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# Discovery and Reuse of Modeling and Simulation Assets

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DoD, M&S, XML, discovery, metadata, standards, reuse

**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 key to optimizing the investment of the estimated billions of dollars spent on M&S within the Department of Defense (DoD).*

*Key enabling technologies include an integrated search and discovery capability, and the specification of a consistent set of metadata that can be used to search across multiple registries and repositories. The objective of this paper is to familiarize the community with these enabling technology efforts. It will describe a common M&S discovery metadata specification and describe how it is related to DoD overarching specifications as well as M&S-specific registry implementations. It describes how the schemas of these sources were integrated to formulate a concise, practical, and flexible schema, and how that schema can best be used. It also examines the M&S Catalog development effort, which offers a search and discovery capability using negotiated data exchange agreements with a variety of primary sources to respond to user queries about M&S. Additionally it discusses how data structures at each source are translated to the corresponding metadata specification, and then communicated to the M&S Catalog central search engine.*

**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.

## 1. Introduction

Although their business models are different, the Simulation Interoperability Standards Organization (SISO) and the omnipresent Internet search engine Google have something in common. Part of SISO's mission is "to provide an open forum that promotes the interoperability and reuse of models and simulations [1]." Google's mission is "to organize the world's information and make it universally accessible and useful [2]." Clearly, both seek to promote the discovery and reuse of content.

In fact, the ability to discover existing M&S resources is a critical need for enabling effective reuse and for reducing the duplication of capabilities. Such visibility and accessibility is key to optimizing the investment of the estimated billions of dollars spent on M&S within the Department of Defense (DoD). Because Google has

been so successful in its similar mission, it behooves us to consider for a moment how Google works.

Google got its start in January 1996 as a thesis project by graduate student Larry Page, after whom "PageRank" is named [3, 4]. Page's theory was that by tracking and crawling related hyperlinks on a web page, one could use such data to produce more relevant candidate search results as compared to a typical search engine at that time, which simply compared keywords of a web page to a search string. From a user's perspective, the search string would still be the input, but searching data based on the merit of "associations" within a webpage, which are citations and links to other resources such as web pages, images, and videos, is central to the modern Google Engine that we know today [5]. The search engine is just one part of the solution; the other part is making sense of the metadata within a page that provides these associations.

Thus, what the DoD M&S community needs is not just a search and discovery capability, but also specification of a consistent set of metadata that can be used to search across multiple registries and repositories.

## 2. Discovery Metadata

M&S resources are typically not described by HTML tags as are the web pages that Google and other web-based search engines crawl and index daily. M&S resources are tagged and bagged in a number of different ways -- if at all. Current web-based technologies based on the Extensible Markup Language (XML) permit more explicit markup of information on the Web. Such markup can be exploited to make search and discovery of M&S resources more efficient, particularly as the DoD moves toward the Global Information Grid (GIG) and its Net-Centric Data Sharing Strategy.

Of critical importance is determining what information is most useful for search and discovery of M&S resources. Consider for a moment if you walked into a grocery store to find it well-stocked with unmarked products and goods and none of the items were labeled. Would you be able to understand what products were on the shelf? Such a trip to a grocery store would be perplexing and frustrating. Perhaps you have experienced a similar frustration when shopping at a store where the prices are not clearly identified on the shelf or the product. The likelihood is that a product with no price presented to the consumer will remain on the shelf and not be purchased. In fact, customers with the intent to buy are interested in seeing several pieces of information to aid in their selection process, such as product name, manufacturer, size, weight, and nutritional content. What we learn from this is that metadata is vitally important.

Likewise, those of us that are producers and consumers of M&S assets need a common way to tag and understand M&S resources. This *discovery* metadata, which provides the labeling of a resource, is in many ways independent from the *structural* metadata that reveals the interior composition of a resource. Back to the grocery store analogy: the cereal that you might look for on the shelf can only be discovered if the box containing the cereal is decorated and annotated in a way that you can recognize. You probably do not need

to know the chemical make-up of its ingredients. That structural metadata may be important to some stakeholders (e.g., mothers) BUT only after discovery.

A common discovery metadata labeling system for M&S resources has been a long need. The M&S Community of Interest (COI) Discovery Metadata Specification (MSC-DMS) has been developed in response to this need [6]. It provides a consistent schema for discovery, analogous to the nutritional labeling now common on foods marketed in the U.S. (See Figure 1.)



Figure 1 -- Tagging M&S Resources

The MSC-DMS specification was introduced previously at the 2008 Fall SIW, under paper 08F-SIW-043 [7]. In the current paper, we dive deeper to expose elements of the MSC-DMS that can be used to reveal useful associations to assist in the discovery of relevant candidate M&S resources. In many ways, we are attempting to follow Google's approach in identifying parts of a web page that could be used to reveal citation-based associations matching the keywords entered by a person searching for relevant M&S assets, but with the advantage of greater contextual precision through the use of the Extensible Markup Language (XML).

### 2.1 MSC-DMS Internals

First, we quickly look at the overall structure of the MSC-DMS XML language, and then we identify some of the key aspects of the MSC-DMS that could be used to expedite the crawling, indexing and searching of M&S resource. Figure 2 offers a glimpse of the MSC-DMS structure.

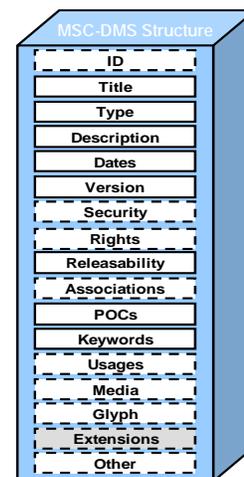


Figure 2 -- MSC-DMS Structure

```

<?xml version="1.0" encoding="UTF-8"?>
<ms:Resource
xsi:schemaLocation="http://metadata.dod.mil/mdr/ns/MSCDM/1.1/ MSC-DM-v1_1.xsd"
xmlns:ddms="http://metadata.dod.mil/mdr/ns/DDMS/1.4/"
xmlns:ms="http://metadata.dod.mil/mdr/ns/MSCDM/1.1/"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <ms>Title ms:value="battle sim sprocket model"/>
  <ms>Type ms:value="software"/>
  <ms>Description>
    <ms:Text>Battle Sim software that models space sprockets</ms:Text>
  </ms>Description>
  <ms:Dates>
    <ms>Date ms:type="created" ms:value="2007-08-13"/>
  </ms:Dates>
  <ms:Version ms:value="1.4"/>
  <ms:Releasability ms:value="A: Unlimited distribution "/>
  <ms:POCs>
    <ms:POC>
      <ms:Role ms:value="publisher"/>
      <ms:Person>
        <ms>Name ms:first="Samuel" ms:last="Adams"/>
        <ms:AddressInfo/>
        <ms:Phone ms:type="work" ms:number="555.123.4567"/>
        <ms>Email ms:type="work" ms:address="sadams@sprockets.sims"/>
      </ms:Person>
    </ms:POC>
  </ms:POCs>
  <ms:Keywords>
    <ms:Keyword ddms:value="software"/>
  </ms:Keywords>
</ms:Resource>

```

**Figure 3 – Minimum Required MSC-DMS XML Structure**

Not everything identified at the core level of the MSC-DMS XML view in DMS is mandatory; there are some common but optional elements that are used only if needed. The

Figure 3 depicts a well-formed and valid XML document that adheres to the MSC-DMS based on the required fields.

Essentially only 8 root elements and 11 sub elements are required: *Title, Type, Description, Date Created, Version, Releasability, POC, Keywords*. We begin with these essential elements to first identify the core basic elements that can be used to support a simple search.

## 2.2 Simple Search

The common input device for searching for items of interest is a simple keyword text window illustrated in Figure 4. The simplicity offered to the user is that they have one spot to enter the keyword and values of interest. The engine then needs to be smart and know how to leverage those keywords. Likewise, the author or publisher of a resource needs to be aware of what element tags ought to be populated to aid in a search.

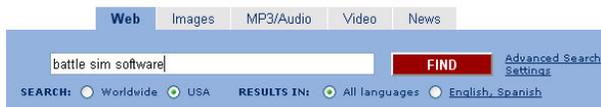


Figure 4 -- Simple Search Screen

The core element tags that could be leveraged from the MSC-DMS metadata in a simple search would include the following:

- *Title*
- *Type*
- *Description*
- *POC.Person.Name\**, or
- *POC.Organization.Name\**
- *Keywords.Keyword*

*\*only one of these needs to be declared (person or organization)*

Keep in mind these fields reflect the type of mine-able metadata that “simple search” criteria would likely use. This “simple search” approach has existed long before the Google engine came into existence. As an example, a good way to locate a high-probability candidate would be to enter a quoted phrase into the search window, then seek records whose *Title* and *Description* tags contain the quoted phrase. If such a match is found, then it would be elevated to the top of the search list as the best, most likely candidate. Typically, however, the

“simple search” approach results in less than stellar discovery list of candidates.

There are several additional fields offered by the MSC-DMS that are optional, but which can be extremely useful with the Simple Search method. They include the following:

- *Usage*
- *Media*
- *Security*
- *Rights*
- *Releasability*

The MSC-DMS specification gives further details for each of these MSC-DMS elements, and the reader is encouraged to explore these further.

## 2.3 Citation-based Associations

The next logical question is what other aspects of metadata can be leveraged for improving discovery beyond the simple search? There are several non-essential (not required) metadata elements provided by the MSC-DMS that can be used to reflect citation-based associations, which are used for identifying information of possible interest related to an M&S resource. The specific metadata elements that support this capability that we will examine further include the following:

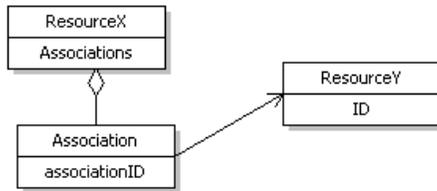
- *Resource Association (ID, value)*
- *POC Person/Organization (ID, URL)*
- *Usage.History (POC ID)*
- *Media (location)*

### 2.3.1 Resource Association Citations

A few years ago the M&S acquisition community proposed a convention within their Product Development Metadata Specification (PDMS) specification for tagging resources with a unique ID. Additionally, the development teams for the Base Object Model (BOM) and High-Level Architecture (HLA) Evolved standards defined a means to reference external object model components either defined in other parts of the model, or found within external models. This capability is accomplished through the use of an ID tag. This concept was integrated into the MSC-DMS during its development so that M&S

resources could be uniquely identified and referenced by other resources.

The *Resource.ID* is a unique identifier that can be associated to an M&S resource record. It is intended to be used to support cross referencing by other resources and also for the benefit of organizing data hosted by one or more repositories. Consider the example illustrated in Figure 5.



**Figure 5 -- Resource ID Citation**

In this example the *ID* for ResourceY is cited as an *Association* of ResourceX. The *Association* subcomponent offers a way to cite other sources, which may be either resource assets or support assets. Associations can be made to various types of resource and support assets including software, tools, data models, documents, and more.

There are two ways the *Association* subcomponent can be used to reference external assets. One is the *associationID* tag, which we just described, and the other is the *value* field, which is used to identify an associated source that may be not be cataloged by an *associatedID*. Figure 6 provides an XML example of an *Association* subcomponent that employs the *value* field.

```

<Association
  qualifier="URL"
  value="http://www.simsrus.com/BMA1003.xml"
  schemaHref="http://www.simsrus.com/schemas"
  schemaQualifier="na"
  relationship="is-described-by"
  type="related documents"
/>
  
```

**Figure 6 -- Association Value Example**

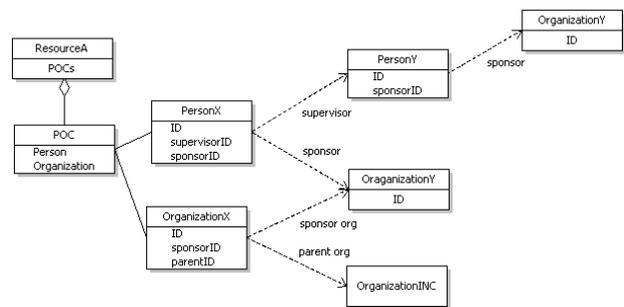
In this example an *Association* within the resource metadata is made to an external XML document. The *qualifier* attribute specifies the reference format of the external source as a Universal Resource Locator (URL). The *value* attribute specifies the actual external source, in this case the file location and name. The *schemaHref*

attribute identifies the schema type needed to parse/digest the cited source. And the *relationship* element identifies how the cited source is related to the principal resource, ResourceX.

The benefit in having an *Association* is that it provides more quality material for a search engine to crawl, index, and search. A cited *Association*, whether it is provided by an *association ID* or a by a reference *value*, likely offers additional metadata that can be canvassed against the search criteria entered by a user. This allows a page (a resource) to be weighted and sorted by the search engine.

### 2.3.2 POC Citations

Let us now turn our attention to the Point of Contact (POC) component of the resource metadata. Just as an M&S metadata resource can be uniquely identified by an ID, so can also a *POC*, such as a *Person* or *Organization*. And, much like the *Association* component of an M&S metadata resource, a *POC* can cite other *POC IDs* such as a sponsor, supervisor, or parent organization. Figure 7 provides an example illustration of how such *IDs* can be referenced by other *POCs*.



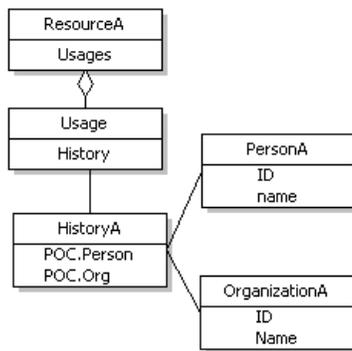
**Figure 7 -- POC ID Citation**

In this example, any POC sources linked to PersonX and OrganizationX become items of interests. As more relationships are identified through ID citations then more information can be leveraged by the search engine. The more sources that can be crawled, indexed and searched using the keyword criteria provided within the search request the greater the discovery competency. The higher the rate of search criteria keyword matches that are found within these additional sources will result in a greater a “PageRank” for the original resource for which these sources were cited. Consider again the

example in Figure 7. PersonY, OrganizationY, and OrganizationNC have become resource items of interest due to the POC ID associations cited by ResourceA. Any other resource related to these POCs can be further interrogated by the search engine to determine if there is additional history for these POCs in matching with the keyword search criteria. The more matches that are found would elevate the original resource for which these POCs were cited as a probable search result candidate.

### 2.3.3 Usage History POC Citations

*Usage History* offers an additional means to explore how resources have been used and integrated. Much as Amazon.com provides user feedback on a product, so does the intent of the MSC-DMS. A repository that offers visibility to the discovery metadata of a resource should also allow integration use and experience of that resource to be captured and re-shared with the community. A POC that provides such experience as history can be identified within the metadata. This is illustrated in Figure 8.



**Figure 8 -- Usage History POC ID Citation**

What this citation-based association offers is a means to investigate the POC. Has the person or organization garnered enough experience in the use (or development) of other related resources for their comments to be considered? If so this data is mined (crawled, indexed and searched) more strongly than others. And if their comments are valuable because of a rich history and there are significant key word matches with their other related resources, then that would elevate the original resource of interest to be higher on the candidate list.

### 2.3.4 Media Location Citations

Often *Media* properties may be associated to an M&S resource to identify the physical or digital manifestation of the M&S resource. The *Media* properties include *Format* and *Location*. The *Location*, as its name implies, provides a means to identify the location of the media. It is, in essence, an address that may be used to access the information resource content, e.g., a URI or file system location. At this point it should be clear that this field is a citation-based association, and that the potential exists to crawl, index and search the media content identified by the *Location* property.

Drilling into any of these citation-based associations and interrogating resources further can be accomplished using both “Simple Search” mechanisms described earlier and through further (next layer) “Citation-Based Association” mechanisms used to find additional mapped and related resources. The desired result is a well organized set of available candidate resources that support stakeholder needs.

### 2.4 Weighted-based Search

The fields of the MSC-DMS can also be weighted. Consider the previous discussion pertaining to the strength of a POC’s shared experience of resources, which was based on *History* entries within a repository. The more experience a POC has the greater their comments should be weighed.

Consider again a web page. The philosophy of an engine like Google is that, “Words in a larger or bolder font are weighted higher than other words [5].” For example, the words in the *Header* of an HTML page means much more than the words within a set of *Paragraph* tags found on the same page. In the same way, some of the metadata tags provided by the MSC-DMS can be and should be weighted differently when it is being crawled by a search engine.

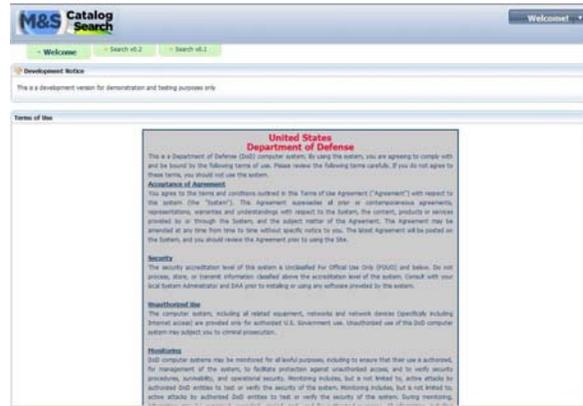
A valuation of the MSC-DMS components as they relate to supporting weighted-based searches is reflected in Table 1.

**Table 1 -- MSC-DMS Valuation Weight**

MSC-DMS Component	Valuation Weight	Comment
Title	Hi	This is an extremely visible and important aspect of the metadata. If the words in the title of a resource match the search criteria, then it

		is highly probably that the resource is a top search candidate.
Type	Medium	The values for representing types may be coincidentally reflected in a key words of the search criteria. But in most cases a match would be of great intrigue, but certainly less than Title.
Description	Medium	Unless the search criteria are provided in a quote string, then this field is medium.
Dates	Medium	Specific dates identified in the search criteria, if they match with the Dates of a resource would be of great intrigue. Dates however, are not often identified search values.
Version	Low	This is not a highly weighted search tag.
Security	Low	Security is important to an M&S resource, but it not typically a strong element of the search criteria.
Rights	Low	Rights is important to a M&S resource, but it is not typically a strong element of the search criteria
Releasability	Low	Releasability is important to a M&S resource, but it is not typically a strong element of the search criteria
Associations	Medium	Much can be learned by examining the associations of a resource.
POCs	Medium	Names of Persons and Organizations are often an intriguing search area. Matches at this level could be useful in learning about other resources associated to these POCs that also satisfy the search criteria.
Keywords	High	Keywords are defined within a metadata resource for the purpose of easy discovery; in other words they mean something. Therefore it is important to keep keywords hi on the list of tags to be explored when a search engine is examining resources.
Usages	High	There is a lot of solid information that can be captured in the Usages component including purpose, application domain, limitations, history, and capabilities. If matches are found it is likely that such resource is a good candidate
Media	Medium	If the search criteria is specific on identifying the media it is attempting to locate, than this component of the MSC-DMS should not be considered lightly by a search engine
Glyph	Low	Typically search of information is very rarely focused on the visual representation of the resource.

by the search engine. The M&S Catalog, via a web portal, offers a search and discovery capability to respond to user queries about M&S resources. The catalog is a web-based application that stores and indexes data and metadata, taking advantage of the MSC-DMS XML schema [6]. Its welcome screen is shown in Figure 9 **Error! Reference source not found..**



**Figure 9 -- M&S Catalog Welcome Screen**

Sources currently include the Navy Modeling and Simulation Resource Repository (MSRR), DoD MSRR, Air Force MSRR, Army MSRR, and Analysis M&S Tool Registry. The M&S Catalog collects (meta)data from its sources by a combination of web crawling and direct insertion of content. In its current implementation, the search engine is powered by a Google Search Appliance (GSA). The GSA engine can natively process HTML files typical of web sites, but it does not “understand” XML tags in general. (Meta)data following the MSC-DMS XML schema must be translated into a simpler, one-layer-deep system of “meta tags” as illustrated in Figure 10.

### 3. M&S Catalog Effort

The M&S Catalog effort is the first project that has begun to apply a search engine against resources tagged with the MSC-DMS. Various sources enter into negotiated data exchange agreements to permit indexing

```
<metadata>
  <meta name="title" content="Extended Air
    Defense Simulation - EADSIM"/>
  <meta name="description" content="The
    Extended Air Defense Simulation
    (EADSIM) is a many-on-many simulation
    of air, missile, and space warfare. It
    is used to support analysis, training,
    test, and operational planning. EADSIM
    is one of the most widely used
    simulations in the world with over 350
    user agencies worldwide. EADSIM is
    managed by the U.S. Army Space and
    Missile Defense Command, as the
    executive agent for the Missile
    Defense Agency (MDA)."/>
  <meta name="POC" content="John Doe (256)
    555-1111, DSN xxx-1111 E-Mail:
    john.doe@smdc.army.mil"/>
</metadata>
```

**Figure 10 -- Example Meta Tags Searched by GSA**

This translation works fine for fields provided by the MSC-DMS like *Title* and *Description*, but is problematic for complex elements like *POC*. For example, a search for records with a POC containing a specific person's name and a specific agency name might return records that contained one POC with the person's name and another POC with the agency name, but no POC with both – in other words, a “false positive” hit.

To allow more precisely controlled “targeted search”, the M&S Catalog project will establish a data store to receive the full MSC-DMS-formatted XML records provided by sources. This collection of intact XML records can then be queried using XQuery. Results returned from the data store search will be collated with results returned from the parallel text-based search performed by the GSA.

The MSC-DMS-inspired data store will not replace the GSA, because we have no intention of reinventing the web-crawling or text-search wheels, although use of an open source search engine is a future possibility. However, it will be necessary to solve some problems to avoid chaos. Large among these is maintaining consistency. When one record is returned by the data store search and another is returned by the GSA search, how do we know whether they are the same record? Similarly, when a source sends us a record, how do we

know whether it is a completely new record or an update of a record we already have?

One possibility for the problem of record identification is to have the sources provide a unique identifier (ID) associated to the resource. Since the sources must already have a way to keep their own records straight, we should take advantage of it. Two records from different sources about the same underlying resource, if they are tagged with different unique IDs, would be treated as two different records, although they might both be returned (or ignored) as results for a search.

The MSC-DMS can support such record identification in multiple ways as described in Section 2.3. However, it is still a matter of negotiation among the participants to determine which MSC-DMS elements should be used for this purpose.

A broader but related question is how to associate records returned from the GSA and from the data store when they are NOT identical. Matching titles and phrases within description fields is conceptually straightforward, but more interesting would be records that share associations. Finding associations in the MSC-DMS schema is easy: they're explicitly marked. Finding such associations in results of a text-based GSA search would be more challenging. One possibility is to pick out words or phrases from the MSC-DMS association elements, then look for them as text strings in the GSA result set.

Another intriguing possibility is to allow end-user feedback of which results are best (or worst) associated with each other. It might be possible to construct a mechanism that constantly improves itself based on such feedback.

Problems like these will provide ample challenge to keep sharp coders interested in their work. Current research into Semantic Web technologies shows great promise for improving contextual relationships across web-based resources and is being investigated for application to the handling of M&S resources.

#### **4. Other M&S Resources and Repositories**

Beyond the large-scale M&S repositories managed by various DoD agencies and organizations, there are numerous repositories managed by industry, schools,

and non-governmental organizations that hold potentially valuable M&S resources. Some of this information is searchable in the so-called “surface web,” while much of the information is found in the “deep web,” the vast collection of information not accessible by web search engines [6]. A worthwhile long-term objective of the M&S Catalog and MSC-DMS is identification of auxiliary M&S resources that may be discoverable that can further benefit the M&S community.

As an example, the Naval Postgraduate School Modeling, Virtual Environments, and Simulation (MOVES) Institute manages a number of repositories of 3D graphics models expressed in the Extensible 3D Graphics (X3D) international standard for 3D on the Web. One repository, the Scenario Authoring and Visualization for Advanced Graphical Environments (SAVAGE) repository holds over 1,200 3D models and model components available for reuse by the M&S community. These are XML files using the X3D standard to describe scene graphs. A standard set of metadata, called the Savage Modeling and Analysis Language (SMAL), is used inside the files to describe the content and provide author and other historical information about the development of the model. As models are added to the repository, this metadata is read to auto-generate HTML files providing a catalog that can be browsed by users. While these generated HTML pages are indexed by web search engines, the underlying X3D files are not. During this auto-generation process, an easy addition is execution of an Extensible Stylesheet Language Transformations (XSLT) file to generate MSC-DMS metadata from the SMAL metadata embedded in the X3D files. These metadata files can be provided to the M&S Catalog to enable these resources to be discovered for reuse. Over time, we anticipate that such voluntary provision of discovery metadata will bring about ever-greater visibility into the many collections of M&S resources that have been developed across government, academia, and industry.

## 5. Summary

As stated in SISO’s vision statement, those involved in supporting modeling and simulation interoperability and reuse include “developers, procurers, and users, worldwide. [1]” These stakeholders require ways for systems

and simulations to connect, interoperate, and function cooperatively. To this end, a primary goal is “to promote and achieve reuse.”

In this paper, we have explored ways to achieve this goal by way of leveraging the capabilities of the MSC-DMS schema. The MSC-DMS is the result of integrating common practices and templates used within the M&S community for tagging resources. It offers a concise, practical, and flexible schema including the types of “citation-based associations” and “weighted based valuation” of metadata content that can be leveraged to better support the search and discovery of M&S assets. We have also examined the M&S Catalog, supported by the MSC-DMS in parallel with a Google mining engine, which uses negotiated data exchange agreements with a variety of sources to respond to user queries about M&S.

We highly recommend that DoD community members take an important step towards cataloging M&S resources in a common way, by adhering to the MSC-DMS structure. Doing so will help bring to bear associations that allow search engines to find relevant M&S resources, thereby supporting our interoperability and reuse needs.

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## Biographies

**PAUL GUSTAVSON** is Chief Scientist at SimVentions, Inc, and has over 19 years of experience including the design and development of DoD standards, simulation systems, software applications, and numerous technical publications and tutorials on simulations and software development. Currently he is supporting the M&S Coordination Office (M&S CO) in helping to identify key metadata needed for the cataloging and discovery of M&S resources. He has been an active leader within the Simulation Interoperability Standards Organization (SISO) involved in multiple standards efforts including the Base Object Model (BOM), Distributed Simulation Engineering and Execution Process (DSEEP), and HLA Evolved. He is a co-author of several books including "C++Builder 6 Developer's Guide." Mr. Gustavson holds a Bachelor of Science degree in Computer Engineering from Old Dominion University, and lives in Virginia with his wife and two boys.

**ALI NIKOLAI** is the Principal Data Engineer on the System Engineering Technical Assistance contract for the Defense Modeling & Simulation Coordination Office (M&S CO), She provides technical support on issues and projects regarding data management, including: 1) Analyzing both current and future issues and DoD policies involving data in regard to M&S initiatives in the DoD M&S community; 2) Developing plans and managing technical projects for the M&S CO. Ms. Nikolai has over 30 years of experience in systems management and development serving DoD clients, including management of the DoD Data Architecture program for DISA. She also has provided system

engineering and logistic support for the active Army and the Reserve Component. Ms. Nikolai holds a Bachelor of Science degree in Biology from Gannon University in Erie, PA and a Master of Science in Management from Troy State University in Alabama.

**ROY SCRUDDER** is an Associate Director at the US DoD Modeling and Simulation Coordination Office (M&S CO) where he is the lead for data activities. He has over 25 years experience in information systems analysis and development, concentrating the last 13 years in information management for M&S. Mr. Scrudder's professional experiences are in the areas of data management and data engineering with a specialization in metadata. He has served as the director for the M&S Resource Repository Board of Directors and led the Analysis of Alternatives for future capabilities in that area. Mr. Scrudder holds a Bachelor of Science degree in Applied Mathematics from the University of Tennessee.

**CURTIS BLAIS** is a Research Associate with the Naval Postgraduate School MOVES Institute. His primary areas of research and development include application of semantic web technologies to improve interoperability and for identifying and delivering valued information in network-centric environments such as the Global Information Grid. Mr. Blais earned Bachelor of Science and Master of Science degrees from the University of Notre Dame. He is currently a Ph.D. candidate in the MOVES program.

**RICHARD DAEHLER-WILKING** has been a computer scientist in the Command and Control Department of the Space and Naval Warfare Systems Center Charleston, South Carolina, since 2000. He is a longtime participant in the NETWARS community, having led the development of models for both EHF Milstar and UHF DAMA satellite communications. More recently, he has begun supporting 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.