include the following:

- Resource
- Associations
- POCs (Organizations and Persons)

IDs can be very useful for uniquely marking assets and referencing other previously marked assets. The above three uses of IDs are discussed in the following subparagraphs.

Resource

A resource record may be marked by a unique identifier to support cross referencing by other resources and for the benefit of organizing data by one or more repositories. The ID provides a way to uniquely distinguish a resource allowing it to be referenced and used by community members. In fact, with MSC-DMS version 1.3, there can be two types of IDs identified: an ID for the metacard, which stands alone from the resource; and an ID for the resource itself. In theory the ID values could be the same; however, the M&S Catalog has elected to differentiate between the metacard and the resource by using a different ID. Fortunately the metacard can be used to identify the related resource ID.

An example of an ID is shown in the following listing.

```
<ms:Resource
ms:ID="0BFC70E9"
ms:Metacard_ID="0XDC31E9"
xsi:schemaLocation="http://metadata.dod.mil/mdr/ns/MSCDMS/1.2/
MSC-DMS-v1_2.xsd"
xmlns:ddms="http://metadata.dod.mil/mdr/ns/DDMS/2.0/"
xmlns:ms="http://metadata.dod.mil/mdr/ns/MSCDMS/1.2/"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:icism="urn:us:gov:ic:ism:v2">
```

In this XML snippet, the ms:Resource tag[1] identifies a unique ID in the ms:ID attribute, which relates to the specific M&S resource. The ms:Metacard_ID attribute provides a unique ID that can be associated to the standalone Metacard represented by this XML document. The attributes that follow identify the related namespaces identifying the vocabulary used in the content of the XML metacard document.

[1]The "ms:" prefix in the XML element and attribute names is called a namespace prefix. A little further in the example, this namespace prefix is associated with the namespace for the MSC-DMS vocabulary ("http://metadata.dod.mil/mdr/ns/MSCDMS/1.2/").

Associations

An MSC-DMS metacard can define *associations* to other M&S resource assets or support assets. This is a very powerful component for supporting Semantic Publishing, which is discussed in greater detail later. An XML metacard example is provided below that shows how associated resources are referenced by ID.

In the following XML snippet, the metacard identifies an Association to another document. An ID Tag (ms:associationID attribute) of "4352" is used to mark what additional resource it connects to. We will explore this further later in this paper.

```
<ms:Associations>
    <ms:Association
        ddms:qualifier="URL"
        ddms:value="http://www.sa1s.com/BM1.xml"
        ddms:schemaHref="http://www.sa1s.com"
        ms:relationship="is-described-by"
        ms:type="related documents"
        ms:associationID="4352"
    </ms:Association>
</ms:Associations>
```

Points of Contact (POCs)

IDs are also used to identify POC organizations and persons. The types of IDs for POC organization and persons are shown in Table X.

ORGANIZATION	PERSON
• ID • sponsorID • parentID	• ID • sponsorID • supervisorID

Table X.

Both an Organization and Person are uniquely identified by an ID. It is intended to distinguish that organization or person from others.

POC Organization

An organization may identify what sponsor it is supporting pertaining to the resource of interest. This is marked with the sponsorID attribute. Additionally the organization may identify a parent organization that it is part of. An example highlighting how to document a POC Organization element is provided below:

```
<ms:POC>
   <ms:Role ms:value="publisher"/>
   <ms:Organization
         ms:ID="330"
         ms:parentID="320"
         ms:sponsorID="720">
      <ms:Name ms:value="SpyFlight IT"/>
      <ms:Type ms:value="industry"/>
      <ms:AddressInfo>
      <ms:Phone
            ms:type="work"
            ms:number="540-324-2208""/>
      <ms:Email
            ms:type="work"
            ms:address="info@spyflt.com"/>
            <ms:URL
            ms:value="http://www.spyflt.com"
            />
      <ms:ContactInstruction ms:value="For general assistance, dial 0
            for an operator"/>
   </ms:Organization>
</ms:POC>
```

In this XML snippet, the metacard identifies a POC Organization uniquely identified by the value "330" in the ms:ID attribute. Assuming this value is somehow registered with that organization (via a repository for example) the ID value can be used as an association or reference by other POCs. For example, this XML snippet references a sponsor with the ID tag "720" (ms:sponsorID attribute), and references a parent organization with the ID tag "320" (ms:parentID attribute).

POC Person

Like an Organization, a Person may identify what sponsor he or she is supporting pertaining to the resource of interest. This is marked with the sponsorID attribute. A Person may also identify his/her supervisor (i.e., manager) pertaining to the resource of interest. An example highlighting how to document a POC Person element is provided below:

```
<ms:POC>
  <ms:Role ms:value="publisher"/>
  <ms:Person
        ms:ID="53530"
        ms:sponsorID="720"
        ms:supervisorID="51230">
  <ms:Title
        ms:value="Technical Reviewer"/>
  <ms:Name
        ms:first="Lindsey"
        ms:last="Piddleton"/>
  <ms:Position
        ms:value="Writer">
    <ms:Org ms:organizationID="320">
          <ms:Name
             ms:value="SpyFlight Industries"/>
    </ms:Org>
  </ms:Position>
  <ms:AddressInfo>
    <ms:Phone
        ms:type="mobile"
        ms:number="540-755-5555"/>
    <ms:Email
        ms:type="work"
        ms:address="writer@spyflight.com"/>
    <ms:ContactInstruction
        ms:value="Leave message w/ personal assistant if not
        available."/>
    </ms:Person>
</ms:POC>
```

In this XML snippet, the metacard identifies a POC Person, Lindsey Piddleton, uniquely identified by the value "53530" (ms:ID attribute). Assuming this value is somehow registered to that person (i.e., last 5 digits of her social security card for example), then the ID value can be used as an association or reference by other POCs. For example, this XML snippet references a sponsor with the ID tag "720" (ms:sponsorID attribute), and references a supervisor (i.e., manager, or technical Point of Contact (TPOC)) with the ID tag "51230" (ms:supervisorID attribute).

Generating and Using Unique IDs

One of the tools available to help define a unique ID is a web service known as UUID Generator (http://www.uuidgenerator.com). Neither the MSC-DMS, nor the Implementation Guide, nor M&S CO mandates the use of this service or any other similar service. But it is something to consider. Keep in mind though, it should be the responsibility of the individual and his/her organization to identify by what means an ID should be distributed and received. It is likely that the policy and practice for attaining IDs would be provided or addressed by the repository and repository portals in which an individual and organization wishes to participate.

For purposes of the M&S Catalog, the Resource ID character string should be *unique* and *stable* for the M&S Catalog. It should be *unique* in the sense that at any given time, no two records from a single Source, which maintains M&S resources such as repository, should have the same Resource ID value. And it should be *stable* in the sense that if a metacard record is submitted that updates or replaces a metacard record submitted earlier, then it should have the same Resource ID value as the earlier metacard record.

Creating Semantic Meaning via Associations

No matter what type of M&S resource may be cataloged, invariably there are other materials that could be associated with the resource. The MSC-DMS provides a powerful mechanism to capture and reflect these associations. The MSC-DMS and Implementation Guide walk through each of the specifics that can be attributed to an Association, but we highlight some of the useful characteristics to support the concept of Semantic Publishing.

First we should explain what we mean by Semantic Publishing. The term comes from the Semantic Web community. Semantic Publishing refers to publishing information on the web as document resources accompanied with semantic markup. Publishing resources in such a way allows computers to digest the markup and understand the meaning of published information thereby facilitating better search and data integration.

The Associations component of the MSC-DMS provides a way to correlate related resources and artifacts. Specifically it supports the following type of relationships:

has-a,
is-part-of,
is-type-of,
is-described-by

It's important to understand what these four relationship types mean.

- Has-a indicates that the M&S resource is composed of another asset. This type of association therefore identifies the child to that resource. It is useful for supporting decompositions.
- Is-part-of indicates that the M&S resource is part of the composition of another asset. This type of association therefore identifies a parent asset. It is useful

for supporting compositions of aggregate sets.

- Is-type-of indicates that the M&S resource is an instance or a manifestation of another type of asset. This type of association therefore identifies the type of asset the resource exemplifies. It is useful for resources that support a specific need, specification or use case.
- Is-described-by indicates that the M&S resource is specified or more clearly described by another asset. This type of association identifies the clarifying document, specification, material (such as a web site), or subject matter expert (SME). It is useful for providing more amplifying information by providing a link to such information rather than having to restate specific information within the metacard.

Types of associations that can be identified using Version 1.3 of the MSC-DMS include the following:

- *software,*
- *tools,*
- *federations,*
- *software components,*
- *services,*
- *data,*
- *data models,*
- *interface specifications,*
- *software design documents,*
- *infrastructure,*
- *supported events,*
- *future capabilities requirement,*
- *related documents,*
- *environment,*
- *subject matter experts (new).*

The nine items on the left hand column are reflective of the types of things that not only can be associated to an MSC-DMS metacard, but the types of artifacts that can be fully cataloged and described by the MSC-DMS template itself. The items on the right hand column reflect the types of things that are not intended to be cataloged or described by an MSC-DMS metacard, but which still may be referenced by a MSC-DMS based resource. However, it should be noted that a Subject Matter Expert, which has been added as a new enumeration value for the pick list of association types in Version 1.3, can be cataloged and described by a subcomponent of the MSC-DMS known as the POC type. POC type includes both Organization and Persons.

Multiple associations can be made by the MSC-DMS resource metacard. This is illustrated in the XML snippet provided below for a metacard describing a notional simulation which models surface-to-surface missiles:

```
<ms:Associations>
  <ms:Association
      ddms:qualifier="MIL-STD-498"
      ddms:value="Ballistic Flight Model SRS"
      ms:relationship="is-type-of"
      ms:type="requirement"
      ms:associationID="8A3EFF336"
      ms:constraints="exclude section 4.6"/>
  <ms:Association
      ddms:qualifier="C++"
      ddms:value="Ballistic Scud Model Source Code – Al Hussein"
      ms:relationship="has-a"
      ms:type="software_components"
      ms:associationID="73343321"/>
  <ms:Association
      ddms:qualifier="C++"
      ddms:value="Ballistic Scud Launcher Module"
      ms:relationship="has-a"
      ms:type="software_components"
      ms:associationID="247098233d"/>
  <ms:Association
      ddms:qualifier="HLA"
      ddms:value="Missile Defense HLA Federation"
      ms:relationship="is-part-of"
      ms:type="federations"
      ms:associationID="f0923f93"/>
  <ms:Association
      ddms:qualifier="URL"
      ddms:value="http://www.shortrangealgos.com/Defending-
      BMD-Threats.html"
      ddms:schemaHref="http://www.shortrangeschemas.com"
      ms:relationship="is-described-by" ms:type="related document"
      ms:associationID="4352"/>
</ms:Associations>
```

In this notional XML metacard excerpt, five associations are shown. The first association identifies a requirement or set of requirements as depicted by a MIL-STD-498 document identified as the "Ballistic Flight Model SRS" and indicates that the resource *is-type-of* Ballistic Flight Model Simulation. The second and third association, which are has-a relationship types, marries software components with the resource metacard. The fourth association identifies that the simulation *is-part-of* an HLA federation. And finally, the fifth association identifies a related HTML document that further *describes* the resource.

The specification and Implementation Guide provide further amplification of the Association element regarding how other attributes and subelements such as the a Description component, can be used. In addition, paper 10S-SIW-055 further elaborates on the association capability of the MSC-DMS in supporting Semantic Publishing and the Semantic Web [9]. For such understanding to be achieved however, there also needs to be clear publication and identification of the taxonomy that is being applied. The MSC-DMS version 1.3 provides a method to identify specific taxonomies as well. These new capabilities of MSC-DMS 1.3 are highlighted in the following section.

What's New in MSC-DMS 1.3

Since the last time the MSC-DMS was presented to the community, the MSC-DMS has benefitted from two minor yet significant updates: Version 1.2.1 and Version 1.3 (anticipated to be released by the Spring 2010 SIW). Changes have included updates to several types of enumerated values (or "pick-lists") that are available. The specific pick-lists that have been updated that can be assigned to some of the MSC-DMS attribute values include the following:

- Usage Application Domain Set (added "intelligence")
- Date Type (added "last_verified")
- Association Qualifier (was an open text field; added new pick-list which includes "URL")
- Association Type (added new association types including "Subject Matter Expert")

In addition to these enumeration types, the following other adjustments have been made for Version 1.3:

- Formally added a capability to identify specific taxonomies for any MSC-DMS element
- Modified and improved the VV&A Coverage Metadata Set extension/supplemental component
- Corrected grammatical errors (such as PostalCode, which was misspelled as PostcalCode)

The MSC-DMS will continue to evolve as the user base grows. Processes are in place to manage change requests to benefit the community. [10]

SUMMARY

The ability to discover existing modeling and simulation (M&S) assets is a critical need for enabling effective reuse and for reducing the duplication of capabilities. In the last two years, tools such as the MSC-DMS, and the M&S Catalog, including its connection to various repository Sources, are making it easier for DoD organizations to build, connect, discover and share M&S resources. However, it is only the beginning. The DoD M&S community is encouraged to continue to leverage the MSC-DMS in creating well-described and easily discoverable M&S resources and to utilize the M&S Catalog as way to query and locate M&S resources of interest. Sources are sought to add to the collection of connected resources available to the M&S Catalog. Furthermore, the M&S community is encouraged to share their experiences and provide their feedback so that the MSC-DMS, the M&S Catalog and associated tools can be better understood and further improved.

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Discovery and Reuse of Order of Battle Data Across the M&S Enterprise

Discovery and Reuse of Order of Battle Data Across the M&S Enterprise

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ABSTRACT

The integration of Live, Virtual, and Constructive (LVC) models and simulation (M&S) federations with live Command, Control, Computer, Communications, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems has blurred the lines between these systems. These systems are being integrated at different technical levels for mission planning, course of action (COA) analysis, mission rehearsal, training, testing, analysis, experimentation, and other purposes by each of the DoD communities enabled by M&S. There are many types of scenario data that must be prepared and correlated between each simulation and each C4ISR system before the start of an event (StartEx) and exchanged during "run-time" (execution of the event). However, force structure is a common reference point to integrate and manipulate related data. Order of Battle (OOB) data is a military operational term that includes organizations, personnel, equipment, and other information related to force structure.

The key to system interoperability is data interoperability. Data interoperability is achieved through data standards: standard metadata, standard conceptual models to define common semantics, standard information exchange data models (IEDM), and data translations. The DoD is currently transitioning to the DoD Net-Centric Data and Services Strategies to enable a distributed collaborative service-oriented Net-Centric Environment (NCE). A web-enabled service oriented architecture (SOA) provides loosely coupled web service applications and discoverable shared data spaces. Data standards and shared data spaces provide opportunities to reuse data to significantly reduce data production time and cost. Standard conceptual data models, IEDM, and database schemas must include the appropriate discovery and structural metadata to ensure the data is discoverable, accessible, understandable, trustworthy, and interoperable. Traditional authoritative data sources are transitioning to net-centric data repositories with web service interfaces such as the Global Force Management Data Initiative (GFM-DI) Organization Servers.

ABOUT THE AUTHOR

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INTRODUCTION

As current and new threats and missions (counter insurgency, stability, support operations, etc.) evolve, a new level of responsiveness and agility is required by DoD forces. This responsiveness and agility must be reflected in our approach to data management across the DoD enterprise. "The current DoD network consists of information silos that cannot communicate with each other unless they are pre-wired to do so. In addition, these silos cannot scale to accommodate the levels of interaction that will exist. The DoD's current stove-piped information environment must shift to a more robust and agile information environment that can support and enable net-centric operations" [1]. "The DoD cannot transform its operations to support a net-centric force by merely maintaining and expanding the current DoD network or by creating new stove-piped web services. Patching stovepipes together is a temporary solution that leads to a fragile environment, which will eventually crumble under the high demands and unpredictable needs of the users" [1].

"DoD systems effectively carry out the functions for which they were designed. However, they don't work together to provide a complete or unified picture that can inform the decision making process because each system was designed to meet its own functional needs rather than the more collective needs of the enterprise. Without common standard interfaces designed into the systems, integrating data is largely a manual, time-consuming process, lacking accuracy and timeliness necessary for senior decision makers" [6]. "Without a common reference point, disparate systems across the Defense enterprise are unable to seamlessly exchange information thus obtaining and integrating data will continue to be a labor-intensive, time consuming process. Force structure is foundational to every DoD function" [6]. "While functional systems focus on their specific functional domain (e.g., planning, programming, budgeting, analysis, execution, C2, training, testing, etc.), many use some form of force structure data to perform their assigned function. Force structure, or Unit Order of Battle (UOB), can serve as a common reference point to integrate, correlate, and manipulate data" [6].

"The DoD's vision is to establish a Net-Centric Environment (NCE) that increasingly leverages shared data and services within a Service Oriented Architecture (SOA). This NCE is to be supported by the required use of a single set of common standards, rules, and shared secure infrastructure provided by the Enterprise Information Environment Mission Area (EIEMA)" [1]. "The DoD Net-Centric Services Strategy (NCSS) [1] builds upon the DoD Net-Centric Data Strategy's (NCDS) [2] goals of making data assets visible, accessible, and understandable. The NCSS establishes services as the preferred means by which data producers and capability providers can make their data assets and capabilities available across the DoD and beyond. It also establishes services as the preferred means by which consumers can access and use these data assets and capabilities. A service oriented approach can accelerate the DoD's ongoing effort to achieve net-centric operations by ensuring that warfighters receive the right information from trusted and accurate sources when and where it is needed" [1]. "A web-enabled SOA provides loosely coupled web service applications and discoverable shared data spaces. Data standards and shared data space provide opportunities to reuse data to significantly reduce data production time and cost" [3]. A SOA provides opportunities for sharing both web service applications and data across the DoD enterprise. A SOA demands well thought-out conceptual data modeling that results in physical database schemas that are well structured, normalized, and have clearly defined data element semantics and syntax.

What is the Scope of Order of Battle (OOB) Data?

The DoD Dictionary of Military and Associated Terms defines *order of battle* as "the identification, strength, command structure, and disposition of the personnel, units, and equipment of any military force" [7]. "In classical and preindustrial warfare, OOB is the scheme and sequence in which units arrived and deployed on the battlefield" [8]. "OOB data is defined in modern use, as the identification, command structure, strength, and disposition of units, personnel, and equipment of an armed force during field operations. Various abbreviations are in use, including OOB, O/B, OB, or ORBAT" [9]. "An *order of battle* is standard military terminology for the description of a military organization. It presents which units exist, how they are organized (command structure, subordinate/superior relationships, equipment) and their responsibilities (geographic area, operation capabilities)" [10].

During mission planning, rehearsal, training, and testing events involving M&S and live C4ISR systems, it is essential that these scenario-specific organizations, equipment, and their capabilities be accurately and consistently modeled to produce valid results. Mission planning and rehearsal can be a very time sensitive process as units are alerted, task organized, and deployed to a theater of operations. "C4ISR and M&S systems must be rapidly initialized and synchronized with accurate, complete, and consistent scenario-specific data before the start of the exercise or event (StartEx)" [3].

Scenario OOB data can include friendly, hostile, neutral, or organizations with unknown intentions. Scenario OOB data can include conventional military forces, paramilitary organizations, insurgent organizations, government and non-government organizations and agencies, local populations, tribal factions, etc.

See the Battlespace, See the Enemy, and See Yourself

These are the three key factors of "battlespace visualization" and the military decision making process.

Within the DoD Intelligence Community the focus is on OOB data of threat forces. "OOB information is crucial to battlefield success; a commander who is unaware of the

number, type, and quality of opposing forces risks disaster" [11]. OOB intelligence analysts scrutinize all information pertaining to a military force to determine its capabilities, vulnerabilities, and probable courses of action.

Seeing the battlespace and the enemy is very important to mission success, however, seeing yourself can also be the difference between success or failure on the battlefield. Not knowing the current status and location of your own units, weapon systems, and sensors in the preparation for battle or during critical points during execution of the battle can result in disaster. For example, information that your ground breach assault force has a high percent of their obstacle clearing equipment damaged or down for maintenance, or knowing that your scout platoon is in the proper position with fully operational Reconnaissance, Intelligence, Surveillance, and Target Acquisition (RISTA) sensors are all critical commander's information requirements. Many times, in training events and actual combat, commanders are not aware of the status of their units, personnel, and mission-critical equipment until units are past the "point of no return" and are under enemy fire.

Entity-level resolution is not only an M&S OOB data term. Commanders at all echelons must have situational awareness (SA) of friendly forces "two levels up and three levels down". For example, a company commander must have SA of his higher battalion and brigade operations, and more importantly, he must know the location and status of his platoons, platforms, and key weapon systems, sensors, and other mission-critical equipment. Today's technology and C4I systems on the battlefield allow the commander to have unparalleled situation awareness of his forces.

Components of Order of Battle (OOB) Data

OOB data includes the Unit Order of Battle data (UOB) data that consists of organizations or units and associated equipment. Units are related within a hierarchy of certain command and support relationships between each unit echelon. The UOB may include a default or "organic" command and support hierarchical force structure or certain

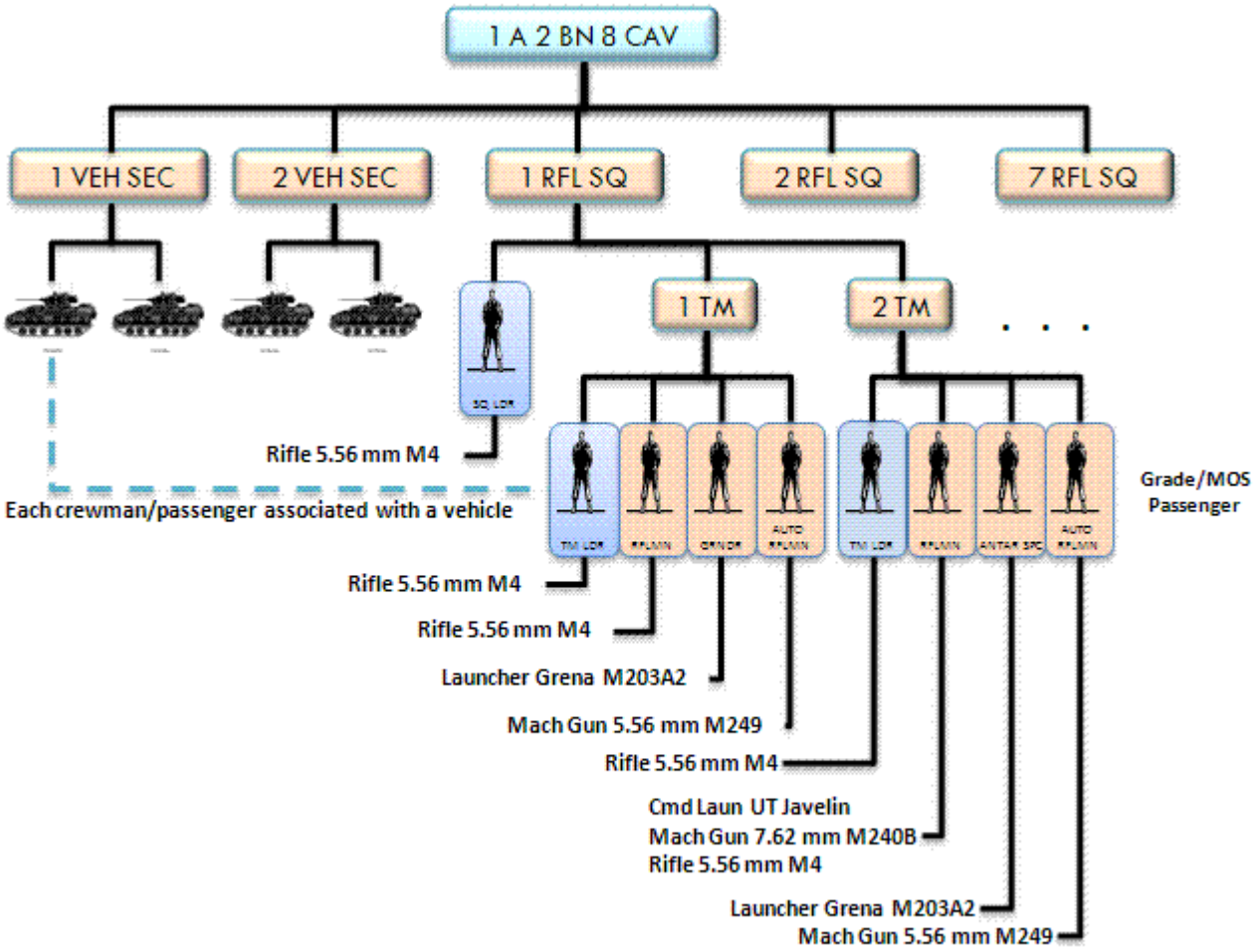

Figure 1. US Army Platoon UOB Example

units may be tasked organized (Unit Task Organization) for a particular mission or M&S event. Each unit echelon includes personnel and equipment. UOB data may be aggregated to higher echelons or de-aggregated down to the entity level. Entities include "platforms" (vehicles, aircraft, vessels, etc.) and personnel (billets). Certain weapon systems, sensors, RISTA, communications, computers, and other simulation-relevant equipment can be mounted on or associated with each platform and personnel. Personnel have associated "roles" such as commander, squad leader, medic, driver, gunner, loader, etc. Platforms include certain personnel that are designated as a crew and can also include a certain number/roles of passengers. Figure 1 above is an example of the UOB for a US Army mechanized infantry platoon.

Each entity (vehicle, aircraft, vessel, personnel) has certain characteristics and performance (C&P)/parametric data associated with each entity type composition of a base platform with certain associated weapon systems/ munitions, sensors, armor, and other simulation-relevant equipment. Weapons effects data such as probability of hit/ kill (Ph/Pk) are calculated based on shooter-target paring of each entity type composition. Models and simulations include algorithms based on accurate and realistic entity C&P/parametric data that determine the entity's performance, lethality, detectability, and vulnerability. Figure 2 below is an example of a US Army Entity-Type Composition (ETC) with certain M&S, C2, and logistics identifiers.

OOB data also includes the Electronic Order of Battle (EOB) that consists of network computer and communications nodes, C4ISR systems, network structure, configuration, and addressing data that must be accurately

Figure 2. Example of a US Army Entity-Type Composition (ETC).

modeled within simulations and within interfaces between simulations and C4ISR systems. This network structure, configuration, and addressing data are established to support a particular Unit Task Organization (UTO). EOB data includes data elements such as the Unit Identification Code (UIC) and the Unit Reference Number (URN) to uniquely identify units, however there is no enforcement of policy to ensure these identifiers are used consistently across each UTO. URNs are used as unique network addressing data elements for units and for individual computer systems such as Blue Force Tracker (BFT).

Logistics data is also commonly associated with OOB data and includes equipment entity authorizations, Line Item Numbers (LIN), Table of Authorized Materiel Control Numbers (TAMCN), and National Stock Numbers (NSN) to properly model equipment replacement and repair processes. This logistics data also includes unit, platform, and weapon system basic loads and stockage levels to model resupply of the different classes of supply. Unit personnel, equipment, and supplies must also be accurately modeled to plan and simulate strategic and tactical transportation deployment requirements and processes. Unit-specific resupply and maintenance techniques, tactics, and procedures (TTPs) must also be accurately modeled.

M&S Need for Accurate, Consistent, and Correlated OOB Data

M&S developers, technicians, and operators (Subject Matter Experts-SMEs) currently spend too much time and resources on the mundane tasks of obtaining, correcting, correlating, and maintaining OOB data [3]. Communities enabled by M&S are investing in scenario data generation and data management environments/systems, however, there remains great potential to better automate these processes and to share (re-use) enhanced and correlated OOB data and tools (services) across the M&S Enterprise. The implementation of the DoD Net-Centric Data and Services Strategies can significantly reduce M&S OOB data production time and cost [3].

Individual simulations are developed with the capabilities to manually build scenario-specific data by a technician entering data into the simulation graphical user interfaces (GUI). Some technicians will "cut-and-paste" OOB data into the simulation GUI from external data sources. Some simulation software developers have added the capability to "ingest" OOB data from a certain external data file in a particular format (spreadsheet, coma delimited, XML, etc.) from which the technician can manually edit the data for a particular scenario before StartEx.

As individual simulations were "federated" on a LAN/WAN to form a federation of simulations, a new requirement emerged to synchronize the scenario data that was shared between the "federates". Ad-hoc local M&S federation site procedures and semi-manual processes and tools were developed to build and synchronize the scenario data common to the federates and to initialize the federation before StartEx.

Today, many of the communities enabled by M&S are investing in semi-automated federation, community and service-level M&S scenario data generation and data management environments. Each is designed to meet their specific community or service M&S scenario data requirements in support of multiple M&S LVC federations. Some of these M&S environment/systems can access OOB data from multiple data sources and integrate, fuse, and correlate data to produce a standard M&S XML data interchange format (DIF) (e.g. Order of Battle Service-OBS, Military Scenario Definition Language- MSDL, C2 Core, etc.) that can be ingested by multiple simulations and federations. However, this process is still a very time intensive, SME-in-the-loop process to establish and maintain OOB data repositories and scenario-specific OOB datasets.

In the development of these M&S environments, the different communities have realized that, although there are some community-unique data requirements, many of their M&S data requirements are common or "overlap" [3]. Although many of their M&S data requirements are common, their scenario generation requirements, discovery and structural metadata, DIFs, and "run-time" data file formats can be quite different.

Currently, each of these federation, community, or service-level M&S scenario data generation/data management environments access many of the same UOB, EOB, and logistics data sources and perform the same or similar data integration, fusion, and correlation processes.

There is potential to significantly reduce M&S OOB data production time and cost (obtain source data, integrate/correlate data from multiple sources, and translate to standard/native formats) by making enhanced and

correlated OOB datasets discoverable, understandable, accessible, and reusable across the M&S Enterprise (SOA data provider web services on the NIPRNet and SIPRNet) [3].

The DoD Net-Centric Data and Services Strategies direct the development of many data repositories, registries, catalogs, and web services to enable discovery and dissemination of data to anticipated and unanticipated data consumers (with the proper permissions) across the DoD Enterprise.

Authoritative data sources may be traditional "raw" data sources or data sources that provide "enhanced and correlated" [12] data that is produced from the integration, fusion, and correlation of data from multiple data sources. DoDD 8320.03 defines an Authoritative Data Source (ADS) as "a recognized or official data production source with a designated mission statement to publish reliable and accurate data for subsequent use by customers *(traditional "raw" data source).* An authoritative data source may be the functional combination of multiple, separate data sources" *("enhanced and correlated" data source)* [12].

OOB data Extensions to Standard Discovery and Structural Metadata Specifications

Shared data must include the appropriate discovery and structural metadata to ensure the data is discoverable, accessible, understandable, trustworthy, and interoperable [3]. Discovery is defined as "ability to locate data assets through a consistent and flexible search" [15]. "Discovery metadata is focused on tagging the outer shell of resources in a way so that the resource is clearly marked and re-discoverable, whereas structural metadata is focused on describing the framework and organization of information" (the internal aspects; e.g. data model, XML schema, data dictionary, ontology, etc.) [15]. Adequate standard discovery metadata must be provided for a data consumer to discover and assess the ability of the data to meet the consumer's intended purpose. Adequate standard structural metadata must be provided for the data to be understandable and usable.

"The DoD M&S Steering Committee commissioned the creation of the M&S Catalog to establish a web-based search capability that provides a "card catalog" level of detail about M&S tools, data and services" [16]. Metadata registered with the M&S Catalog will allow the user to discover a particular data repository and browse detailed discovery, pedigree, usage history, and structural metadata about the individual OOB datasets contained in a repository and the available standard M&S DIFs.

The M&S Community of Interest (COI) has published the M&S COI Discovery Metadata Specification (MSC DMS) that identifies both the mandatory core set of metadata and recommended core set of metadata for the discovery of M&S assets, and identifies the supplemental set of discovery metadata for supporting specific community M&S datasets [15].

Adequate OOB metadata extensions to a supplemental set of discovery metadata of the MSC DMS would further assist a user to determine if a particular OOB dataset/format will meet his needs. In addition to the core discovery metadata elements of the MSC DMS, examples of possible extensions for a OOB dataset may include the high-echelon unit names/identifiers included in the dataset, the resolution level (aggregation level, entity-level, etc.) of the data, and other type of data/sources correlated with the unit force structure (EOB, logistics, etc.).

Uniform Resource Locators (URLs) of M&S data provider web services and other information in the M&S Catalog will allow the user to gain proper permissions, access the proper repository, and select and download individual OOB datasets in available standard M&S DIFs. These "reused" datasets can then be edited, tailored, and translated in the community or service-level M&S scenario data generation environment/system to meet the specific needs and formats of the community's LVC M&S federations.

Following the Lead of the DoD Operational Community

Although there are M&S-unique categories of data, most of the data required by federation, community, or service-level M&S scenario data generation environments is operational (C4I) data [3]. The first annex of the standard military operations order (OPORD) is Task Organization. The scenario-specific OOB data must be initialized and synchronized across each simulation of the federation and the live C4ISR systems that will interface with the M&S federation.

The DoD operational community has started implementing the DoD Net-Centric Data Strategy (NCDS) by determining C2 data needs, inventorying existing authoritative data sources (ADS), exposing C2 data with

standard discovery metadata, and registering data sources in the DoD Enterprise ADS Registry (EADS). The operational community has also developed a standard C2 Core Information Exchange Data Model (IEDM) and an associated XML schema to enable the unambiguous exchange of C2 data between US and coalition systems. The C2 Core data model/XML schema has been registered with the DoD Metadata Register to facilitate, coordinate, and extend the development of the standard across C2 systems and overlapping communities of interests (COIs) (i.e. M&S COI).

Federation, community, or service-level M&S scenario data generation environments must interface with DoD operational data repositories and data provider web services to include this data in the M&S data production process (obtain source data, integrate/correlate data from multiple sources, and translate to standard/native M&S formats). M&S scenario data generation environment developers should "reuse" and extend core operational discovery and structural metadata specifications and standard information exchange data models such as the DDMS, UCore, C2 Core, JC3IEDM, etc.

Sources of OOB Data

There are many sources of US and non-US (coalition, threat, neutral) OOB data. Irregular Warfare (IW) M&S data requirements include more non-conventional OOB data such as paramilitary organizations, insurgent organizations, government and non-government organizations and agencies, local populations, tribal factions, commercial voice and digital communications, social networks, etc.

Sources of US DoD OOB Data

For US DoD forces, each of the Services (USA, USN, USMC, USAF, USCG) have many systems to document and manage force structure, personnel, and equipment authorizations. For example the Army's Force Management System (FMSWeb) and the Marine Corps' Total Force Structure Management System (TFSMS) are currently the authoritative source for Table of Organization and Equipment (TO&E) data.

"The Global Force Management Data Initiative (GFM DI) is a Joint Staff and OSD initiative designed to standardize force structure representation, making it visible, accessible, and understandable across the DoD Enterprise. Unique identifiers associate organizations, billets, crews, equipment, and chain of command links, enabling integration and electronic manipulation across multiple systems. Through the establishment of an information exchange data standard- the GFM Information Exchange Data Model (GFMIEDM), GFM DI enables DoD systems to exchange force structure data in a common format while exploiting the net-centric data environment" [4].

"As a key enabler for DoD Readiness, Joint Force Providing, and Adaptive Planning processes, GFM DI will provide data to existing programs such as the Defense Readiness Reporting System (DRRS) as well as future programs requiring authoritative force structure data" [4].

The GFM DI is divided into two tasks:

"Task One documented department-wide authorization data in the Organizational and Force Structure Construct per DoD Instruction 8260.03, Organizational and Force Structure Construct (OFSC) for Global Force Management (GFM), to make the data available via Organization (ORG) Servers by FOC in March 2011. There are seven GFM ORG Servers (USA, USN, USMC, USAF, Joint Staff, Office of the Secretary of Defense, and the Intel Community) on both NIPRNet and SIPRNet" [4].

"Task Two, known as GFM DI Next Steps, focuses on incorporating the Default Force Structure data contained in the seven GFM ORG Servers into other DoD authoritative data sources (ADS). The intent is to link units, personnel billets, and authorized equipment types and quantities of the GFM ORG Servers data with on-hand equipment types and quantities and unit readiness reporting" [4].

DoDI 8260.03 directs the GFM ORG Servers to be the authoritative data source of authorized DoD force structure and directs implementation of Force Management Identifiers (FMIDS) [13]. Figure 3 below depicts the GFM DI Concept of Operations (CONOPS) [5].

"The GFM ORG Servers will use the standard DISA Joint User Messaging (JUM) web service to provide data to GFM data consumers. The JUM service and interface will implement Web-Service Notification standards allowing GFM ORG Servers to publish data to pre-defined topics for systems to receive GFM data and to subscribe to changes in the data using pre-defined user access roles." [4] These standard JUM interface specifications can also be used to implement data web services between federation,

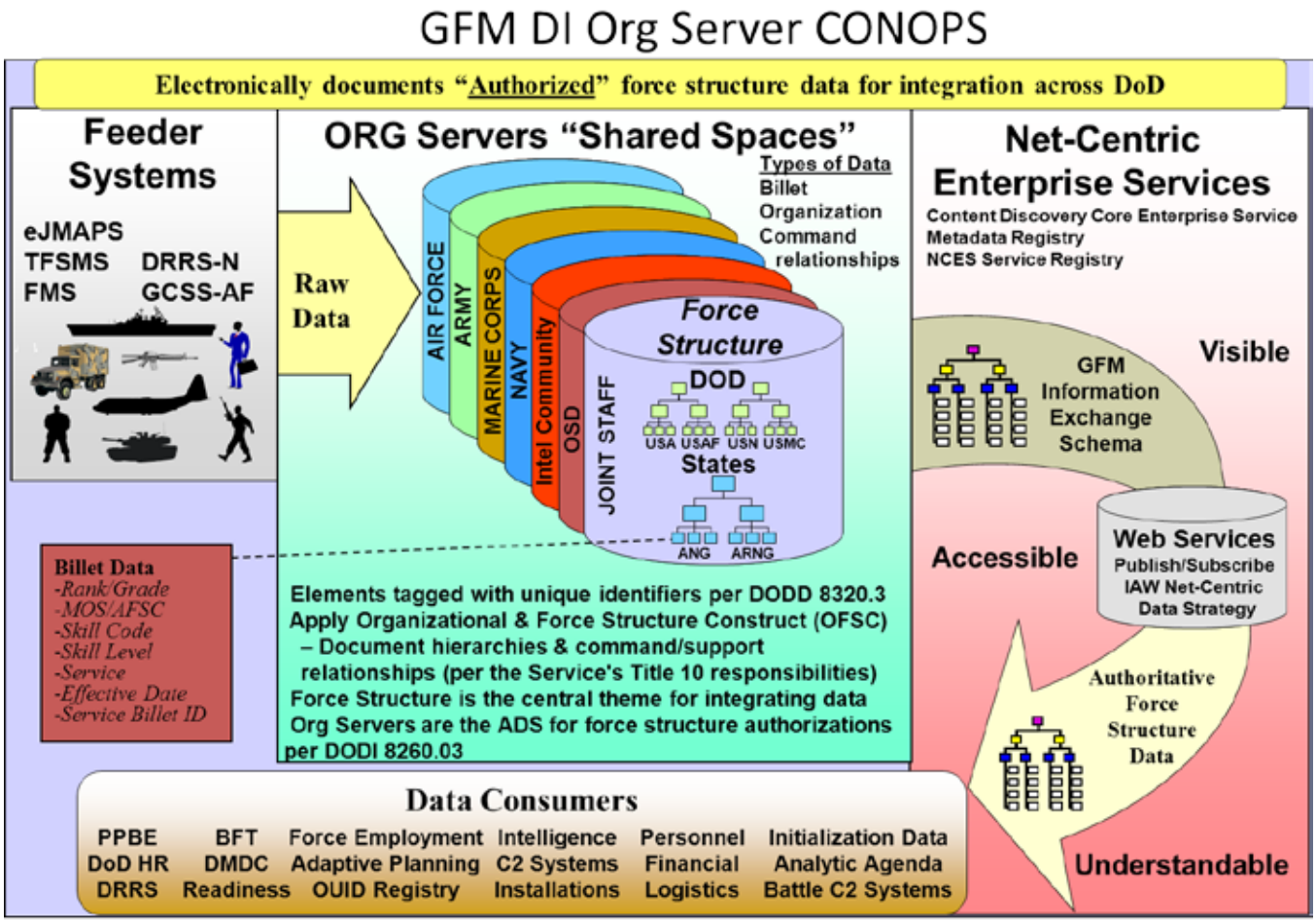

Figure 3. GFM DI Concept of Operations (CONOPS) [5].

community and service-level M&S scenario data generation and data management environments/repositories (and their end-user M&S federations) to share/reuse OOB datasets across the M&S Enterprise.

The GFM DI Organizational and Force Structure Construct (OFSC) of the data in the GFM ORG Servers provide a number of significant improvements for both the operational and M&S communities:

The UOB data structure will be hierarchical from the highest organization echelon down to the entity level (personnel billet and equipment type level). Data can be aggregated or de-aggregated as required. The proper weapon systems, sensors, and other simulation-relevant equipment are associated with the proper entity (vehicle, aircraft, vessel, billet) assigned to the proper unit. Each personnel billet will be assigned the proper MOS, grade, and role. Each platform has an associated crew with the proper assigned personnel billets. However, until the GFM DI "Next Steps" are complete, these units, billets, and equipment types will be authorized types and quantities, not on-hand. Mission planning, COA analysis, and mission rehearsal events require on-hand units, personnel, and equipment to provide the best results. Figure 4 below depicts the authorized data of the GFM ORG Servers and the linkage to on-hand and readiness data [5].

The use of DoD enterprise-wide identifiers will greatly facilitate automated data linkage, mediation, and translation. For example, the GFM ORG Servers will enable the use of unique, unambiguous identifiers, known as Force Management Identifiers (FMIDS), for organizations (units), personnel billets, and equipment types. "The FMIDS will provide the basis for the Organizational Unique Identifier (OUID) which will be used to uniquely identify organizations across the DOD Global Information Grid (GIG/SOA)" [6]. The FMIDS are key data elements of the GFMIEDM and the associated GFM XML schema (XSD). These DoD enterprise-wide identifiers will enable OOB data to be unambiguously linked between different datasets and databases.

Figure 5 below depicts force structure as the common reference point with universal identifiers to enable

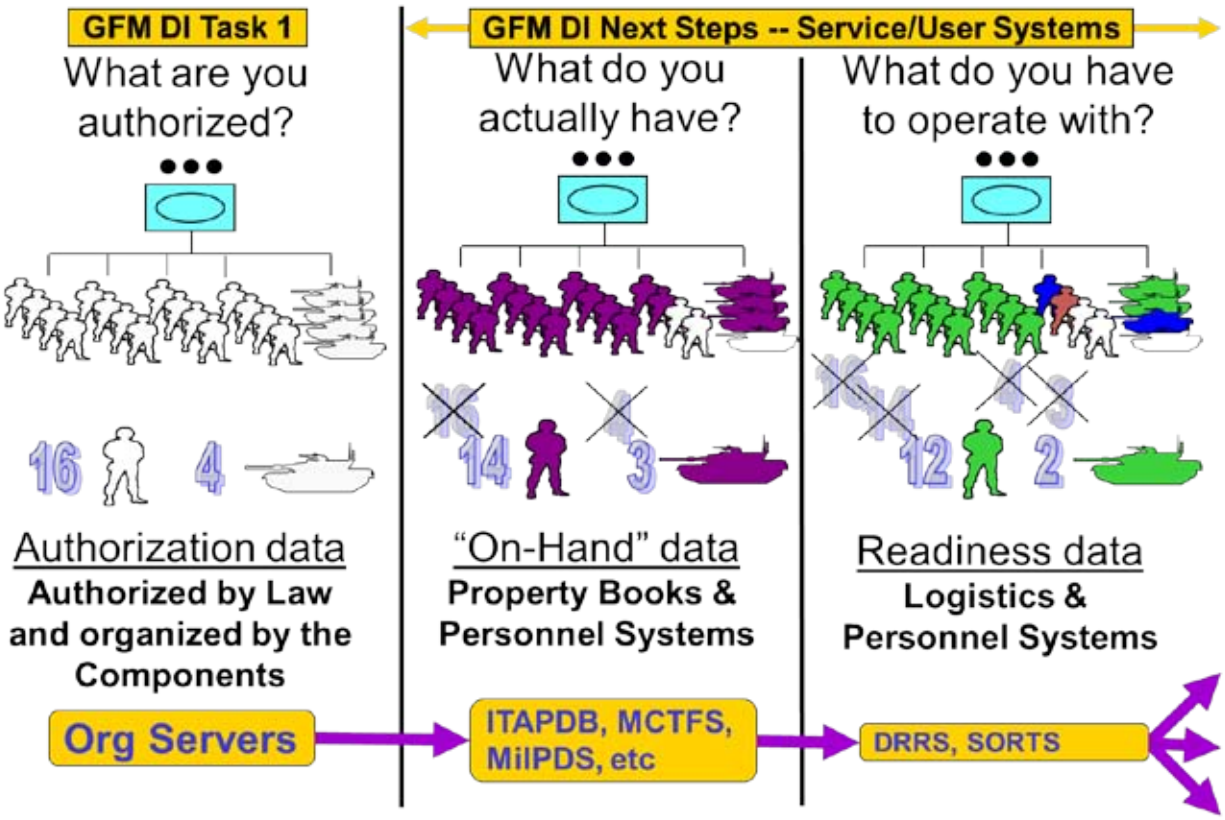

Figure 4. GFM DI Task 1 and GFM DI Next Steps [5]

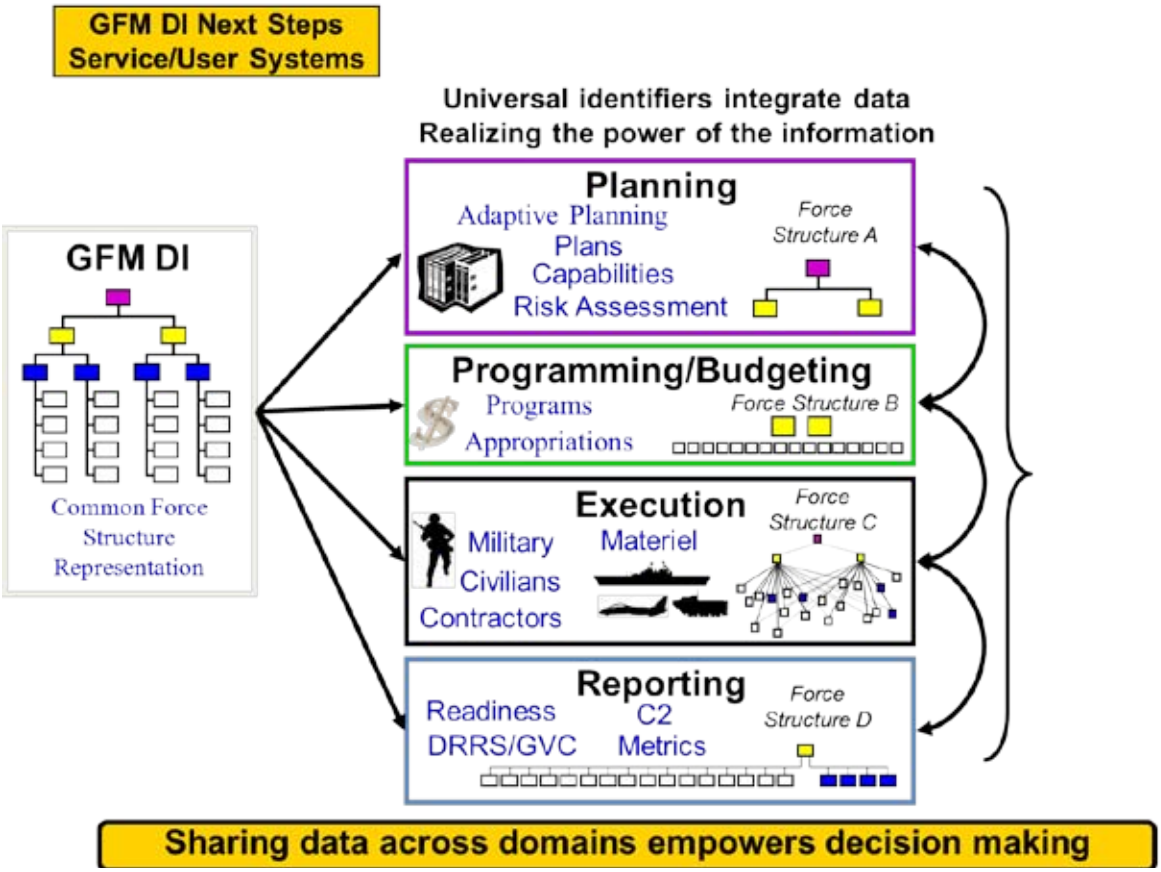

Figure 5. Force Structure is the Common Reference [5]

unambiguous data linkage between datasets and databases [5].

"Currently, names are used to identify force structure elements (units, personnel billets, equipment type, etc.) which frequently differ among DoD information systems. With FMIDS, systems will consistently reference elements of the force structure, such as organizational elements and command relationships, thereby facilitating interaction and integration" [6].

The most important aspect of FMIDS is that they will greatly facilitate the automated integration, fusion, and correlation of OOB data from multiple disparate databases. Federation, community and service-level M&S scenario data generation and data management environments can leverage FMIDS to enable automated integration of UOB, EOB, logistics, C2, and other types of OOB data from multiple sources and generate reusable OOB datasets in standard M&S data interchange formats.

For example, an a UOB dataset can be rapidly and automatically compared, fused, and correlated with a EOB dataset (supporting a certain UTO) of units, C4I network nodes, network types, addressing data, and C4ISR systems mounted on certain platforms and personnel based on matching the FMIDS of the units, personnel, and equipment. Likewise, a UTO dataset can be rapidly and automatically integrated, fused, and correlated with logistics, resupply, maintenance, and personnel data based on matching the FMIDS of the units, personnel, and equipment.

Sources of Non-US OOB Data

The DoD Intelligence community invests a great amount of resources in establishing and maintaining non-US OOB data. There are many sources of non-US OOB data (coalition, threat, neutral) for both conventional armed forces of the nations of the world and for non-conventional forces such as paramilitary organizations, insurgent organizations, government and non-government organizations and agencies, local populations, tribal factions, commercial voice and digital communications, social networks, etc. Some of the authoritative sources of threat OOB data include the Defense Intelligence Agency (DIA), National Air and Space Intelligence Center (NASIC), National Ground Intelligence Center (NGIC), Missile and Space Intelligence Center (MSIC), and the Office of Naval Intelligence (ONI). Most of these sources maintain web portals and classified databases that reside on the SIPRNet or JWICS. However, these web portals currently are not standard SOA web services and the classified disparate database schemas are not based on common standard conceptual data models, common standard data element semantics, or standard metadata.

In addition to these classified sources of threat OOB data, there also exists a need for unclassified threat OOB data. "A *threat* can be any specific conventional foreign nation forces or non-conventional organizations with intentions and military capabilities that suggest it could become an adversary or challenge the national security interests of the US or its allies. With the current myriad of global asymmetric threats, it is no longer possible to identify one or two nations or forces as the potential adversaries against which DoD forces need to train on a regular basis" [14].

"Mission planning, mission rehearsal, or contingency training requires actual threat-based OOB data with the greatest possible fidelity (classified). However, cases may exist in which constraints on the use of classified information or the lack of information, at any level of classification, preclude the use of actual threat data. To fill in gaps, in such cases, users could use the parts of unclassified capabilities-based Opposing Force (OPFOR) data that are most consistent with what they do know about a specific threat" [14].

"In more typical cases, however, the US forces simply need to train against an OPFOR that represents a particular level of capability rather than a particular country. The *capabilities-based OPFOR* is a realistic and flexible armed force representing a composite of varying capabilities of actual worldwide forces" [14].

"Current baselines of capabilities-based OPFOR OOB data include doctrine, tactics, organizations, and equipment. These baselines provide a challenging, uncooperative sparring partner that is representative, but not predictive, of actual threats. These baselines consist of OPFOR modules. Each module has its basis in the doctrine and organization of various foreign forces. These OPFOR modules are *composites* deliberately constructed to provide a wide range of capabilities. The modules do not provide a fixed order of battle. Rather, they provide the *building blocks* from which users can derive an infinite number of potential orders of battle, depending on their event requirements" [14].

The problem with these current baselines of capabilities-based OPFOR OOB data is that they are not usually in a database format and thus are difficult to be used to establish net-centric OOB data repositories. Net-centric capabilities-based OPFOR OOB data repositories and data provider web services could make such OOB data sets discoverable, understandable, accessible, and reusable across the M&S Enterprise.

Perhaps a net-centric paradigm similar to the GFM Data Initiative's technical approach for US OOB data could also be used to standardize, expose, manage, and disseminate non-US (coalition, threat, neutral) OOB data (classified and unclassified) for both conventional armed forces and for IW non-conventional OOB data.

CONCLUSION

The DoD operational community is transitioning to a net-centric environment (NCE) based upon the DoD Net-Centric Data and Services Strategies. A SOA provides opportunities for sharing both web service applications and data across the DoD Enterprise. DoD enterprise-wide identifies will enable automated integration of data across multiple databases. Data standards and shared data space provide opportunities for DoD data consumers to discover and reuse data to significantly reduce data production time and cost.

The communities enabled by M&S must also transition from point-to-point interfaces with traditional data sources and live C4ISR systems to a common net-centric SOA environment of loosely coupled web service applications and discoverable shared data spaces. The GFM DI ORG Servers will provide entity-level authorized force structure data through a standard SOA web service interface. GFM FMIDS will enable automated integration and correlation of UOB, EOB, logistics, transportation, C2, and other types of OOB data from multiple sources. A net-centric paradigm similar to the GFM Data Initiative's technical approach for US OOB data could also be used to standardize, expose, manage, and disseminate non-US (coalition, threat, neutral) OOB data (classified and unclassified).

M&S federation, community and service-level M&S scenario data generation and data management environments should develop a common DoD M&S data discovery and sharing net-centric environment to reuse enhanced and correlated OOB datasets in standard M&S data interchange formats. There is great potential to significantly reduce M&S OOB data production time and cost by making OOB datasets discoverable, understandable, accessible, and reusable across the M&S Enterprise.

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GLOSSARY

ADS	Authoritative Data Source
BFT	Blue Force Tracker
C2	Command and Control
C2 Core	Command and Control Core
C4ISR	Command, Control, Computer, Communications, Intelligence, Surveillance, and Reconnaissance
COI	Community of Interest
CONOPS	Concept of Operations
COA	Course of Action
DIF	Data Interchange Format
DISA	Defense Information System Agency
DIA	Defense Intelligence Agency
DRRS	Defense Readiness Reporting System
DoD	Department of Defense
DoDD	DoD Directive
DDMS	DoD Discovery Metadata Specification
DoDI	DoD Instruction
NCDSS	DoD Net-Centric Data and Services Strategies
NCDS	DoD Net-Centric Data Strategy
NCSS	DoD Net-Centric Services Strategy
EOB	Electronic Order of Battle
EADS	Enterprise ADS Registry
EIEMA	Enterprise Information Environment Mission Area
FOC	Final Operating Capability
FMIDS	Force Management Identifiers
FMSWeb	Force Management System
GFMIEDM	GFM Information Exchange Data Model
ORG	GFM Organization (ORG) Servers
GFM	Global Force Management
GFM-DI	Global Force Management Data Initiative
GIG	Global Information Grid
GUI	Graphical User Interfaces
IEDM	Information Exchange Data Models
IW	Irregular Warfare
JC3IEDM	Joint Command, Control, Consultation, Information Exchange Data Model
JUM	Joint User Messaging
JWICS	Joint Worldwide Intelligence Communications System
LIN	Line Item Numbers
LVC	Live, Virtual, and Constructive
LAN/WAN	Local Area Network/Wide Area Network
MOS	Military Occupational Specialty code
MSDL	Military Scenario Definition Language
MSIC	Missile and Space Intelligence Center
M&S	Models and Simulation
MSC DMS	M&S COI Discovery Metadata Specification
NASIC	National Air and Space Intelligence Center
NGIC	National Ground Intelligence Center
NSN	National Stock Numbers
NCE	Net-Centric Environment
NIPRNet	Non-classified Internet Protocol Router Network
ONI	Office of Naval Intelligence
OSD	Office of the Secretary of Defense
OPORD	Operations Order
OPFOR	Opposing Force
OOB, O/B, OB, or ORBAT	Order of Battle
OBS	Order of Battle Service
OFSC	Organizational and Force Structure Construct
OUID	Organizational Unique Identifier
RISTA	Reconnaissance, Intelligence, Surveillance, and Target Acquisition
SIPRNet	Secret Internet Protocol Router Network
SOA	Service Oriented Architecture
SA	Situational Awareness
StartEx	Start of Exercise
SME	Subject Matter Expert
TAMCN	Table of Authorized Materiel Control Numbers
TO&E	Table of Organization and Equipment
TTP	Techniques, Tactics, and Procedures
TFSMS	Total Force Structure Management System
URL	Uniform Resource Locator
UIC	Unit Identification Code
UOB	Unit Order of Battle
URN	Unit Reference Number
UTO	Unit Task Organization
UCore	Universal Core
XML	eXtensible Markup Language
XSD	XML Schema

The Environmental Data Cube Support System

The Environmental Data Cube Support System: Realistic Environmental Data, Products, and Services in Support of the DoD Modeling and Simulation Enterprise

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KEYWORDS

DoD, M&S, modeling, simulation, natural, environment, representation, production, distribution, data, effects, products, hypercube, scenario, resources, authoritative.

ABSTRACT

As a provider of correlated, integrated natural environments to Department of Defense (DoD) modeling and simulation (M&S), the Environmental Data Cube Support System (EDCSS) is becoming a key component of the DoD M&S Data Enterprise. Currently under continuing development, the EDCSS is a production capability focused on generating and distributing natural environmental data, effects, and products required to support M&S events. The EDCSS addresses integration across all environmental domains (air, ocean, space, terrain) by constructing environmental representations from authoritative source data providers and generating effects from DoD standard soil strength and mobility models as well as modeled sensor responses. The EDCSS allows for the selection of realistic historical scenarios as the basis of the environment representation. The EDCSS delivers pre-computed environmental effects and system performance metrics as well as simulated operational products (imagery, text, graphics) to support the control domain. The EDCSS supports runtime distribution of products via High Level Architecture (HLA) and has a range of tools to facilitate effective use of these data by simulations and their supporting applications.

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S. MARK WEBB is is the Air Force Weather Modeling & Simulation Requirements and Integration Lead. His duties include assisting the DoD ASNE MSEA Office Chief on environmental representation issues and he is the ASNE MSEA liaison to the U.S. JFCOM Joint Warfighting Center. Mr. Webb's primary focus is on integrating environmental representation models and simulations and identifying specific requirements of the communities enabled by M&S. He is retired from the U.S. Navy and is a graduate of Liberty University.

INTRODUCTION

In the past, including weather and other effects of the natural environment in DoD M&S has been difficult, time consuming, and expensive. Such obstacles have frequently led to the expeditious assumption of benign weather, nominal sea states, and dry ground. However, in the spirit of training like we fight, weather and other environmental factors should be expected and prepared for similar to the manner in which we plan for equipment failure. Natural challenges such as adverse weather, high sea states, and muddy terrain will happen. The unknowns are when the conditions will occur and how severe they will be. Thus, the effects of weather and other natural phenomenon must be a factor for decision makers, planners, operators, etc. and should be realistically incorporated into M&S.

To that end, the Air and Space Natural Environment (ASNE) Modeling and Simulation Executive Agent (MSEA) office spearheaded a proof-of-concept effort to integrate realistic weather effects into M&S. This initial effort met with great success. However, the experience highlighted two additional needs: to include all natural domains (air, space, ocean, and terrain effects) and to make the natural environment and its effects consistent across all aspects of federated events. Thus, a project was launched, in coordination with the Ocean and Terrain MSEAs, to provide a correlated and consistent suite of environmental products - the Environmental Data Cube Support System. Efforts began with the atmosphere, then the space and oceanographic domains were subsequently added. Work is currently in progress to fully integrate all natural domains (atmospheric, space, ocean, and terrain effects) into the system. The EDCSS is beginning to revolutionize the way environmental factors play in DoD M&S.

The EDCSS is not a data repository and is not an environmental model itself; rather the EDCSS comprises a net-centric services architecture and standard support processes to facilitate the meaningful inclusion of natural environment representations in DoD M&S activities. Current users of environmental data exist in all Services and are present in all of the communities enabled by M&S: Acquisition, Analysis, Experimentation, Intelligence, Planning, Testing & Evaluation and Training. The EDCSS improves and expands the use of environmental data and effects within all of these communities by providing ready access to authoritative data with relevant conditions to their Warfighter objectives, and in forms that reduce the time, cost, and risk of including environment representations. The EDCSS has already demonstrated its prototype functionality and usefulness with atmospheric data in COCOM events and through its support of the Training, Acquisition and Analysis Communities.

The EDCSS Construct

The EDCSS construct, shown in Figure 1, begins with an integrated environment representation built from authoritative environment resources available from national resource providers.

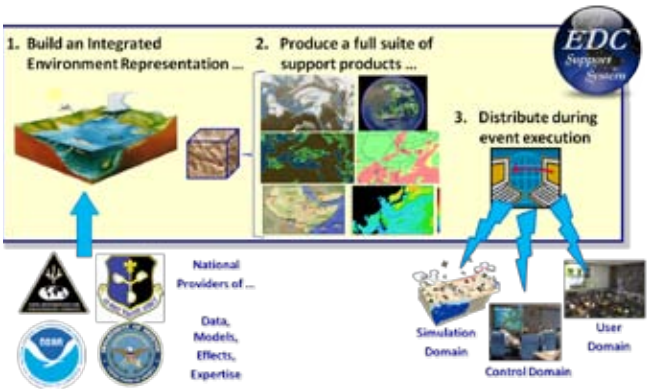

Figure 1. The EDCSS Concept Definition

Authoritative environment resources for the EDCSS include:

- **Atmosphere:** Primarily the Weather Research and Forecasting (WRF, see http://www.wrf-model.org) and Coupled Ocean/Atmosphere Mesocale Prediction System (COAMPS, see http://www.nrlmry.navy.mil/coamps-web/web/home) as well as post-processing algorithms obtained from Navy, Army, and Air Force Research Laboratories (NRL, ARL, AFRL) and National Oceanic and Atmospheric Administration (NOAA)/ National Weather Service (NWS).
- **Ocean:** The WaveWatch III and Navy Coastal Ocean Model (NCOM) models in operational use by NMOC, as well as post-processing algorithms obtained from NRL.
- **Space:** All space weather modeling capabilities are provided by National Geophysical Data Center (NGDC), AFRL, and/or AFWA.
- **Terrain:** Terrain models / tools for use with EDCSS are the subject of current research and further required capability definition by the Terrain MSEA.

The EDCSS includes the Scenario Search capabilities of the Environmental Scenario Generator (ESG), allowing for the selection of realistic historical scenarios to be used as the basis of the environment representation. From this integrated representation, the EDCSS offers a production capability focused on the full spectrum of products required to support the M&S domain. In addition to simulation specific data sets, the EDCSS offers pre-computed environmental effects ("hypercubes" discussed below) and system performance metrics, simulated operational products such as satellite imagery, text observation reports, and forecaster products, and a wide range of graphic capabilities to support situational awareness. Finally, the EDCSS supports runtime distribution of this full suite of products and a range of tools to facilitate ingest and effective use by simulations and supporting applications.

Current Capabilities, Services, and Products

The services under continued development in the EDCSS Program are depicted inside the shaded box in Figure 2, and make direct use of the authoritative data sources identified by the MSEAs throughout the national provider community.

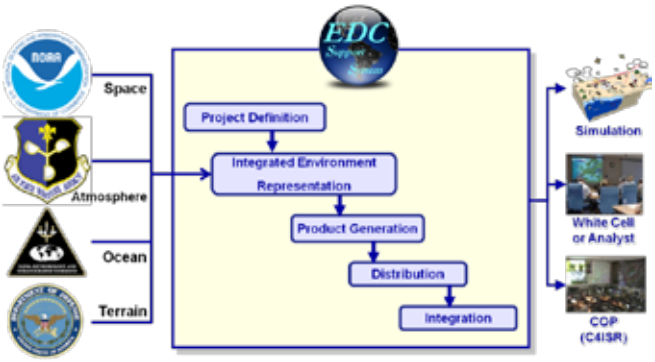

Figure 2. The EDCSS Conceptual Architecture

These providers are leveraged for off-the-shelf data sets, modeling capabilities, product generation services, and subject matter expertise on their respective domains.

Project Definition services provide for the capture and management of requirements in a meaningful form to the EDCSS end-users. The EDCSS requirements model emphasizes the association of customized products with the simulations and support applications familiar to a community. Also included in this area is the ESG concept of Scenario Searching to support the identification of one or more historical environmental scenarios. Operational since 2007, the ESG concept is a proven technology that provides relevant conditions for a simulation event. Examples of an 'event' include training exercises, technical or interoperability demonstrations, or campaign or weapon system analyses.

Given a fully defined EDCSS Project, ***Integrated Environment Representation*** services assist with the identification of one or more environmental resources required to support the event and ensuring access to all data from the national providers.

EDCSS ***Product Generation*** services provide for the transformation of the integrated environment representation into the myriad of custom defined products required to support an event. Product Generation is accomplished via an open services architecture that allows new generation services, whether internal to the EDCSS or hosted remotely, to be rapidly integrated for use.

EDCSS ***Distribution*** services facilitate coordinated access to the resulting simulation support package by end-users in all three EDCSS user domains.

EDCSS ***Integration*** services provide for the direct access to EDCSS products by a simulation or supporting application, including the use of any required decoders to access EDCSS product formats.

EDCSS Domain Definition

EDCSS technology components are being developed to be 'domain-neutral' rather than to support specific environmental data or modeling capabilities. The MSEAs for Air and Space, Ocean, and Terrain are responsible for the identification of data and modeling resources suitable for use by DoD communities enabled by M&S. The atmosphere and ocean domains include modeling of all aspects of the earth's fluid systems from the solid terrestrial surface to the near-earth space environment. The ocean domain includes models of the ocean bottom and sub-bottom. The space domain focuses on representing the space weather effects that can impact both space-based and terrestrial assets and operations. Within the EDCSS construct, the terrain domain includes those elements of the earth's surface representation that are dynamically coupled to the atmosphere and/or ocean. The EDCSS does not prepare traditional "synthetic environment" terrain databases that include visual representations and 3D models of simulated objects. However, the EDCSS leverages underlying terrain representations

(e.g. digital elevation models / and polygonized surfaces) to create its synthetic environment package.

The authoritative resources used for each domain are data archives that can be searched for suitable conditions to achieve the desired environmental effects during a simulation event. The data archives integrated for use with the EDCSS are expected to evolve over time as the scientific community continues to improve available reanalysis databases.

In general, modeling capabilities are also required to achieve the desired content and resolution for simulation applications. The foundational data archives can be used to stimulate the environmental models. The models for each domain can be coupled together to the highest extent possible, resulting in physically consistent cross-domain environment representations. Atmosphere and ocean domain models are routinely coupled, as are atmosphere and land surface models to provide both a realistic atmospheric boundary layer and near-surface soil characterization. As with the data archives, modeling capabilities will continue to evolve over time and the EDCSS will need to be continually updated to leverage the most up-to-date models.

EDCSS Product Types

The EDCSS Production Site provides for the generation of the correlated suite of products required to support the full range of players associated with a simulation event. The EDCSS products types that can be generated are defined below:

Simulation Specific Data

Each component of a simulation event can potentially have its own unique data requirements in terms of both content and format. The EDCSS provides for the registration of these simulation-specific data requirements and the subsequent production of data sets with the content and format that meet these requirements. Each data set can have a unique spatial and temporal representation, but all are derived from the single underlying base representation to ensure consistency across all data consumers.

Effects / Performance Hypercubes

In many cases, simulation applications cannot afford the runtime computational expense of computing realistic environmental effects and/or military system performance impacts that ultimately drive realistic behaviors. The Hypercube concept allows for the pre-exercise computation and efficient storage of environmental effects and/or systems performance metrics in a manner consistent with the underlying environmental scenario. Hypercubes can be alternatively described as n-dimensional lookup tables. Hypercubes can be used within simulations at runtime to very rapidly access the pre-computed effects or performance metrics associated with particular behaviors. EDCSS Hypercubes can be constructed for any system domain from physics-based tactical decision aids to simple rule-based system impact definitions. Hypercubes have been developed for infrared sensors and soil mobility applications.

Operational Support Products

Decision makers associated with a simulation event desire standard support products like those seen in normal operational C4I systems. A unique requirement for working with simulated environmental scenarios is the need for recreating other associated products such as satellite images, radar, and observations that are fully consistent with the underlying environment representation, as well as with each other. The EDCSS is able to generate a full suite of graphic and text products from the underlying base representation in a form that matches operational products.

Environmental Situational Awareness Products

With the injection of realistic environmental data and effects into multiple simulations supporting an event, it becomes critical that the event controllers and simulation operators have meaningful and consistent insight into the expected influence of the environmental scenario. The simulation domain often does not work with standard C4I applications, instead making use of integrated Geographic Information System (GIS) visualization tools, such as Google Earth, or visualization capabilities built into simulations. The EDCSS provides a range of visual support products in the form of standard graphic and/or GIS formats used to assist the simulation domain with environmental situational awareness before and during an event.

EDCSS Product Distribution

The EDCSS leverages emerging enterprise-level architectures and infrastructure initiatives, providing products that facilitate interoperability among M&S and C4ISR systems. The EDCSS provides enabling capabilities for the meaningful inject of environmental data and effects into simulation applications, as well as the supporting products to support the Human-In-The-Loop (HITL) aspects of simulation execution.

The design and documentation of the EDCSS addresses and incorporates DoD system security requirements to facilitate integration into DoD systems and networks. As EDCSS capabilities mature, they will be made available via the NIPRNET and SIPRNET and the EDCSS itself will access data resources from the national providers on these networks. The EDCSS can also be accessible from specialized network domains such as the Joint Training and Experimentation Network (JTEN) or Distributed Mission Operations Network (DMON). To enable the EDCSS on these and other networks, all deployed EDCSS capabilities will be subject to the DoD Information Assurance Certification and Accreditation Process (DIACAP) as defined by the Air Force Network Integration Center (AFNIC) guidelines.

EDCSS End-users

There are myriad current and potential end-users of EDCSS technology. Essentially, any government organization involved in M&S work requiring a representation of the physical environment is a potential user of the EDCSS. It can support both stand-alone simulations and federated events. Currently the EDCSS is being, or has been, used for wargaming analysis, flight simulations, numerous COCOM-level exercises, US Navy Fleet Synthetic Training, and pre-deployment training.

The EDCSS can provide data in numerous usable formats, therefore there are a number of federates that can access, display, and use EDCSS data. The list of federates that ingest EDCSS data is always expanding. The following is a list of federates that have employed EDCSS:

- Air Warfare Simulation (AWSIM)
- Combat Air Forces Distributed Mission Operations (DMO) Community Federate Simulation Programs
- Joint Analysis System (JAS)
- Joint Conflict and Tactical Simulation (JCATS)
- Joint Semi-Automated Forces (JSAF)
- National Wargaming System (NWARS)
- Naval Continuous Training Environment (NCTE) Community through Navy Training Federation Program (JSAF, ATLOS, SMTTE, SAST & NASMP flight simulators)
- Navy Fleet Synthetic Training (FST)

Supporting the DoD M&S Enterprise Vision and Goals

Development of the EDCSS has been, in large part, sponsored by the DoD M&S Steering Committee. In light of this, it is important to understand that the EDCSS supports the stated vision and goals of DoD M&S.

The **DoD M&S Vision** is: "Empower DoD with Modeling and Simulation capabilities that effectively and efficiently support the full spectrum of the Department's activities and operations." The desired end state being: "A robust modeling and simulation (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."

The EDCSS clearly supports DoD's M&S Vision since it transforms the difficult, time consuming, and expensive process of including weather and other effects of the natural environment into an efficient, rapid, and cost effective process which is available to the entire Department.

The EDCSS clearly supports the published goals of the DoD's M&S efforts since it:

- Can be shared across the Enterprise, is readily accessible, and can be reliably applied by users
- Promotes interoperability and will be a common M&S capability when fully developed
- Minimizes duplication and encourages reuse of M&S capabilities
- Leverages research and development to respond to emerging challenges
- Is government-owned and is not encumbered by proprietary restrictions
- Can be leveraged to provide an M&S capability across the DoD, other government agencies, international partners, industry, and academia

- Comprises tools that:
  - Support the full range of DoD interests
  - Provides timely and credible results
  - Makes capabilities, limitations, and assumptions easily visible
  - Is useable across communities.

The EDCSS and the DoD M&S Data Enterprise

A subset of the DoD M&S Enterprise is the "DoD M&S Data Enterprise". Currently, a five year strategy is under development to coordinate data efforts and investments across the Services, communities, and related M&S projects. The emerging M&S Enterprise Data Strategy plans to: (1) leverage lessons learned from previous projects, (2) order implementation steps to achieve M&S data production and sharing goals, and (3) include a current understanding of the necessary production environment and a roadmap for technical implementation. The ultimate end-state is an M&S Enterprise which more efficiently uses M&S data, produces better data faster, makes discovery of M&S data assets easier, and increases sharing of M&S data across the enterprise. This end-state will fulfill the important strategic objectives of an enterprise focus, interoperability, and reuse. Because of its advanced existing capabilities and its compatibility with the stated end-state, the EDCSS is positioned to become a significant part of the DoD M&S Data Enterprise.

SUMMARY

The Environmental Data Cube Support System is a nascent, DoD-owned capability to include the effects of the natural environment in DoD M&S. The project is revolutionizing the way environmental factors play in DoD M&S. Benign weather, nominal sea states, and dry ground no longer have to be assumed. Warfighters are finally enabled to train like they fight. Natural environment challenges can be included in M&S. In addition, natural environmental data and its effects can be consistent across all aspects of federated events using correlated environmental products created and distributed by the EDCSS. The EDCSS provides an enterprise-wide capability which addresses many of the goals of the DoD M&S Enterprise. Lastly, as the primary provider of correlated, integrated natural environments to DoD M&S, the EDCSS is positioned to become a key component of the DoD M&S Data Enterprise.

MSEA Message: Putting the Power of GEOINT in Your Hands

Modeling and Simulation Executive Agent (MSEA) Message: Putting the Power of GEOINT in Your Hands

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The Goals

The NGA Director has set two main goals for achieving her vision of "Putting the Power of GEOINT in Your Hands."

- Provide online, on-demand access to NGA's GEOINT Knowledge: Give access to NGA content, services, expertise and support, and to tools that empower users to serve themselves.
- Create new value by broadening and deepening NGA analytic expertise. Provide deeper, contextual analysis of places, informed not only by the earth's physical features and imagery intelligence, but also by "human geography."

First

We have to fundamentally change the user's experience, to take what NGA has done for the user and put that power directly in their hands, on mobile devices or means of their choosing. And change their online experience to one where they can interact with dynamic content and services, if and when they want, through online, on-demand access to global seamless foundation, imagery, product, and activity layers.

We need to take the complex geo-processing of a GIS and deliver to the user intuitive, but powerful, apps that perform the tasks they need. Modeling and Simulation (M&S) database developers will greatly benefit from this approach as it includes providing:

- Transparent access to as much raw data as possible, including open source data.
- A proliferation of "apps," developed by both providers and users, that empower doing it themselves, when and where they want.
- An innovative use of social networking behavior and technology to enhance and easily share what is known on a continual basis.

In other words, see an NGA customer base empowered to achieve a much better interaction in meeting their data and information needs through online services. There are many ways to participate in creating online, on-demand access to GEOINT knowledge. For example:

- Provide input toward improving the ability to discover NGA data and services
- Empower developers to create apps that give users the power that they need
- Move toward a seamless coverage model and away from discrete products
- And participate in making that content accessible globally.

Operating as an online, on-demand GEOINT knowledge service requires altering the way we think about NGA data and analysis and how we deliver GEOINT knowledge so that it can be accessed in a timely, customized, and responsive manner.

Second

GEOINT is not only about describing the spatial; Where? What? When? or How Many? It's also about possibilities, trends and implications. It's about context and anticipating: what could happen, where it could happen, and why it could happen. GEOINT is synonymous with a deep contextual understanding of places / locations on the Earth. This understanding is informed by:

- What we know about the earth's physical features.
- What structures people build.
- How people use those structures.
- And by "human geography," this is data and information that can be understood spatially and depicted visually that further deepens and enriches our understanding of a "place" and includes things like: tribal boundaries, political ideology, birth and death rates, population, proximity to health facilities, principal market commodities, ethnicity, languages,

education, access to media, and other cultural features.

Unlike terrain or man-made features the human geography and structural use data change rapidly and dramatically based on the situation. GEOINT is the examination of all these data viewed through a spatial and temporal lens. What is needed is data exploitation; to discover patterns, trends, signatures and correlations; and to communicate the GEOINT analysis visually. The resulting analysis will be greatly enriched by understanding the interrelationship of all GEOINT factors, the Earth's physical features, imagery intelligence, and human geography.

There are many ways to help meet these objectives by providing innovation in handling:

- Vast amounts of unstructured data.
- Untagged data.
- Pattern recognition in large data sets.
- Visual analytics, including four-dimensional visualization capabilities.
- Behavioral modeling.

The M&S community has significant experience in many of these challenge areas, including perspectives for online, on-demand data discovery and access. Participate in shaping and achieving the NGA Director's vision by contacting Paul Foley, NGA M&S Executive Office, at 571-557-3168, or by email at paul.g.foley@nga.mil.

This article is developed from the keynote speech delivered at the Geospatial Intelligence (GEOINT) 2010 Symposium by Letitia A. Long, Director of the National Geospatial-Intelligence Agency (NGA) describing her vision of: Putting the Power of GEOINT in Your Hands.

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