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Towards a Business Model to Encourage Re-use of Models & Simulations in DoD

DTIC: Resources Made Visible for Re-use

A Re-use Lexicon: Terms, Units, & Modes in M&S Asset Re-use

The Modeling and Simulation Catalog for Discovery, Knowledge & Re-use

FROM THE EXECUTIVE EDITOR

The theme of this issue of the M&S Journal is asset discovery. With respect to data assets, the Department's Net-Centric Data Strategy gives specific guidance for sharing data in a net-centric environment, including visibility, accessibility, understandability, and interoperability. This is good news because data, or more specifically, metadata, play a critical role in the asset discovery process. Here is the bottom-line-up-front: To re-ruse existing M&S assets, one must be able to discover them, and discovery requires metadata, as well as useful tools, standards, and web services. Let's take a closer look.

Discover. A good place to begin is common semantics. The paper entitled "A Re-Use Lexicon: Terms, Units, and Modes in M&S Asset Re-use" suggests that a detailed glossary of key terminology can help members of the M&S Enterprise better understand the assets available for re-use, as well as the technologies involved with discovery. With this shared knowledge, some current initiatives are gaining acceptance. The M&S Catalog, described in "The Modeling and Simulation Catalog for Discovery, Knowledge, and Re-use", enables producers of data, tools, and services to make their metadata visible, and allows users to quickly and confidently find products they need and can re-ruse for their specific purposes.

Re-ruse. Re-ruse has been a major goal for M&S for some time, which suggests that it is not a trivial process. "Towards a Business Model to Encourage Re-ruse of Models and Simulations" discusses barriers to re-ruse and outlines some specific actions that can be taken to advance the effort. Re-ruse is not only a goal to work toward; it's a mindset that needs to be cultivated. When an asset such as a model is needed, too often the tendency is to build a new model from scratch. We need to encourage a new mindset that first asks, "What already exists that I can use to reduce cost, time, effort, and programmatic risk?"

Innovate. Many organizations are, in fact, developing new ways of doing business. The Defense Technical Information Center presents their vision and strategic plan to foster re-ruse in "DTIC: Resources Made Visible for Re-ruse". M&SCO is working diligently to move M&S data, tools and services toward net-centricity. Organizations that develop these assets can help by publishing discovery, semantic, and structural metadata. These and other efforts to increase sharing among the M&S Enterprise are the basis for innovation. Asset discovery is a collaborative effort and I encourage you to *Join the Innovation!*

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Guest Editorial

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Asset discovery, along with visibility and re-use, have been paramount objectives of the Department of Defense (DoD) Modeling and Simulation (M&S) world for decades – unfortunately, reaching those objectives has been as elusive as the early explorers' searches for the Fountain of Youth. Recent and very encouraging efforts within the Department's M&S Coordination Office (M&SCO), M&S Steering Committee (M&S SC), and communities enabled by M&S are revitalizing pursuit of those elusive objectives and appear to have us on a successful path into the future.

These efforts include:

- Establishing new processes focused on reducing the distance between asset owners, proponents and potential re-use partners;
- Investing in common tools, services, and standards that reduce the cost and pain of sharing information;
- Implementing an aggressive program to leverage and learn from the efforts of other organizations and communities.

But we can't stop there – asset discovery, visibility, and re-use are key to effectively answering new calls for DoD efficiencies while satisfying ever-increasing demands on M&S to save dollars, reduce acquisition time, provide better systems, train warfighters and fuel innovation.

The DoD Net-Centric Data Strategy outlines the vision for achieving these objectives in our net-centric environment [1]. The goals of this strategy revolve around making data visible, accessible, reliable, and manageable. To manage and employ M&S capabilities effectively across the DoD, senior leaders, managers, and users must have visibility into the DoD's M&S portfolio. Knowing which tools and data exist, along with descriptive information concerning their relevance, is vital to ensuring that organizations supported by M&S can find the tools that meet their requirements or determine the need to develop capabilities that fill identified gaps.

Those that have heard my discussions about M&S asset discovery, visibility, and re-use have heard me use one of two different analogies to express the challenges that face us:

- **Analogy 1:** The challenge associated with asset discovery can be represented as a pyramid with three layers. The top layer of the pyramid is asset discovery tools (search engines, metadata "card catalogs", etc.). The middle layer is metadata about M&S assets supporting metadata standards, metadata development tools, metadata portals, etc. The foundation is comprised of the M&S assets themselves, the data, services, tools, repositories, catalogs, infrastructure, etc., and the owners and proponents, for those M&S assets. The most important layer is the foundation; yet, we continue to try and build the pyramid from the top down. A building must have a strong foundation; otherwise, it will become just a pile of rubble.
- **Analogy 2:** Our previous approaches to asset discovery have been like the farmer who goes out and buys a shiny, new harvester, but forgets to grow or fertilize the grass that will become the hay. The mowing gets done faster – but there's still not much hay.

These analogies aren't just intended to be cute or folksy. They are intended to make the point that asset visibility doesn't start or end with a better search engine, a cooler web-site, or the best standard for metadata. Effective asset visibility, which means, "Can I find it, share it, re-use it to achieve better, timelier, and more effective results?" must, by necessity, begin and end with the users, owners, and proponents of the assets themselves. They are the most important, and also the most frequently neglected, part of achieving asset visibility, discovery, and re-use. I believe, and sincerely hope, that recent efforts undertaken by the DoD's Modeling and Simulation Enterprise are addressing the asset side of asset visibility. Expanding on a common phrase in the M&S Community: "It's all about the data," I'd like to add, "It's also about the assets – and the ability to share them." It's about finding the right carrots (and sticks – only where required) to reduce the cost and burden to the owners and proponents of M&S asset metadata. Then their information can be shared with potential users to leverage re-use by discovering information that's timely, relevant, and sufficiently detailed to inform their decisions.

The Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (OUSD(AT&L)), M&SCO and the M&S SC have made several recent investments, not just in dollars but also in the re-allocation and re-focus of staff and priorities. These investments have been made to promote asset discovery, visibility, and re-use to achieve the vision and goals expressed by the M&S SC in 2007, and by DoD in its recently updated Net-Centric Data Strategy. Three of the most critical investments and on-going efforts by M&SCO are:

- Establishment of the M&S Core as both a funding line and a process by which critical DoD M&S Enterprise capabilities are managed, operated and sustained. This includes the recently fielded DoD M&S Catalog, the M&S Community of Interest (COI) Discovery Metadata Specifications (MSC-DMS) (which is the M&S extensions to the Defense Discovery Metadata Specification (DDMS)), and the integrated tools to support the development and communication of asset metadata. The M&S Core, along with the Modeling and Simulation Information Analysis Center (MSIAC), provides an enduring capability to support M&S asset users and proponents, while providing a single point of contact.
- M&S COI Data Management Working Group (DMWG) established the Metadata Discovery Team to provide technical solutions and recommendations for current problems. This group will fill a key void by establishing a technical collaboration forum for M&S asset discovery tools and services, metadata standards, and user support issues.
- Development of metacard and discovery tools, and services in the Live-Virtual-Constructive Architecture Roadmap (LVCAR) DoD High Level Task (HLT) and evolution of those capabilities via the Rapid Data Generation HLT in their Common Data Production Environment. These capabilities, as well as the incorporation of standards and services being developed by the Defense Information Systems Agency (DISA), promise greater capabilities to assist users in the often thankless task of trying to develop, manage, and share metadata about M&S assets.

The next few months will be exciting. The DoD M&S Catalog, a metadata discovery tool, using a high end commercial search capability also used by NASA, the intelligence community, and Department of National Defence, Canada, has been transitioned from a pilot program to an enduring capability. It was recently federated with another DoD asset repository to enable searches across multiple databases with a single query. Work is also ongoing to streamline the processes by which users promote their metadata in the catalog.

M&SCO is also close to publishing strategies which encourage, and direct, the sharing of asset information through established standards and mechanisms. For the first time, M&SCO will "have it in writing," that metadata about M&S assets must and will be shared. But that's the easy part – implementing, sustaining, and gaining broad consensus on the policies, tools, services, standards, and processes described above is the hard part. That's where M&SCO is focusing its time, energy, and resources – so there are lots of reasons to be very encouraged as we address all three layers of the pyramid (analogy 1) or grow a lot of good M&S hay (analogy 2). Pick your analogy!

REFERENCES

[1] Department of Defense Net-Centric Data Strategy, DoD CIO Memorandum, May 9, 2003.

ABOUT THE AUTHOR

MR. JOHN W. DIEM became the Deputy Director of M&SCO in February 2011.

Mr. Diem's portfolio at M&SCO includes oversight of the M&S Core capabilities package and proponency for M&S standards / standardization; simulation interoperability; verification, validation, and accreditation (VV&A); and workforce development activities.

Mr. Diem has served in a variety of Army simulation, training, and operational and developmental testing positions over the past 30 years. Test and evaluation (T&E) type of duties have included test officer, operations research/systems analyst, simulation lead, and technology division chief. Most of his testing activities have focused on battle command, intelligence, surveillance and reconnaissance (ISR) programs, and communications/network systems.

In addition, Mr. Diem has frequently been involved with the integration of modeling and simulation capabilities to achieve appropriate and realistic test environments. His most recent T&E assignments were held from 2005 to 2007 as the Army Training and Evaluation Command (ATEC) M&S lead and during 2007 to 2009 as the Operational Test Command (OTC) Simulation and Integration Division Chief. Prior to taking the position at ATEC in 2005, Mr. Diem performed as the G-3 for the III (US) Corps and then Director, Plans, Training, and Security for Fort Hood.

His civilian education includes a bachelor's and master's degree from Texas A&M University; his military training includes the Military Intelligence Officer's Advanced Course, Operational and Developmental Test Officer Courses, and the Army Modeling and Simulation Advanced Course. He is Level III certified in Test and Evaluation.

Mr. Diem is currently on a two-year detail at M&SCO from ATEC/OTC. He will return to his beloved Texas in late 2011.

Towards a Business Model to Encourage Re-use of Models and Simulations in DoD

Towards a Business Model to Encourage Re-use of Models and Simulations in DoD

Dennis P. Shea, Julianne B. Nelson

ABOUT THE AUTHORS

MR. DENNIS P. SHEA directs the Information Technology and Operations Team at the Center For Naval Analyses (CNA). He has over thirty years of experience in defense analysis at CNA, including five field assignments with operational forces. His research in modeling and simulation (M&S) has focused on helping the Navy understand the capabilities and limitations of M&S and thereby make informed decisions on the use of M&S to support applications in acquisition, training, test and evaluation, and analysis. Dennis has conducted and/or supervised independent verification and validation (V&V) assessments on over a dozen M&S ranging from campaign-level models to distributed interactive simulations and hardware-in-the-loop simulations. In 1997, Dennis led the independent assessment of the military utility of the Synthetic Theater of War (STOW) technologies during the ACTD. Since 2008, he has been working on business models to promote re-use of M&S resources.

DR. JULIANNE B. NELSON is a senior economic analyst with the Center for Naval Analyses. She has twenty-eight years of experience as an economic and financial analyst, including fifteen years as full-time university faculty and thirteen years as a consultant to a number of DOD agencies, as well as the Federal Bureau of Prisons, the Department of Homeland Security, and several state Departments of Correction. Much of her work with federal and state agencies has involved responding to legislative inquiries concerning the cost of government operations, evaluating outsourcing opportunities, reviewing contracting policies, and developing annual budget and staffing analyses.

ARTICLE

The planning environment facing the Department of Defense (DoD) today is characterized by global tensions, fiscal pressures, short timelines, continuous change, and a significant amount of uncertainty. These features are apparent in the shift from preparing for traditional warfare and major combat operations (MCOs) to training for irregular warfare against any number of asymmetric threats ranging from ballistic missiles to cyber-attacks. New hot spots and threats (e.g., piracy in Somalia, bombings in Mumbai, Iranian submarines in the Red Sea, etc.) are emerging monthly if not more frequently.

In establishing a new paradigm for planning these operations, time and financial resources will be limiting factors: the military must be capable of responding quickly to emerging threats and adapting forces to new scenarios. Future acquisition programs must be more affordable and require less time to field new systems. The outlook for future defense budgets is stable funding at best, and the military services will likely be pressured to do more with less.

Military operations are routinely conducted jointly with other military services and often with other government agencies and coalition partners. Such operations place a premium on interoperability, not only in the warfare systems but also in the decision support tools and databases that support the services and agencies. The world is more interconnected every day with collaboration, sharing, partnerships, and re-use becoming dominant themes in all facets of information technology, including modeling and simulation (M&S).

These factors suggest that the DoD M&S community will often need to draw on models, simulations, databases, and other resources that are available off the shelf, have a strong pedigree, can be shared with and used by other partners, and can be adapted to support a variety of problems. There may not be sufficient time or funding available to develop new M&S tools from scratch; reusing existing M&S resources will be a priority. Tools that can be adapted quickly and easily to a broad spectrum of problems will be preferred over tools that are optimized for a narrow set of applica-

tions or scenarios. The Department will need to pursue an enterprise approach to M&S by acquiring capabilities that support the needs of multiple users across a program's life cycle and, perhaps, across multiple programs, and different communities of interest.

New M&S resources must be built to be reusable, interoperable, and shareable with others. Tools developed with open standards will be preferred over tools with proprietary technologies or interfaces. New investments in M&S must leverage existing resources, avoid duplication, and promote efficient use of M&S throughout the Department. Collaboration, interoperability, and partnerships will be just as important to the M&S community as to DoD overall.

Even in the face of a need to increase re-use of existing M&S resources where practicable, today most M&S development and application efforts begin without seriously considering the possibility of using outside resources. Relatively few M&S resources are re-used—throughout the life cycle of one acquisition program or shared across multiple programs. And, yet a broad range of M&S resources have the potential to be re-used, including models, simulations, databases, scenarios, threat representations, post-processing tools, among others.

The reasons for this lack of re-use are many and can be grouped into six categories:

- Discovering existing resources that are available for re-use
- Assessing the capabilities of existing resources against new requirements
- Acquiring (and perhaps modifying) the resource for a new application
- Ensuring interoperability with a new architecture (or application)
- Compensating the original developer
- Avoiding misuse of the resource and potential liability.

If these barriers can be overcome, re-use offers the possibility of reducing future M&S development costs, shortening the time to prepare for training exercises that rely on M&S resources, and improving the credibility of M&S-based results by employing resources that have withstood scrutiny in prior programs, exercises, and analyses. Overall, re-use will enable the DoD to make more effective and efficient use of its M&S investments.

What is needed to overcome these barriers and advance re-use is a shared business model between the DoD and the M&S development community, including industry, laboratories, and warfare centers. A business model creates value for customers by applying resources in a series of activities and capturing a portion of the value for the organization, here the developer or provider of the M&S resource. A viable M&S business model must balance the government's desire for increased awareness of, and access to, reusable M&S resources at a fair price with industry's need to protect its intellectual property (IP) and receive compensation commensurate with the true value of its M&S products.

As the customer in an M&S business model, the Defense Department must become a more effective negotiator and savvy consumer of M&S goods and services. This will entail understanding how to acquire rights to technical data and software in M&S resources developed by industry, negotiating to obtain best value for the government's M&S investments, and ensuring that future government users will be able to discover, assess, and use the M&S resources acquired from today's investments. Training programs, contracting guidebooks, better search tools, and policies can help.

Unfortunately, one attractive and seemingly natural business model—allowing a government office to recover some of its investment in the development of an M&S resource by selling or licensing resource to another government office—is precluded by current statute and DoD policy. Inter-service and intra-governmental support agreements are designed primarily for business transactions that involve the delivery of services and not the transfer of property such as software.

A viable business model must, therefore, focus on collaboration and partnerships in the development and funding of new M&S resources, sharing of existing government-off-the-shelf (GOTS) products, and multi-user licenses for commercial-off-the-shelf (COTS) products. Specific actions that DoD can take to advance the re-use of M&S resources include:

- Express the intentions to achieve re-use in the RFP (request for proposal) for new models and simulations and then negotiate with industry to obtain the required license rights. For M&S resources that have a high potential for re-use, either downstream within the acquisition program or in some subsequent activity by the sponsoring organization, or use by another organization, the government must state these expectations up front and negotiate to obtain

Government Purpose Rights or Unlimited Rights. The government may have to pay a premium to obtain a multi-user license and documentation to enable others to re-use the resource, but these costs should be significantly less than repurchasing the model or simulation at a later date.

- Implement stronger oversight of the M&S development process to protect government's rights, to include tracking the source(s) of funding and verifying proper markings of deliverables.
- Develop methods and criteria to identify the downstream and cross-program re-use potential of an M&S resource. Early in the development process, the full set of acquisition, training, and analysis opportunities to use an M&S resource must be made visible to government officials investing in M&S. This knowledge will enable the government to decide when to negotiate for broad license rights. This approach could include the creative use of "options" to purchase data rights in the future if and when a re-use opportunity is identified.
- Employ intra-governmental transactions to share (and re-use) resources among government organizations. Use a MIPR (Military Interdepartmental Purchase Request) to cover the additional costs of contractor support to modify the resource, train new users, or extend the license agreements.
- Establish and maintain an M&S resource registry to facilitate the search for available resources. A physical central repository that stores and maintains M&S resources is impractical and unnecessary to achieve re-use. The discovery process, however, can be improved with a requirement that all M&S developed in DoD contracts be registered with sufficient metadata (including license rights) about the resource to enable cataloging and subsequent identification and retrieval by potential re-users. The registry should be supported with a user-edited wiki to allow organizations that have invested in M&S resources to inform the broader community about the license rights they have funded and their experiences with the resource.
- Link the resource registry to a few small repositories that contain validated GOTS products and are controlled by users. Strong candidates include oceanographic products, survivability models, threat models, and visual/terrain databases.
- Centrally fund the common and reusable M&S infrastructure. The set of common reusable resources such as environmental databases and validated GOTS models such as threat and survivability models should be funded "off the top" from a central source. The funds should be administered by a group of long-term users of these resources.
- Strengthen the training and education programs on M&S contracting. Program managers and contract officers have little background in the complex regulatory structure associated with Intellectual Property and law and data rights, including the minimum set of license rights and contract deliverables required to use, share, or modify an existing M&S resource.
- Develop a best practices guide for M&S contracting. The guidebook should support the training and education programs and include lessons learned from first-hand experience on software licenses and technical data rights; negotiating with industry; monitoring the contractor software development process; and specifying contract deliverables to enable re-use.
- Establish a pilot program for an M&S intermediary to broker arrangements for the re-use of established M&S resources within and across government and industry. The concept of an Intellectual Property intermediary is being applied successfully today in the private sector in "open" business models to allow companies to identify and negotiate opportunities to share and license unused internal technologies with other firms positioned to apply the technology in ways the developer cannot. The M&S intermediary would help program managers and other M&S users identify and locate suitable existing resources and help developers find a market for established M&S resources. The M&S intermediary also would document the legal status of each M&S resource and facilitate license agreements between developers and new users.

- Recruit a senior government champion willing to use the bully pulpit to advocate for re-use. M&S re-use requires government and industry to become open to the ideas of collaboration, sharing, and partnerships, including breaking down the "Not Invented Here" culture. This new paradigm will encounter skeptical audiences, including some who believe that a re-use initiative is aimed at displacing industry's position in M&S. A senior government official, with a vision for re-use, can use his or her position and keynote addresses and articles in trade journals to inform industry about government's true aims in re-use and prevail on government and industry partners to work together.
- Enforce strong scientific practices in the development and application of M&S, including transparency and reproducibility. A disciplined M&S process will reassure prospective users that existing M&S resources developed outside their control are of the highest quality.

Table 1 maps these recommendations to the factors limiting M&S re-use today.

Finally, the current laws and regulations on intra-governmental support were written primarily for the delivery of services and not products. They don't reflect the growing importance of knowledge goods and intellectual property, and the need to capitalize on these investments and make them available to others. Updating these directives to make it possible for a DoD office to recover some of the initial development costs of a model or database and to apply these funds to future program costs would provide an additional incentive for re-use beyond what we have recommended above.

Actions to Overcome Barriers	Barriers to Modeling and Simulation Re-use					
	Discover Resource	Assess Resource	Acquire Resource	Ensure Inter-operability	Compensate Developer	Avoid Misuse
Include re-use in RFP			X		X	
Register all resources	X	X	X			X
A few, small, linked repositories			X			
Intra-governmental transactions			X		X	X
Oversee development process			X		X	
Make re-use opportunities visible	X	X		X	X	X
Centrally fund common tools			X	X	X	
Gov't Champion	X					X
Training & Education			X		X	X
Best Practices Guide			X		X	X
Open Business Models	X	X	X		X	X
Scientific Practices				X		X

Table 1. Mapping recommendations to problem areas

NOTE: *This paper is based upon recent work done for the Office of the Deputy Assistant Secretary of Defense for Systems Engineering (ODASD(SE)) and has been approved for "Public release; Distribution Unlimited."*

DTIC: Resources Made Visible for Re-use

DTIC: Resources Made Visible for Re-use

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Note: this article has been excerpted from the "DTIC Strategic Plan, 2011-2016."

ABOUT THE AUTHOR

MR. CHRISTOPHER E. THOMAS was named Acting Administrator of the Defense Technical Information Center (DTIC) in December 2010. Currently serving as the Center's Chief Technology Officer, he has been Director of DTIC's Information Systems Support and Component Information Support Directorates. He has overseen DTIC's development and hosting of more than 100 DoD Web sites, process improvement activities, production of the Center's roadmap, and FY 2011-2016 Strategic Plan.

A Department of Defense (DoD) Field Activity, DTIC is the central source within the department for acquiring, storing, retrieving and disseminating scientific and technical information to support the management and conduct of DoD research, development, engineering and studies programs. The Center also provides information tools and systems to support Pentagon executives and managers.

INTRODUCTION

In the 21st Century, supporting the Scientific & Technical (S&T) and Research Development Test & Evaluation (RDT&E) communities will require that we integrate, more than ever, our collections with databases, information links and the latest information technology, no matter the source.

As the leader of the DoD's scientific and technical information (STINFO) program, the Defense Technical Information Center (DTIC) has the responsibility to develop, coordinate and enable a strong STINFO program for the Assistant Secretary of Defense, Research and Engineering (ASD(R&E)) and the DoD S&T enterprise. Our aim is to maximize the availability and use of technical information and products resulting from defense-funded technical activities while ensuring restrictions in national security, export control and intellectual property rights are safeguarded.

It is DoD policy to establish and maintain a coordinated and comprehensive program to document the results and outcomes of DoD-sponsored and performed research and engineering (R&E) studies and to provide access to those efforts in an effective manner. Our customers, from individual researchers to acquisition professionals, will be able to quickly fuse information into the most complete picture needed in a matter of minutes to hours; not days to months.

DTIC's rich collections contain the technologies that are known; DTIC *is the information repository* from which new technologies arise. We are moving rapidly to create the DTIC Information Cloud, combining the best elements of Web 2.0 capabilities enhanced with the superb collections in DTIC's repository to create one integrated information space, improving the DoD's RDT&E capabilities, reducing costs, reducing development timelines and fielding solutions more quickly. Accessibility to information makes it possible to collaborate with greater efficiency.

DTIC ORGANIZATION AND MISSION

The Defense Technical Information Center traces its beginnings to the Air Documents Division of the Air Technical Service, United States Army Air Corps. At the end of World War II, this division was formed to collect and catalog scientific and technical documents. For more than 65 years, DTIC has been a vital link in the transfer of information within the broader defense community, which includes DoD personnel, DoD contractors and potential contractors, other U.S. government agencies and their contractors, as well as Congress, our allies, and other defense-related organizations. On June 4, 2004, DTIC was designated a DoD Field Activity under the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, reporting to ASD(R&E).

DTIC consists of five Directorates and the IAC Program Management Office reporting to the DTIC Administrator. DTIC Headquarters is located at Fort Belvoir, Va., with a

site in San Diego, CA. DTIC's blended, diverse workforce consists of both government and contract personnel with expertise in technical information, information technology and program management.

DoD Instruction, Number 3200.14, "Principles and Operational Parameters of the DoD Scientific and Technical Information Program," defines DTIC's mission and functions in relation to the DoD RDT&E programs. Under this instruction, DTIC is responsible for the acquisition, organization, storage, retrieval, analysis and dissemination of information produced by, for, or about DoD RDT&E programs, as well as for providing products and services that support the information needs of researchers, acquisition and logistics professionals, Warfighters, program managers, and decision makers working in DoD RDT&E or DoD Components.

As shown in Figure 1, DTIC has three mission areas:

- DoD STINFO Policy, Operations and IAC Manager: Sets and enables policy for scientific and technical information exchanges for the research and engineering community.
- IT Technology and Infrastructure: R&E Hub, connecting users and data in meaningful ways.
- Information Services Repository: World-class STI library with exceptional librarians capable of providing targeted research quickly.

Figure 1 - DTIC Mission Areas

DTIC VISION

In "Nature of Technology," W. Brian Arthur wrote:

> Technology springs from three sources: (1) technology that already exists and can be recombined in new ways to create new technologies, (2) technologies that spring from basic research breakthroughs, and (3) technology that is required to support the new technologies emerging from the previous two methods.

The DTIC vision is to be the hub of DoD Scientific and Technical information interchanges, empowering innovators with greater efficiency, effectiveness, and agility by accelerating the delivery of warfighting technology.

As a DoD Field Activity, we serve as an objective party crossing organizational boundaries and positively affect DoD's ability to meet the challenges put forth by the Secretary. With our strategic and organizational alignment to ASD(R&E), we provide information technology solutions to the entire DoD community.

Recognizing that information technology and information usage demands continually evolve, we will work within DoD and industry to leverage existing tools and pilot new capabilities and approaches to improve information discovery, analysis and collaboration connecting teams and people across the enterprise. To avoid duplication of efforts, DTIC will partner with DoD and other federal government organizations to provide federated access to information resources and tools.

Thirty years ago, the DoD helped to drive commercial R&D. Today, the department contributes a small fraction of the entire worldwide investment in R&D. One of DTIC's major roles is to multiply DoD's R&D investment by helping components across the enterprise leverage work performed by other organizations. We provide a gateway to commercial innovation by facilitating an improved understanding of DoD needs and industry capabilities. DTIC helps DoD maintain and develop a well qualified Science, Technology, Engineering, and Mathematics (STEM) workforce by offering modern tool sets which permit real-time information harvesting and sharing.

DTIC STRATEGIC PLAN

DTIC's strategic plan reflects its continuing effort to keep pace with the ever changing technology landscape and the evolving needs of the DoD. We intend to fulfill the evolving needs of the department by:

- Providing leadership in STINFO policy
- Providing a knowledge base and analysis of STI
- Identifying R&E and S&T repositories and offering

DTIC users federated access
- Becoming a catalyst to collaboration across the DoD R&E enterprise
- Building strong relationships both within DoD and with other partners
- Exploiting current and leveraging new technologies
- Balancing access controls with accessibility
- Creating efficiencies within DoD and DTIC

Providing leadership in STINFO policy

As the DoD STINFO Manager, DTIC will work with the Services and industry to refine STINFO policy to meet the evolving needs of the Department and address external threats. DTIC will work to synchronize STINFO policy to support ASD(R&E)'s vision to "Develop Technology to Defeat Any Adversary on Any Battlefield." As DoD's STINFO Manager, DTIC leads the department in the area of policy development and coordination across the Services and agency STINFO offices.

Providing a knowledge base of STI

DTIC will provide a physical and virtual knowledgebase for the department through effective exploitation of research within and for the DoD, identification of subject matter experts, and awareness of current S&T and R&D efforts. This knowledge base covers the life cycle of R&D from informal communication to budget, to completed work.

DTIC preserves DoD's investment in research through our created and maintained collections and the analysis done by DTIC's Information Analysis Centers (IACs). We provide repeatable solutions, prospective on the changes in technology and approaches to problems, and insight into how past solutions can address current challenges. We continually modernize the structure of our collections and integrate our databases, to provide flexible formats for the retrieval of information. DTIC will provide users with expanded access to unstructured and full-text data, implementing semantic technologies to aid discovery.

The S&T workforce, DoD's human capital, is the basis of DoD STI knowledge. DTIC seeks to provide tools that support the collection and discovery of information beyond traditional documents sources by adding user – provided data on in-progress activities, experiences, and ways they have adapted known technologies to solve new problems. We seek to leverage the resources of the S&T workforce and industry partners by supporting the development of professional networks and tools to allow leadership to quickly identify subject matter experts across the enterprise and apply those individuals to critical needs.

Identifying R&E and S&T repositories and providing DTIC users federated access

Recognizing that relevant R&E and S&T information is stored at organizations across the department, DTIC will expand its collections, virtually, and will work to federate access to users through identity management agreements or by exploiting remote collections through search crawlers, abstracts, links, and other references.

Becoming a catalyst to collaboration across the DoD R&E enterprise

Traditionally, the R&E community has worked in small geographically clustered teams and then shared information broadly through publishing reports on completed work. Internet technologies have changed the paradigm. Web 2.0 collaboration and professional networking technologies bring scientific investigation and research and development to an inflection point. Small geographically collocated teams with limited resources and unique perspectives will combine with other teams around the globe, bringing a diversity of perspectives and experiences to bear on problems to develop innovative solutions quickly. Collaboration tools permit solution providers to fully engage warfighters and decision makers; allowing those working on the solution to interface with those presenting the challenge/problem.

DTIC will enhance our collaborative tools with advanced search – complementing our repositories – to empower users to:
- recognize where resources are applied
- find subject matter experts
- locate state of the art technologies.

Accessibility to information makes it possible to collaborate with greater efficiency.

Providing analysis of STI

Today's leaders must make key decisions quickly. DTIC must present synthesized information products that can

be quickly digested, and provide paths to explore selected focus areas and where appropriate, offer additional research support, community feedback or analysis. Our STI systems and analysis capabilities must be able to answer questions that have not yet been asked, in minutes or hours rather than days or weeks.

As the department's focus shifts to address asymmetric threats, DoD leaders, scientists and engineers do not have the time to sift through mountains of data to uncover essential information. This underscores the value of and necessity for organizations to provide analysis, synthesis, and dissemination of relevant and timely information. DTIC's IAC Program Management Office (PMO) provides such a resource. IACs offer tactical relevance through direct connection to the warfighter, and strategic value through long term trend analysis and recommendations. IAC staff members answer immediate needs, driven by the requirements of the warfighter and acquisition community. Products such as state-of-the-art research and technology reports provide detailed analysis of immediate, critical challenges, while technical inquiry services offer a direct connection to a vast network of subject matter experts from across government, industry and academia. IACs meet the customer on their ground, maintaining involvement in technical communities and working with senior executives to solve the challenges of the day, while anticipating and preparing for those of tomorrow.

With coordination from DTIC's IAC PMO, experienced technical area scientists, engineers, and information specialists (who staff the IACs) establish and maintain comprehensive knowledge bases that include both historical and current technical, scientific, and related information collected worldwide. IACs also collect, maintain, and develop analytical tools and techniques, including databases, models, and simulations, while providing research and analysis services to customers with diverse, complex and challenging requirements.

In a time of shrinking budgets and increasing responsibility, IACs are a valuable resource for accessing evaluated STI, culled from efforts to solve both new and historic challenges. Through the IACs, research data is collected, can be re-used to answer recurring challenges, and analyzed to identify long term trends and provide recommendations to the acquisition community. DTIC's current Strategic Plan contains top level goals and objectives for the IACs. Addi-

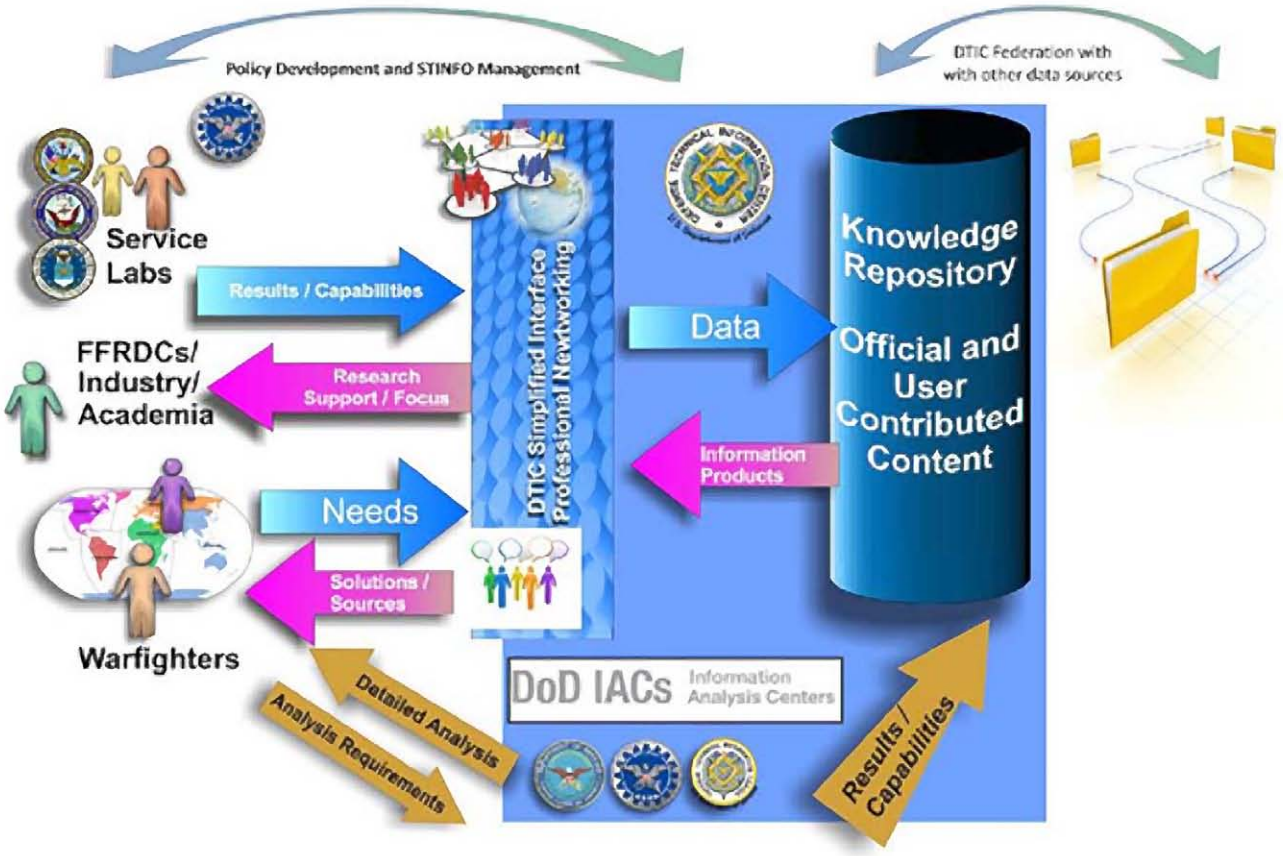

Figure 2 - DTIC Multiplier Effect

tionally, the IAC Strategic Plan provides further detail on its mission, vision, guiding principles, strategic objectives and initiatives.

Building strong internal and external relationships

Building strong relationships with Service Labs, Combatant Command (COCOM) S&T Advisors, and industry partners, while extending our knowledge repository of information and identification of subject matter experts, DTIC bridges the gap between organizational divides and provides visibility of knowledge and activities to the entire Defense enterprise (see Figure 2). This visibility accelerates a commander's ability to recognize the 75% solution by providing all known inputs for review and consideration, and helps justify the investment in 99% solutions based on current data and accurate situational awareness.

DTIC is positioned to be both a clearinghouse of information and a gathering point of DoD mission needs. For DTIC to successfully serve the Defense and S&T communities, it is imperative we understand the mission and goals of DoD and Service Labs. We have to continue our work with those organizations to determine how to best present their information, capabilities, and resources to the COCOMs and other information consumers. The COCOMs have critical operational issues for which they are seeking solutions from the S&T community. They do not, however, have the capacity to describe their specific issues to every lab and industry partner. DTIC can act as the information broker; bridging the gap by supporting not only the S&T and COCOM communities, but other information providers and consumers.

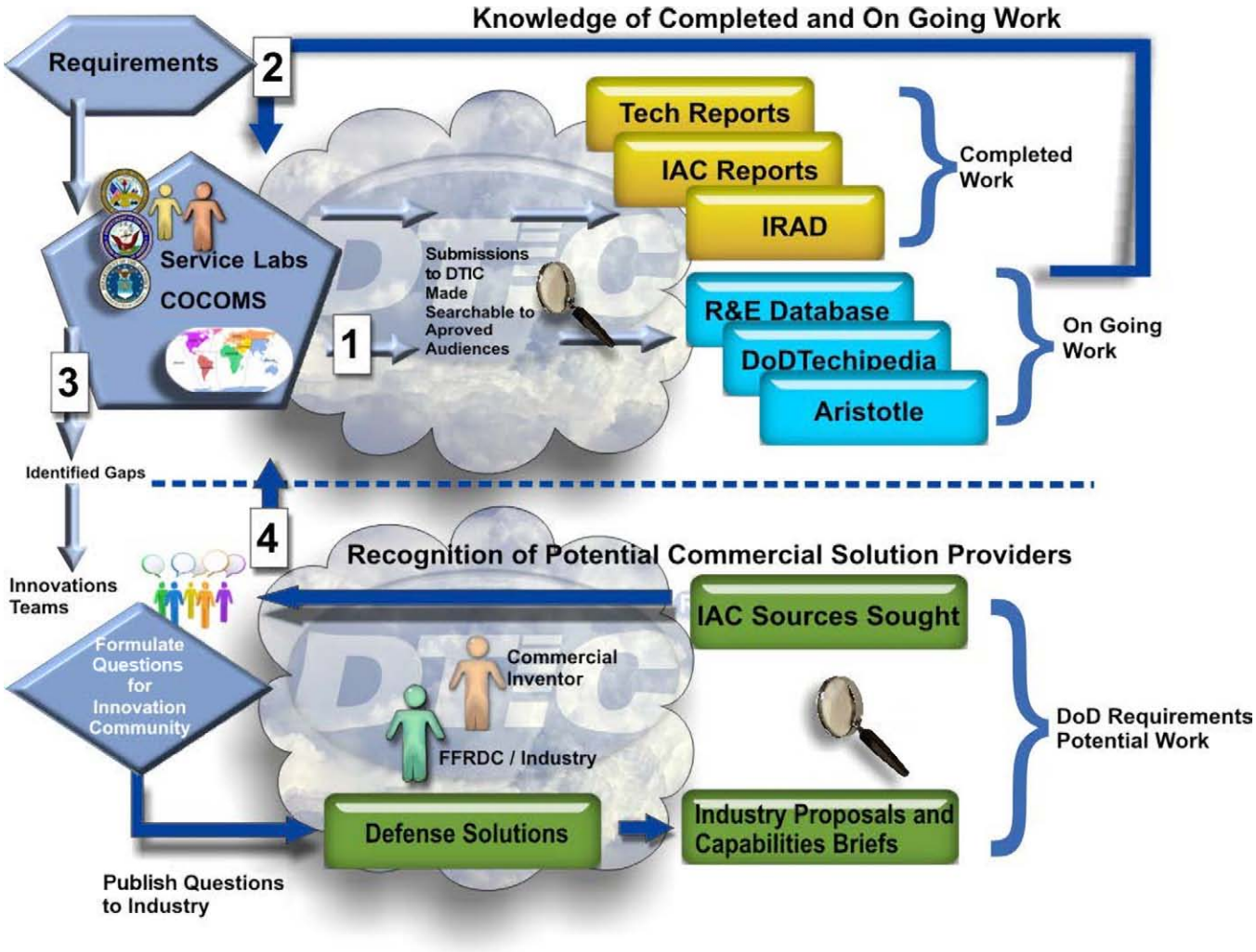

Figure 3 - Future View: Facilitating Innovation

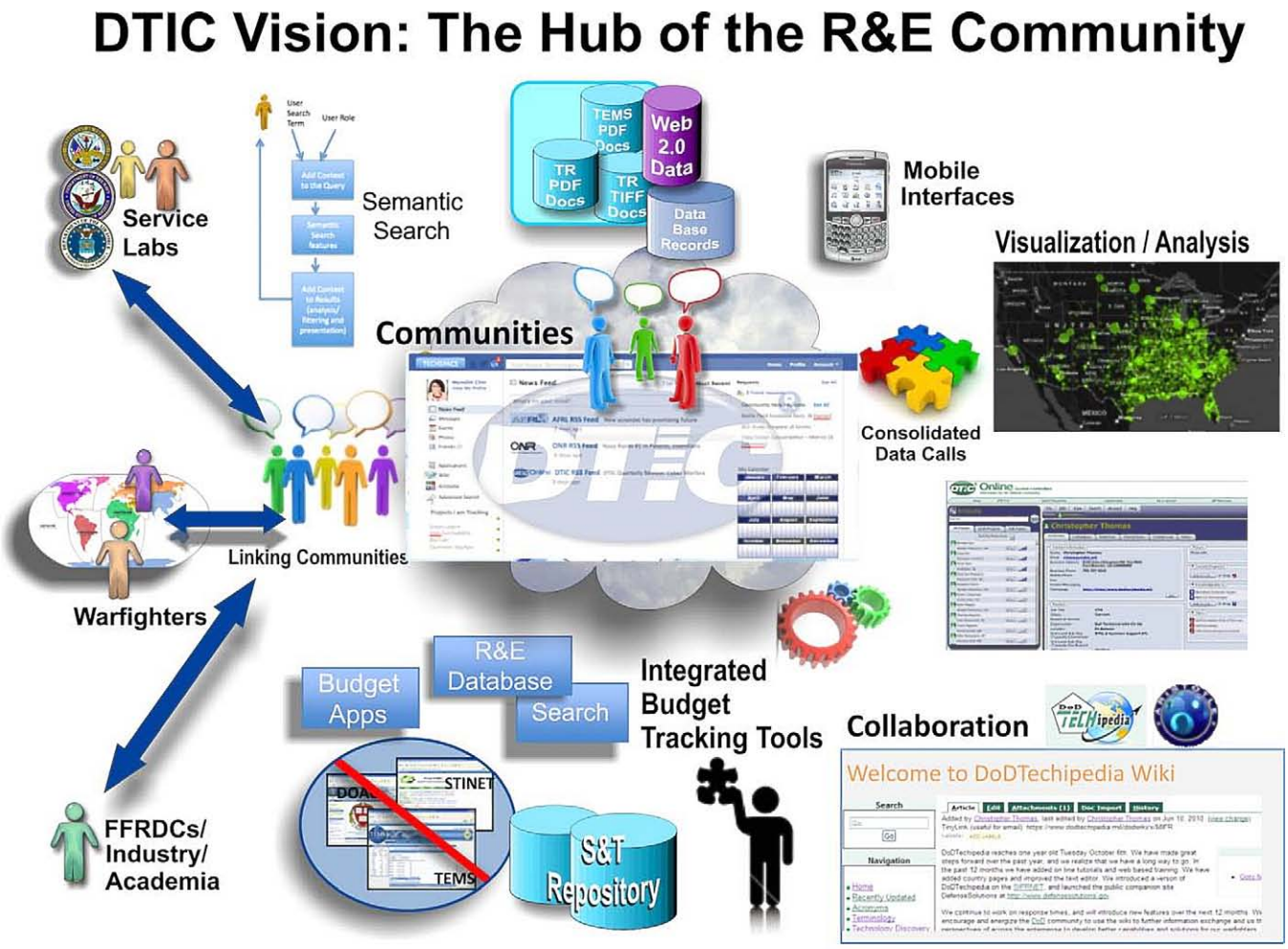

Figure 4 - DTIC Vision: The Hub of the R&E Community

Each DTIC user is both a data provider and data consumer. Information flows into DTIC's knowledge repository and is then available for the benefit of other uses – multiplying value of the work performed and the impact of the effort. Where detailed analysis is required, DTIC offers the IACs to cover key areas of DoD interest and mission need.

We recognize that S&T goes beyond the areas represented in Basic Research (6.1) – Operational System Development (6.7) and into acquisition. DTIC will look for opportunities to work with the acquisition community to develop lifecycle traceability and visibility to technical information.

Leveraging new technologies

Albert Einstein said, "We can't solve problems by using the same kind of thinking we used when we created them." The broad reach of the Internet, NIPRNET, and SIPRNET provides an opportunity to connect and interact in ways never before possible. The S&T community must leverage new information sharing and networking technologies to eliminate stovepipes and develop a new level of integration among the COCOM, acquisition, information technology, and comptroller communities. DTIC provides the technology and tools to promote collaboration, in real time, among the entire enterprise. DTIC will facilitate a new approach to innovation and problem solving by bringing all the key players together regardless of where they are located, which organization or what line of work (see Figure 3).

DTIC will facilitate innovation by (1) making DoD R&E data on completed work identifiable and discoverable; (2) allowing researchers and scientists to report and collaborate on in-progress efforts and providing this knowledge to the services, laboratories and COCOMs; (3) identifying gaps and conveying them to laboratories, FFRDCs, and industry; and (4) identifying solution providers to the DoD (see Figure 4).

Web 2.0 technologies are prevalent in all facets of government. DTIC will continue to deploy Wikis, professional

networking and relationship mapping to empower users to share knowledge, improve the understanding of issues and needs, and develop better solutions. Through our repositories, users can map relationships between historical and emerging information.

DTIC will continue to simplify information discovery through implementation of:

- full-text searching, federation with other government and open source repositories, and the use of new search technologies and concepts including semantic search
- new presentation formats including visualization to draw attention to critical elements and to filter out noise, mapping, display by user roles, adding analysis, and supporting user provided labels and tags
- new media including mobile devices

Balancing access controls with accessibility

Understanding that information is only valuable when it is accessible and timely, we will leverage identity management capabilities in the DoD and federal government to simplify access for properly vetted and authorized users, and provide immediate access to users with either authenticated Common Access Cards (CAC) or Personal Identity Verification (PIV) cards. It is critical not only to protect and share information, but to encourage collaboration and cross-pollination of research. Information assurance, security engineering, identity management, and other data protection and administrative activities must not prevent identified and authorized users from accessing information. The mechanism to identify a user must be accurate, and the determination of authorization must be immediate for DTIC to achieve our mission. DTIC will work with the Defense Manpower Data Center (DMDC) and other providers to offer the best service for our customers. Access delayed is information denied; information that will not be included in research and decision activities.

Creating efficiencies in DoD and within DTIC

We seek to support implementation of efficiencies by allowing users to focus work in the most promising areas, avoiding "known" dead ends, recognizing and avoiding unnecessary duplication of effort, and ensuring teams working on similar initiatives can benefit from each other's work. Further, we are modifying our own processes and will review our organizational structure to gain efficiencies and improve the products we provide to the DoD and industry partner communities.

DTIC sees the next five years as a time of opportunity for the S&T community and for us to increase the value of support we provide warfighters and decision makers. We recognize the need to provide products and services that add value, meet the time sensitive needs of customers and are current, relevant, and concise.

This article is approved by DTIC's Public Affairs Office and is cleared for, "Public Release/Distribution A."

A Re-use Lexicon: Terms, Units, and Modes in M&S Asset Re-use

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ABSTRACT

The Department of Defense (DoD) Live–Virtual–Constructive (LVC) Architecture Roadmap Implementation project is engaged in planning and implementing key enhancements to the capabilities, products, and processes used in the practice of Modeling and Simulation (M&S) within the department. One part of that effort is concerned with the re-use of software, data, and other assets in DoD M&S development, which has been identified by the M&S Steering Committee as an important requirement. Currently, such re-use is neither as frequent nor as effective as it could be. As a consequence, the potential benefits of re-use to the DoD enterprise are not being fully realized.

Part of the reason for this situation may be an incomplete and inconsistent community understanding of the types of M&S assets available for re-use, the range of possible ways those assets can be re-used, and the categories of repositories in which reusable M&S assets may be discovered. To address this inconsistency and to provide a firm basis for an investigation into M&S asset re-use mechanisms, a common understanding of M&S re-use terminology is needed.

A team lead by the Johns Hopkins University Applied Physics Laboratory developed a detailed lexicon of key terminology relating to M&S asset re-use Terms relating to M&S assets, re-use, and repositories were identified and carefully defined, based on existing literature and community consensus. Additionally, taxonomies of the different types of M&S assets commonly re-used during M&S development and the different modes in which those assets are re-used were developed. This paper presents all three of these re-use compendiums for future use and enhancement by the community.

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1. INTRODUCTION

This section provides background and context for the overall paper by briefly introducing the Live–Virtual–Constructive Architecture Roadmap (LVCAR) study, the resulting LVCAR Roadmap Implementation project, and the Asset Re-use task within that project.

1.1 LVCAR Implementation Project Overview

The study group of modeling and simulation (M&S) experts was asked to examine the practice of M&S within the DoD with a goal of improving the effectiveness and efficiency of developing large simulation systems, particularly those composed of models from more than one of the live, virtual, and constructive categories. The study group's report made valuable recommendations with respect to three important dimensions of simulation interoperability: technical architecture, standards, business model. Within the technical architecture area, a specific recommendation was made to "direct efforts towards creating and providing standard resources, such as common gateways, common componentized object models, and common federation agreements" [1].

The Live–Virtual–Constructive (LVC) Architecture Roadmap Implementation project, led by the Johns Hopkins University Applied Physics Laboratory (JHU/APL), is engaged in planning and implementing key enhancements to the capabilities, products, and processes used in the practice of M&S within the DoD, based on the recommendations of the LVCAR study.

1.2 Asset Re-use Task Overview

The re-use of software, data, and other assets in DoD M&S development is neither as frequent nor as effective as it could be, and as a consequence, the potential benefits of re-use to the DoD enterprise are not being fully realized. Improvements in the enterprise culture and processes

supporting re-use are needed to increase the frequency of re-use. Enhancements to the capabilities and coordination of DoD M&S asset repositories are needed to increase the effectiveness of re-use.

Within the LVCAR Implementation project, the Asset Re-use task was intended to address the need for re-use enhancements. The Asset Re-use team performed an assessment of multiple existing repositories using a carefully developed set of M&S-oriented evaluation criteria was conducted to identify where those enhancements are needed. The Asset Re-use team examined thirteen (13) existing M&S catalogs, repositories, and registries of interest to the LVCAR Implementation effort and evaluated the applicability of these and other re-use initiatives. A detailed model of LVC asset re-use mechanisms based on twenty-two (22) comprehensive re-use use cases tied to the DoD Net-Centric Data Strategy and commercial standards for repositories was developed and used to facilitate the research and analysis conducted. Consideration of the state of these LVC asset re-use mechanisms, together with feedback from stakeholders within all communities enabled by M&S in the form of questionnaires, workshop discussions, and interaction in the government-industry profession, informed this study and recommendations.

2. M&S RE-USE LEXICON

This section first explains the motivation and intent for the re-use lexicon, and then presents that lexicon as a series of definitions of re-use-related terminology.

2.1 Lexicon Motivation and Intent

Effective re-use of M&S assets can be hindered by incomplete and inconsistent community understanding of the types of M&S assets available for re-use, the range of possible ways those assets can be re-used, and the categories of repositories in which reusable M&S assets may be discovered. To address this inconsistency and to provide a firm basis for an investigation into M&S asset re-use mechanisms, a common understanding of M&S re-use terminology is needed.

Therefore, as one part of its overall task, the Asset Re-use team developed a detailed lexicon of key terminology relating to M&S asset re-use. Terms relating to M&S assets, re-use, and repositories were identified and carefully defined, based on existing literature and community consensus, with an explicit intent to define the terms as they are used generally in the LVC M&S communities in the US and internationally.

2.2 Re-use Definitions

Accreditor. A role; a person or organization that accredits assets for use and re-use for specific purposes or categories of purposes; responsible for certifying that a federation has been verified and validated [2]; authorizes the use of the federation for its intended use. Synonym: accreditation authority.

Adjunct tool. Software and/or hardware used to provide part of a simulation environment or to transform and manage data used by or produced by a simulation environment. Differentiated from model in that a tool does not model anything [3]. Synonyms: tool, support tool, utility.

Artifact. A document, unit of source code, or a data set relevant to a particular model, system, or application, but not necessarily reusable [4]. Compare to: asset (which is a collection of related artifacts).

Asset. (1) A collection of associated artifacts that together composes a system or subsystem [4]. May exist in two types: resource asset and support asset. (2) A reusable collection of associated artifacts that together composes a system of subsystem. An asset has capability or content useful beyond its original application, has been developed or enhanced to be of sufficient generality and quality to support re-use, has been approved for re-use, has been documented with pertinent metadata, and has been placed into a repository. Compare to artifact (which is not necessarily reusable), resource (which is necessarily reusable).

Catalog. (1) A system that accepts, stores, and provides access to discovery metadata for assets. (2) A system that accepts, stores, and provides access to metadata, discovery and structural, for assets. Synonym: metadata catalog. Compare to: registry (which stores metadata schemas or templates, but not metadata).

Collaboration. Work by more than one person or organization on a single project or event. May be synchronous, when the collaborators exchange information and assets in real-time through face-to-face, teleconference, or

web-enabled interactions; or asynchronous, when one collaborator posts artifacts or assets to a repository where they are later re-used by another collaborator. The latter asynchronous method is sometimes called "store and forward" collaboration.

Component. (1) A reusable software package or module that encapsulates a set of related functionality and communicates with other components via an interface [5]. (2) Encapsulated unit of software with a known set of inputs and expected output behavior where the implementation details may be hidden or unknown; it is an interchangeable element of a system that conforms to a specification [6]. Compare to: module (which has less stringent criteria), asset (a component is one type of asset).

Composability. The capability to select and assemble simulation components in various combinations into simulation systems to satisfy specific user requirements [7]. Relates to re-use in that the components being composed may be assets discovered and retrieved from a repository, and thus effective re-use mechanisms can contribute to enabling composability.

Conceptual model. (1) A model that documents those aspects of a real-world or notional system to be simulated, including entities and their interactions. May be expressed in a variety of notations, including expository text, mathematical equations, and UML diagrams [8]. (2) A description of what a model or simulation system will represent, the assumptions limiting those representations, and other capabilities needed to satisfy the user's requirements [9].

Configuration management. Recording and reporting of change processing and implementation of M&S resources.

Data model. (1) Abstract but formal representation of entities or objects (distinguishable persons, places, things, events, or concepts) about which information is kept, their properties, and relationships among the entities and/or properties. May be constructed to describe high-level or detailed concepts (conceptual and logical data models) or instantiations of data structures such as XML documents or relational databases (known as physical data models) [3]. (2) Abstract representation of the structure of data, used to define or document that structure [10]. Most data modeling methods are based on diagrammatic notations, such as entity-relationship diagrams or UML [11].

Defense Discovery Metadata Specification. A standard for discovery metadata elements for resources that have been posted to repositories [12].

Discovery metadata. Metadata that aids in the recall and retrieval of an artifact [4]. May be registered in a metadata catalog. Makes the artifact visible. Compare to: metadata (which includes other types of metadata).

Discovery services. Services that enable the formulation of search activities within shared space repositories (e.g., catalogs, directories, registries), providing the means to articulate the required service arguments, provide search service capabilities, locate repositories to search, and return search results [13].

Discovery. The process of searching, identifying, and selecting assets for re-use. Enabled by discovery metadata and facilitated by user interfaces with features that support the discovery process.

Federate. In the High Level Architecture (HLA), single application within a federation that interacts with other federates. May be a model or a tool. Synonyms: application (Test & Training Enabling Architecture (TENA)), member application (Distributed Simulation Engineering and Execution Process (DSEEP)) [14].

Federate developer/integrator. A role; a person or organization that creates reusable assets; an individual or organization responsible for integrating a simulation into the federation; responsible for ensuring the simulation is compliant with federation agreements [2].

Federation. In HLA, named set of interacting federate applications, a common object model, and software infrastructure through which they communicate that are used as a whole to achieve some specific objective [3]. Synonyms: logical range (TENA), simulation environment (DSEEP) [14].

Federation engineer/integrator. A role; a person or organization that selects, integrates, and tests federates within a federation (or in DSEEP terms, the member applications within a simulation environment), and in the process of doing so may re-use assets of various types; responsible for negotiating the majority of federation agreements between all participants; expert in the chosen middleware/infrastructure so as to resolve integration issues [2].

Federation manager. A role; a person or organization responsible for managing a federation execution, including coordinating federation participants; may be a domain subject matter expert rather than a federation engineer [2].

Federation tester. A role; a person or organization that tests (verifies and validates) an asset; responsible for establishing the test criteria to ensure that the federation is meeting requirements [2].

Gateway. A member application in a distributed simulation that connects member applications using different interoperability protocols (such as DIS, HLA, or TENA) by translating messages between protocols at run time.

Information technology support/hardware engineer. A role; a person, or organization responsible for network configuration, support software installation, hardware configuration, and troubleshooting to support a federation [2].

Interface specification. Set of structures and/or classes including properties, methods, and/or events which serve to provide a well-defined agreement for which applications (M&S software and adjunct tools), federations, components and/or services can connect and communicate [3].

Metacard. Discovery metadata for a particular asset. Often stored in a catalog (or metadata catalog).

Metadata. (1) Data about data; specification of the content, meaning, structure, and use of the data [10]. (2) Information describing the characteristics of data; data or information about data; descriptive information about an organization's data, data activities, systems, and holdings [15]. (3) Searchable data that describes the function and use of an artifact [4]. If the artifact is a model, rather than data, sometimes called a metamodel [11]. (4) Structured, encoded data that describe characteristics of information-bearing entities to aid in the identification, discovery, assessment, and management of the described entities [16]. Compare to: discovery metadata, (which is more specific), structural metadata (which is more specific).

Metamodel. (1) A model of a model; an abstraction of another model, relating more generic concepts [13]. (2) Metadata about a model [11].

Middleware. Software that connects or integrates other software modules or components, typically providing a set of communications or interaction functions that may be invoked by the linked modules [17].

Mode of re-use. A distinct method or procedure for reusing a unit of re-use or an asset. The details of the mode may vary by the type of asset (e.g., reusing a model specification may require writing new source code that implements that specification, whereas reusing a component may not require coding for component).

Model. A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process [13].

Model specification. Precise specification for a specific model which, if implemented properly, will produce anticipatable results, e.g., dead reckoning or coordinate conversion. Compare to: modeling method (which is less specific, typically larger in scope).

Modeling and simulation data. (1) Representation of real-world facts or concepts in a format usable by models during simulation. Differentiated from a model in that M&S data is generally not itself executable, but is rather input to a model that can be executed. May be operational data, data specifically derived from operational data that has been formatted or augmented for M&S use, or synthetic data created for M&S use [3]. (2) Data produced by a model during a simulation that provides a synthetic view of reality [3].

Modeling and simulation data model. A data model that describes modeling and simulation data [3].

Modeling and simulation service. A service that provides a capability useful in modeling and simulation; may or may not itself be a model or simulation [3].

Modeling and simulation software. Software that implements a model or simulation [3].

Modeling and simulation software component. A software component used as part of modeling and simulation software. May be source code, binary or byte code, or remote procedures; can be used to construct models and/or provide functionality for simulation systems [3].

Modeling method. Set of organizing principles, fundamental concepts, and common algorithms and data structures for a class of models, e.g., discrete event simulation or finite element modeling. Category of models with a common basis or modeling technique, e.g., Lanchester equations, finite state machines. Synonyms: modeling paradigm. Compare to: model specification (which is more specific, typically smaller is scope).

Module. Unit of software code that does not satisfy the definition of component, i.e., a module may not be encapsulated or may not have a defined interface. Compare to: component (which has more stringent criteria).

Net-centric environment. A framework for full human and technical connectivity and interoperability that allows all DoD users and mission partners to share the information they need, when they need it, in a form they can understand and act on with confidence, and protects information from those who should not have it [18].

Program manager. A role; a person or organization that monitors, guides, and controls development and/or re-use projects and processes; manages to schedule and budget, allocates personnel, ensures establishment and adherence to program level processes [2].

Query. A particular set of criteria and requirements that is used to search for assets during discovery. Any particular asset may or may not satisfy the query. A query may be saved, modified, and re-used.

Registry. A system that accepts, stores, and provides access to schemas or templates for metadata (discovery metadata and/or structural metadata), but not the metadata itself. Compare to: catalog (which stores discovery metadata).

Release. A specified collection of artifacts making up an asset at a fixed point in time. Typically, a release reflects an asset considered reusable [4].

Repeated use. Using a previously developed asset for substantially the same purpose or in the same context as previous uses; e.g., running another training exercise using the same federation as the last training exercise. Considered to be a special case of re-use; may not require the use of re-use mechanisms. Compare to: re-use (which is more general, allowing the use of an asset for a new purpose).

Repository. A system that accepts, stores, and provides access to assets that may be re-used. Typically includes both hardware (e.g., disk storage) and software (e.g., configuration management) aspects. May store software (components or modules), artifacts, metadata, data, or other assets. Compare to: catalog (which specifically stores discovery metadata), registry (which specifically stores metadata schemas), storehouse (which is generic for storage systems).

Resource asset. A reusable asset that has been tagged with discovery metadata. Synonym: resource.

Resource. An asset that is recognized as reusable [4].

Re-use. Using a previously developed asset again, either for the purpose for which it was originally developed or for a new purpose or in a new context. Re-use may save time, effort, or cost for development or testing. Re-use may add credibility to the new application if the asset underwent verification, validation, and accreditation for its previous use. Compare to: repeated use (which is more specific, denoting the use of an asset for the same purpose as previous uses).

Role. A related and coherent set of actions, responsibilities, and authorities which a person or organization may undertake as part of the overall process of developing a federation and/or reusing assets. One of several perspectives a person or organization may have on those processes. Re-use roles include accreditor, federate developer/integrator, federation engineer/tester, federation manager, federation tester, information technology support/hardware engineer, program manager, security engineer, sponsor, user/operator, verification and validation agent [2].

Search. (1) The portion of the discovery process where assets' discovery metadata is compared to a query to determine whether or not they meet the criteria expressed in that query. (2) A single execution of that portion of the discovery process.

Security engineer. A role; a person or organization responsible for establishing security requirements for a federation and for any facilities in which federation members are housed; responsible for security issues related to software, personnel, and storage media used in a federation [2].

Service. In a service-oriented architecture, a process or procedure with a well-defined interface that provides specific computation, interaction, or data retrieval functionality and that can be called or invoked by external users. Similar to a component, with encapsulated functionality and interface, but not available for direct integration into a software system; rather invoked via remote procedure call, web service invocation, or similar method.

Shared space. A mechanism that provides data storage and access capabilities for users within a given network space; provides virtual or physical access to any number of data sets (e.g., catalogs, Web sites, registries, classification networks, document storage, or databases) [13].

Simulation. (1) Executing a model over time [19]. (2) A technique for testing, analysis, or training in which real world systems are used, or where a model reproduces real world and/or notional systems, processes, or phenomena [19].

Simulation environment. (1) A set of interconnected M&S support elements (infrastructure) and resources used to conduct an event [3]. (2) In a distributed simulation, a set of interoperating member applications, e.g., an HLA federation or a TENA logical range [14]. (3) A generic term for the category of modeling and simulation implementation types whose specific instances are live, virtual, and constructive [20]. Synonym: modeling and simulation environment.

Sponsor. A role; a person or organization that provides programmatic support to the development, maintenance, or use of assets; an individual or organization for which a federation is being developed, likely responsible for funding and contract issues [2].

Storehouse. Generic term for a storage system; includes repository, catalog, and registry.

Structural metadata. Metadata that documents the internal characteristics of an artifact [4]. May include name, description, data constraints, and tag relationships. The HLA OMT standard is an example of structural metadata, where the data described is an HLA object model; an HLA object model is itself structural metadata with respect to a specific run-time set of objects and their attribute values. Makes the artifact understandable. Synonym: resource metadata. Compare to: metadata (which is more generic).

Support asset. An asset that is of value to the community, but is not a unit of re-use, and is not normally tagged with discovery metadata.

Unit of re-use. A specific, identifiable, and bounded unit that can be searched for, discovered, selected, and re-used. May be a concept set (e.g., modeling method), a unit of software (e.g., a component or module), a service, or a data set. Synonym: resource. Compare to: asset (which is not necessarily reusable).

User/operator. A role; a person or organization responsible for running a simulation during integration, testing, and execution [2].

Verification and validation agent. A role; a person or organization responsible for verifying and validating an asset or federation. [2].

3. UNITS OF RE-USE

This section introduces the notion of units of re-use, and provides definitions and examples of those units.

3.1 Introduction to Re-use Units

M&S assets of different type, such as models or data, may be re-used. Even within a single type, the scope or size of the re-used asset is quite variable. Consider reusable source code assets; such assets may be classes, modules, libraries, federates, and more, and any of these can be usefully re-used in a suitable context. We define a *unit* of re-use as the size and nature of the reusable asset.

3.2 Definitions and Examples

Table 1 and Table 2 provide definitions and examples of units of re-use among reusable assets. In these tables, units of re-use are organized into two types and listed. For each unit, the form in which that unit is expressed is stated, examples are identified, and explanatory comments are provided.

4. MODES OF RE-USE

This section introduces the notion of modes of re-use, and provides definitions and examples of those modes.

4.1 Introduction to Re-use Modes

Reusable M&S assets may be re-used in different ways. This may be dependent on the unit of re-use, i.e., a source code module will be re-used in a different way than a terrain file. However, in some cases even a single unit of re-use may be re-used in different ways in different circumstances. We define a *mode* of re-use as way, or method, a reusable asset is re-used.

4.2 Definitions and Examples

Table 3 provides definitions and examples of modes of re-use among reusable assets. In the table, modes of re-use are related to when in the system development process that mode is used. Table 4 cross-references the modes of re-use with the units of re-use to which the modes apply.

5. FINDINGS AND FUTURE WORK

Employment of a common and consistent vocabulary was important to the work of the Asset Re-use team of the LVCAR Implementation project, and development of a lexicon document substantially facilitated that common usage. In the process of developing the lexicon, the most "controversy" (the term is used with some exaggeration) arose with respect to two items: First, regarding the correct definition of the crucial term *asset,* the lexicon's definition, which defines an asset as a collection of multiple artifacts, was neither unanimously agreed upon nor consistently employed in that sense by the Asset Re-use team members; asset was often used in a singular sense, to refer to a single artifact, rather than a collection. Second, regarding the set of possible *re-use roles,* there was an alternative set of role names developed that has fewer HLA-centric terms; that list was not included in the lexicon for consistency with other LVCAR Implementation efforts. Despite these issues, the lexicon was of considerable value to the task. Recommended future work includes expanding the lexicon to add additional re-use-related terms and seeking additional definition sources to corroborate (or revise) the definitions listed. Additionally, there may be value to including the lexicon within the scope of the SISO Repository Study Group and defining it as a SISO product in that context.

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Table 1. Units of Re-use (Part 1 of 2).

TYPE	UNIT	EXPRESSED AS	EXAMPLE(S)	COMMENT(S)
Model	Component	Source code Object code	Network interface Event queue class Java library classes	Reusable software package that encapsulates a set of related functionality and communicates with other components via an interface. Encapsulated unit with a known set of inputs and expected output behavior where the details may be hidden or unknown. An interchangeable element of a system that conforms to a specification. AKA package or module, but compare to **Module**. Within one or more but not necessarily all federates in a federation; compare to **Middleware.**
	Module	Source code	Search algorithm Coordinate conversion	Reusable "chunk" of code that does not satisfy definition of Component, i.e., not encapsulated, no defined interface. May be re-used via "copy and paste". Compare to **Component.**
	Middleware	Source code Object code	RTI TENA middleware MATREX	Within all federates in a federation; compare to **Component.**
	Standalone model	Source code Object code	Workforce model Most CFD models	Complete implemented model that will execute as-is, e.g., an Arena model of an assembly line. Analogous to a federate but not interoperable.
	Federate	Source code Object code	Gateway OneSAF JTLS	Complete federate, reusable without modification, though it may be modified.
	Federation	Source code Object code	EnviroFed	Existing Federation rerun for new exercise or experiment. Data (e.g., scenario) may change from earlier uses.
	Service	Source code Object code	Web validation service	Similar to a component, with encapsulated functionality and interface, but not available for integration; rather invoked with RPC, web, SOA, GIG, etc.
	Modeling method (or paradigm)	Text UML	Discrete event Monte carlo Lanchester equations Finite state machines	Set or organizing principles and common algorithms and data structures for a class of models. Category of models with common basis. Concepts and structure re-used, but model(s) reimplemented.
	Model specification	Text UML	Dead reckoning models Radar return equation	Precise specification for a model that, if implemented properly, will produce anticipatable results.
	Conceptual model	Text UML	Various	Single conceptual model may have multiple implementations. Conceptual models may be modified and/or composed.

Table 2 Units of Re-use (Part 2 of 2)

TYPE	UNIT	EXPRESSED AS	EXAMPLE(S)	COMMENT(S)
Data	Terrain file	Custom binary XML	OTF JNTC CTDB Ft. Knox	The unit here is the specific terrain file, not the file format.
	Performance data file	Custom binary Text XML	Ph/Pk tables	The unit here is the specific performance data file, not the file format.
	Other data files	Custom binary Text XML	Various	Potentially reusable data files come in a variety of categories: Configuration file, Scenario file, Visual model file, Symbol/Icon file, …
	Data model	HLA OMT ER Diagrams UML	RPR FOM Various BOMs TENA data model	The unit here is the data model, i.e., the structure of the data, not the actual data values. Could be categorized as type **Model**, rather than type **Data.**

Table 3 Modes of Re-use

MODE	WHEN	DESCRIPTION
Use method	Design	Implement model using concepts and conventions of modeling method.
Follow specification	Implementation	Implement model using details of model specification.
Integrate source	Compile	Integrate source code component/module/middleware unchanged into a body of source code.
Link object	Link	Link object code component/middleware into a body of object code.
Modify source	Implementation	Make modifications to a source code re-use unit, then re-use as appropriate for the unit.
Modify data	Execution	Make modification to a data re-use unit, then re-use as appropriate for the unit.
Use as-is	Execution	Re-use unit unchanged.
Invoke service	Execution	Invoke or call re-use unit offered as service via RPC, web, SOA, GIG, etc.
Use method	Design	Implement model using concepts and conventions of modeling method.

Table 4. Re-use Units x Modes

UNITS	MODES							
	USE METHOD	FOLLOW SPEC	INTEGRATE SOURCE	LINK OBJECT	MODIFY SOURCE	MODIFY DATA	USE AS-IS	INVOKE SERVICE
Component			X	X	X		X	
Module			X		X		X	
Middleware			X	X	X		X	
Standalone model					X		X	
Federate					X		X	
Federation					X		X	
Service								X
Modeling method	X							
Model specification		X						
Conceptual model		X						
Terrain file						X	X	
Performance data file						X	X	
Other data files						X	X	
Data model		X					X	

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The Modeling and Simulation Catalog for Discovery, Knowledge, and Re-use

The Modeling and Simulation Catalog for Discovery, Knowledge, and Re-use

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ABSTRACT

A key to fulfilling the DoD Net-centric Vision is Discovery. "Guidance for Implementing Net-Centric Data Sharing" (DoD 8320.02-G) defines it as the ability to enable consumers to find out who is responsible for specific assets, where the assets are located, what kind of data is available, and how to go about accessing them. Often the focus is on a search tool or website. However, there are associated efforts to create and maintain the metadata, processes to ensure connectivity and business models that support the entire process that must be in place to create the environment needed to make the search engine successful. If you or your organization creates a product that has the potential to be made available on the GIG, you will be involved.

Multiple locations throughout DoD contain metadata about tools and data. The M&S Catalog provides a portal to discover and access M&S metadata maintained at nodes distributed across DoD networks in a centrally managed, "de-centrally" executed process that employs metadata collection and management. The intent is to link information stores and thus preclude redundant location updating. The M&S Catalog uses standard metadata schemas based on the DoD's Net-Centric Data Strategy Community of Interest (COI) metadata specifications. A major schema supporting discovery and re-use is the DoD M&S COI Discovery Metadata Specification (MSC-DMS), promulgated by the DoD M&S Coordination Office (M&SCO) and used by the M&S Catalog. The MSC-DMS is designed to address the Net-Centric Data Sharing Strategy for the M&S COI. It is an Extensible Markup Language (XML) schema of key elements of information needed to describe M&S resources. The M&S Catalog project regularly uses the MSC-DMS and submits recommendations for its improvement.

The M&S Catalog supports source providers and user queries on DoD tools, available data, and activities (e.g., AoAs, studies) supported by the tools. Currently we have 16 sources of data including: Army, Air Force, MSIS, Navy and others that have provided 7,101 initial records of information, but plans on the horizon are being made to bring in hundreds of source providers. The catalog's requirements are based on interviews with leadership, managers and technical personnel in the communities and services supported by M&S. The M&S Catalog discovery service was updated greatly this year so that DoD CAC users can access information via a powerful COTS search engine enterprise suite. Some of these new features include 1) automated facetted search selections guided by community tailored taxonomies, 2) key word search across the metadata or within subsets of tools tailored via the facetted selections or within a specific metadata element, 3) key word search using a Federated search with DoD Enterprise Catalog, 4) user-guided output formats and, 5) search results analysis tools.

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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1. INTRODUCTION

In order to manage and employ Modeling and Simulation (M&S) capabilities effectively across the Department of Defense (DoD), senior leaders and managers must have visibility into the DoD's M&S portfolio. Establishing visibility into M&S resources across the DoD enterprise is one of the goals of the DoD Net-Centric Strategy. This effort is totally dependent on the descriptions and contact information (metadata) being posted in a common format on the Global Information Grid (GIG). Knowing which tools and data exist along with descriptive information concerning its relevance, is vital to ensuring that organizations supported by M&S can find the tools that meet their requirements, or determine the need to develop capabilities that fill identified gaps. This visibility is established through a discovery process that has, at its core, a powerful and agile search capability. The DoD M&S Steering Committee commissioned the creation of the DoD M&S Catalog to establish this search capability for organizations that are supported by M&S. The DoD M&S Catalog is further supported through the Modeling and Simulation Coordination Office (M&SCO) Core activities as part of the DoD M&S Enterprise Tools.

The M&S Catalog is a web-based discovery service that provides a "card catalog" level of detail about M&S tools, data, and services. The DoD M&S Catalog can be found at **https://MSCatalog.osd.mil.** By ensuring the metadata of their products is captured in the M&S Catalog, managers can expand their visibility and user base. Those organizations that use or are supported by M&S will have access to existing tools, data, and services.

2. M&S CATALOG

2.1 Background

The search tool capabilities selected for the M&S Catalog were guided by interviews with senior leaders, users, and technical personnel in the communities that participate in the M&S Steering Committee. The intent was to make the search tool as intuitive and as effective as possible. It is designed to guide a user quickly to a manageable set of alternatives to evaluate.

The resulting visibility into the M&S world will provide significant benefits throughout DoD. Resource owners can use the catalog to establish themselves as an authoritative source in their field, engage in collaborative efforts with joint services, and promote re-use and visibility. Resource seekers can rapidly find what they need and identify potential cost avoidances by discovering existing efforts. The department will achieve better resource management by ensuring resources are not applied to create existing capabilities, but instead focus attention and resources on areas that lack capabilities.

2.2 Sources

The key to the value of the M&S Catalog is the breadth and accuracy of the information it contains. A significant effort is being under-taken to encourage organizations across the DoD enterprise to integrate the information about their products within the DoD M&S Catalog. Metadata can be accepted from a collection, such as a Service M&S Resource Repository (MSRR), the DoD Modeling and Simulation Information System (MSIS), or directly from the manager of a product. To maintain a high level of motivation to keep information current, the vision of the DoD M&S Catalog is to interface as closely to the origin of the metadata as possible.

While many organizations have expressed an interest in providing metadata to the DoD M&S Catalog, often there are limited resources with which to produce and transform metadata. It has become apparent that the level of effort placed on the source organizations must be as minimal as

possible to enable their participation. Providing tools and processes to aid them will not only increase the likelihood of the metadata integration, it will also support consistency in the metadata content and format.

2.2.1 Types of sources

Discoverable items span a wide range of products throughout the M&S domain and its communities of interest. These products include any resource that can be used to support an M&S effort. At a top level, they can be divided into:

1. Services – Organizations that can provide design, development, or analysis support.
2. Tools – Software and hardware to support models and simulations.
3. Data – Data the model or simulation requires.
4. Subject Matter Experts – Domain experts that can provide guidance on the selection of model parameters, problem specific data, and/or validation for models.

3. DISCOVERY PROCESS

"Discovery" is the ability to locate data assets through a consistent and flexible search. The DoD Net-Centric Data Strategy [1], [2], [3] defines goals and approaches that allow users and systems to find and access a wide-range of data assets throughout the DoD enterprise. A successful net-centric data environment depends on the ability of users and systems to locate and access data assets through a consistent and flexible search, or discovery capability.

The discovery process starts when an organization or developer begins to generate a new M&S product or capability, and it is enabled by the creation of metadata about that product or capability. The process requires that metadata be in an electronic format and accessible to some type of search tool or mechanism through which potential users can find the metadata and access the product or service. The steps associated with the discovery process (Figure 1) are:

1. Producer creates metadata with all new products
   a. Product creation
   b. Metadata creation
2. Producer makes metadata electronically accessible to M&S Catalog
   a. Metadata electronically accessible
   b. Integration between search tool and electronic metadata
3. User accesses the M&S Catalog to search for applicable metadata
   a. Access to the search tool and search results
   b. Access to product or service metadata
4. User reviews resulting metadata in order to find the optimum product to meet requirements
   a. Access to product or service

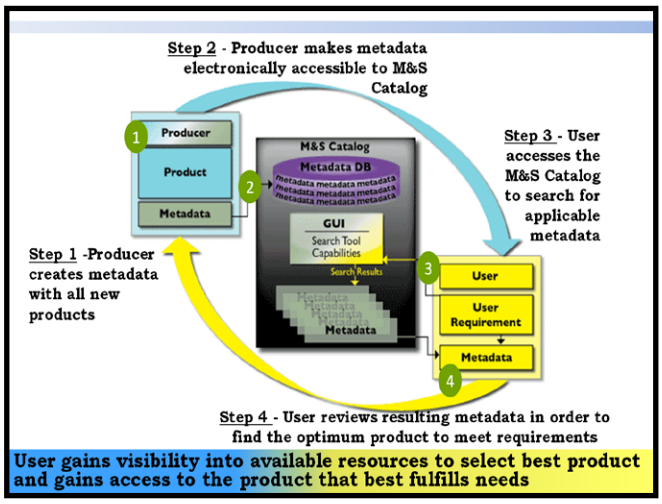

Figure 1: Discovery Process

4. METADATA

If organization and project managers are not aware of a product or capability, they cannot use it. In order for a product to be discovered, information about the product must be available to enable the discovery process. In search terminology, this data is referred to as discovery metadata. Additionally the value of a product and its applicability to a requirement will not be understood if the metadata does not accurately describe the product.

4.1 M&S Community of Interest Discovery Metadata Specification (MSC-DMS)

An element of the DoD Net-Centric Data Strategy [1] is the formation of communities of interest (COI) to address data exchange issues common to that community. One of the tasks of a COI is to establish a common specification for

the discovery metadata to be used within that community. The community discovery metadata specifications (DMS) are to use the DoD Discovery Metadata Specification (DDMS) [4] as a foundational specification and add those metadata elements that are required for the community to accurately describe their products. The M&S COI (MSC) Discovery Metadata Specification (MSC-DMS) [5] specifies the set of information fields that are to be used to describe M&S tools, data or services which are to be made known to the enterprise. It serves as a reference for metadata associated product developers, architects, and engineers.

4.1.1 MSC-DMS M&S Catalog Association

The early design requirements of the DoD M&S Catalog recognized the importance of aligning the metadata used in the M&S Catalog with the standards being established in the DoD enterprise, and specifically within the M&S Community. Since the DoD M&S Catalog is the primary project currently using the MSC-DMS, there has been close coordination between the teams developing each.

Early in the first year of the M&S Catalog project, the development team reviewed and improved on a mapping from the individual Service MSRRs to the MSC-DMS. The team made many suggestions for improvements to the MSC-DMS and these changes were incorporated into later versions of the MSC-DMS. There has been ongoing coordination between the two teams to ensure that the development of the M&S Catalog and MSC-DMS remain aligned.

4.1.2 Integration Process

Metadata that is not accessible has no value for discovery. The intent of the M&S Catalog is to allow search mechanisms to find information and capabilities via a discovery process. This requires capturing the metadata electronically and providing electronic access to it.

One of the lessons learned from the first two phases of the M&S Catalog process was that it is unreasonable to expect all sources to generate metadata in MSC-DMS-compliant XML file format. While some sources have sophisticated skills and can generate whatever is asked, others have only lists kept in spreadsheets or in document form and have only limited data-manipulation capabilities. As Figure 1 illustrates, metadata is essential to the entire process of discovery. It is more important to get the metadata than to demand pristine file formatting. The M&S Catalog must be flexible in the format of the metadata it accepts. While the early efforts aligned strictly to the MSC-DMS metadata elements and associated XML schema file format, the new COTS tool has more flexibility in the formats that can be ingested into the M&S Catalog. Metadata sources are being mapped and transitioned to the M&S Catalog in as close to the source organizations metadata storage format as possible.

4.1.3 Organizational Tasks to Integrate in M&S Catalog:

In order for the discovery process to be successful, organizations will need to make the products and services they provide visible to the web. This will require some level of effort for the producing organization. A high level summary of tasks for the organization must:

1. Determine what resources to integrate
2. Develop or locate metadata for those products
3. Work with the M&S Catalog staff to establish metadata in electronically accessible location
4. Coordinate effort with the M&S Catalog staff to map metadata to M&S Catalog data model
5. Establish business model to ensure metadata accuracy and currency

4.1.4 Metadata Creation Tools

If possible, the level of effort required to develop metadata for a product should be minimized; tools should be used to enable metadata production. Tools could vary from a form that the metadata creator uses to manually input the metadata, to a semi-automated system that pulls the metadata from recognized standard formats and requires manual completion, to a fully automated system that generates the metadata from established formats, semantic analysis, or wiki tags. The automated tools should produce metadata elements in compliance with the community MSC-DMS. They can standardize outputs and reduce typographical errors, which provides a more uniform and consistent product. The more automated the process, the more likely it is that the metadata will be generated.

Recognizing the benefit in overcoming the barriers to metadata development, maintenance and integration with the DoD M&S Catalog, part of the current effort is to develop a first generation of metadata generation

tools. This will start with tools to transform the source organization's metadata into a format that can be ingested directly into the M&S Catalog. The ultimate goal is a set of tools that will enable the collection, electronic compilation and maintenance of metadata, accessible to the M&S Catalog.

4.2 How the M&S Catalog Fits into the Discovery Process

The DoD M&S Catalog is the discovery metadata search mechanism to interface between the producers and consumers. The metadata that is accessible through the M&S Catalog and the functionality of the discovery tool will determine how well a user can find the product that best meets their needs. The metadata format within the M&S Catalog needs to contain the elements that the community uses to differentiate the products they use. The user interface and the flexibility of the search tools will have a positive impact on how quickly the users are connected to their requirements, saving both time and resources. The design, format and content of all other elements of the discovery process must integrate smoothly into the M&S Catalog in order for the process to function well.

4.3 M&S Catalog Current Phase

The current phase of the M&S Catalog builds on the experience of the earlier phases, both in the user interface and, more importantly, in the discovery process as a whole.

4.3.1 Capabilities

Based on lessons learned from the earlier phases and the requirements generated from interviews with the M&S Steering Committee members, it was decided that the third phase of the M&S Catalog project would migrate to a COTS tool that offered a good fit to the desired capabilities. Market research was conducted, the offerings of several vendors were compared, and finally the Endeca Information Access Platform was selected and acquired. The current phase of the M&S Catalog now offers:

- Keyword Search – It provides results for any record that contains that keyword in either the description or the set of terms extracted from various properties (i.e., description, background, keywords, etc.). There is no context to the result, just the existence of the word or words. Once a search has been initiated, the option appears that allows a subsequent keyword search to either be of the current results set (by selecting "within results") or to go back to search the entire database. Facetted Search – Dynamically guided navigational search offering selections based on community driven taxonomies. Each subsequent selection searches within the previous results. Previous selections can be removed individually. This allows the user to create their own taxonomy through the metadata elements they select. (Figure 4 & 8)
- Concept Cloud Search – The "Cloud Search" is based on a term extraction function that pulls re-occurring words and phrases from the unstructured text found in properties, such as description and background. The term extraction assigns the terms found to the record as a property. The larger the font, the more frequent that term appears in the result set. Selecting a word or phrase from the cloud search will act in the same manner as selecting a property in a facetted search. All records of resources from which the term was extracted will be a part of the results set. This capability is in essence providing a set of common keywords that are in the results set. (Figure 6)
- Cluster Search - The Cluster Search function groups resources based on common terms within the set of terms extracted from the resource unstructured text. Upon selecting one of the groupings, the results will be a set of records that have all of the terms or phrases. This search capability provides some context to the terms extracted from the unstructured text through the relation to the other terms. (e.g., "tank" in relation to "tracked" as opposed to "fuel" would indicate it is referring to an armor ground vehicle). A selection would remove from the results set any resource record that did not have all of the terms in the cluster. (Figure 7)
- Federated Search – The Federated search is a function where the DISA Enterprise Catalog is searched simultaneously with the M&S Catalog. By selecting the "Include Federated Search" option while "Keyword" searching the results will be displayed under "Federated Search" (Figure 9)
- Flexible support of different source metadata structures, including unstructured documents.
- Support of quantitative analysis on the search results (e.g., how many tools deal with air-to-air by source organization) (Figure 5)
- User determined search result format – the user selects the metadata elements to be displayed in the search results

Another lesson learned was the need to go beyond the concept of "targeted search", in which the user looks for something with specific attributes, known in advance. It is necessary to support more general discovery, in which the user begins with broad ideas (e.g., aircraft) and narrows the focus based on initial results (e.g., "aircraft" includes helicopters, UAVs, fixed-wing transports, fighter jets, etc.).

Some of these features are illustrated below.

Figure 2 shows the opening screen, the only screen available without a Common Access Card (CAC) or Public Key Infrastructure (PKI) Certificates. This will give the user general information on the M&S Catalog. Along with a way to contact to the M&S Catalog Staff under "contact us" on the left hand side of the screen.

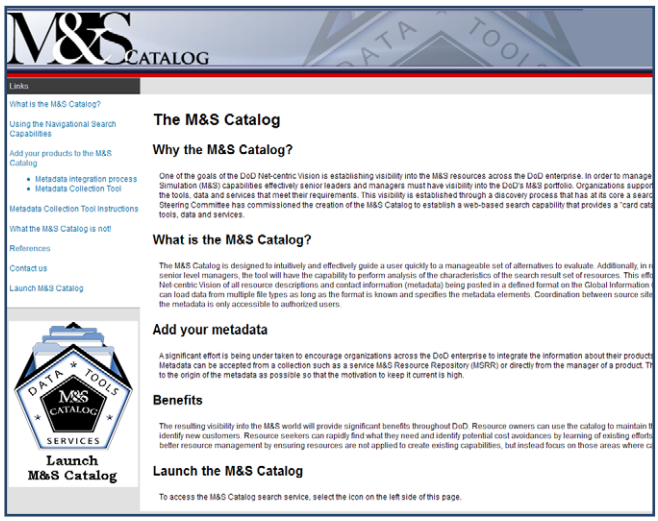

Figure 2 - Opening Screen

Figure 3 is the Main Search screen. At the very top is the keyword search block which can be used at any time in the navigated search process. In the upper center section are the facetted search categories (enlarged in Figure 4). The analytic graphics are in the upper right-hand corner with the cloud term/phrase analysis below it. In the center are the user-format selected metadata records.

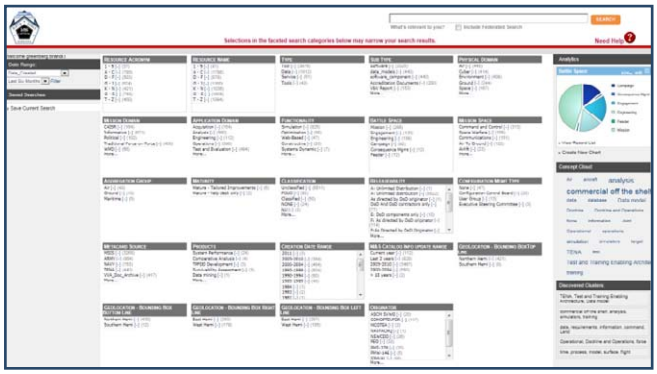

Figure 3 - Main Search Screen

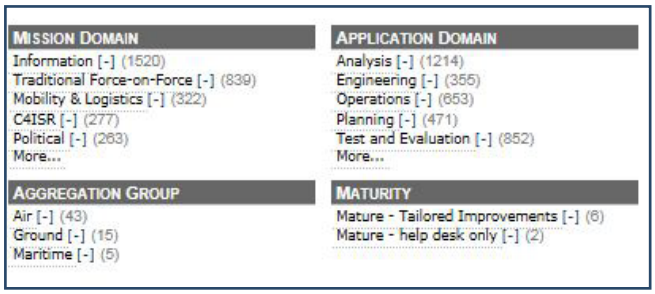

Figure 4 - Facetted Search Screen

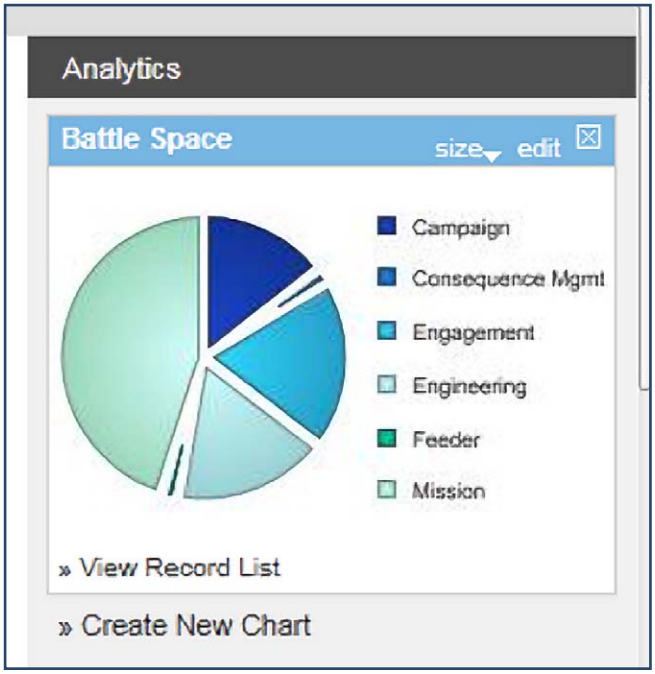

Figure 5 - Analytics

Figure 6 - Concept Cloud

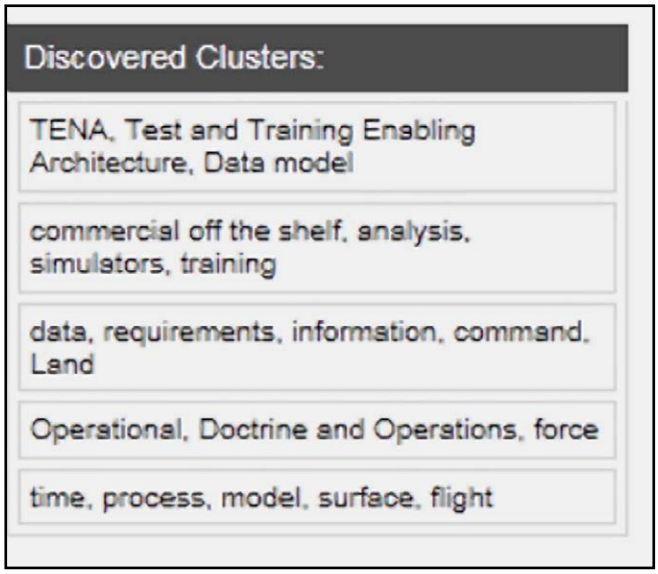

Figure 7 - Clusters

Figure 8 shows the selection history (breadcrumbs) as seen in the upper left hand corner. The user can de-select any previous selection made by clicking on the "X" next to the filter. A particular set of search parameters can be saved for quick access in future using the "Save Current Search" option.

4.4 Benefits

The M&S Catalog offers multiple benefits. Producers and end-users benefit from a business standpoint. Additionally, there are technical benefits from the way the M&S Catalog is implemented.

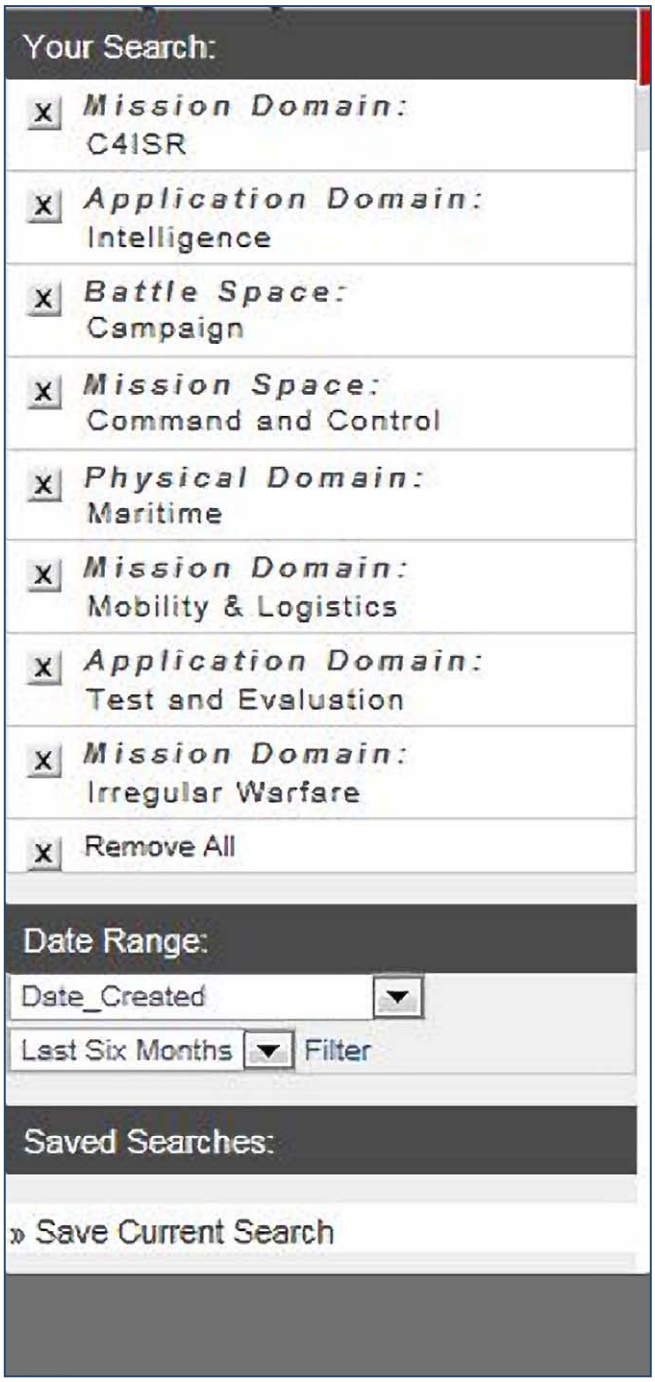

Figure 8 – Breadcrumb selections

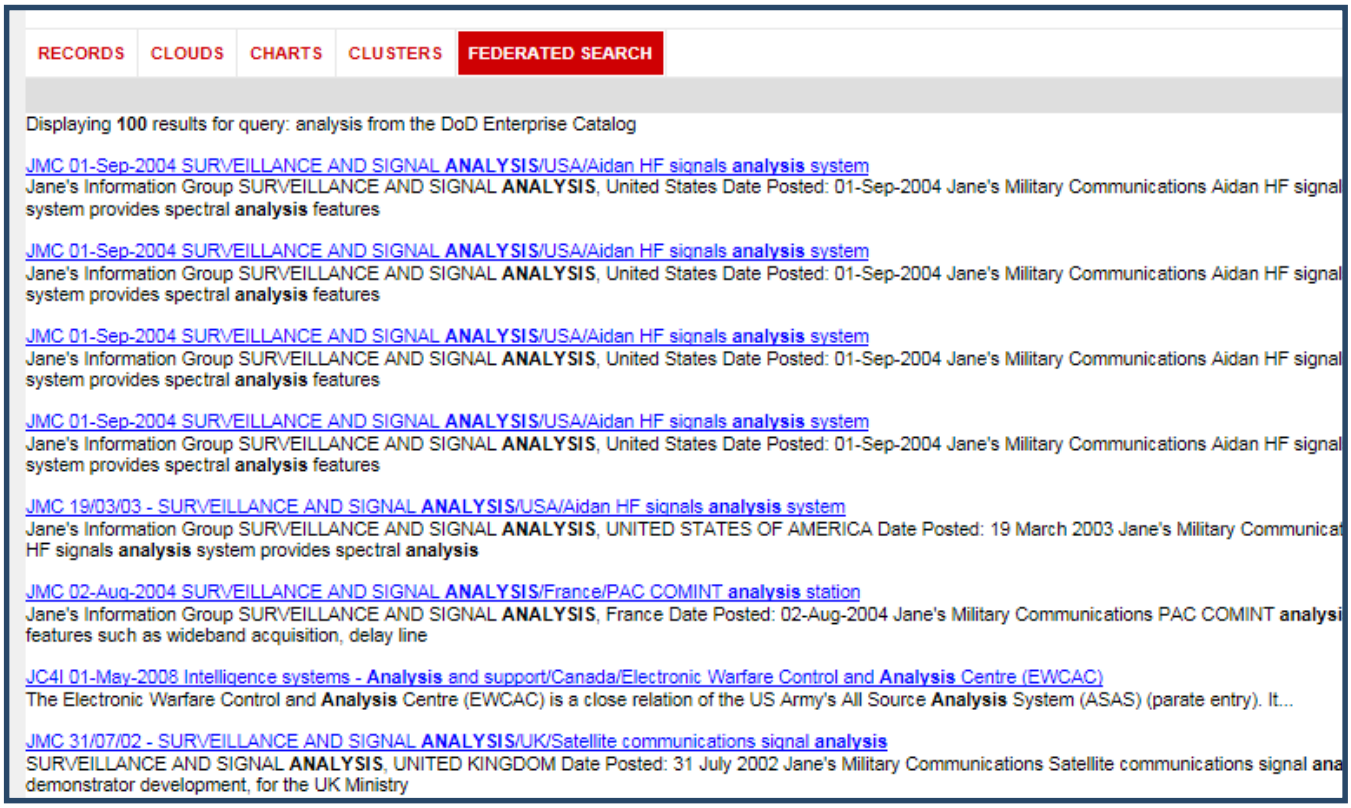

Figure 9 - Federated Search Results

Producers

- Enable interoperability of tools and data formats and methods
- Establish authoritative standing
- More users for their products
- Greater benefit to DoD on investment

Users – Leadership and analyst/technician

- Improved management of M&S resources across the enterprise
- Rapid access to needed data, tools, or services
- Reduced costs and time in fulfilling requirements
- Ability to re-use and build on existing vetted products

Technical

- Common discovery metadata schema
- COTS upload for all file formats
- Web-based, enabling access (even from locked-down workstations)
- Ability to accept metadata push enables network protection

4.5 Impediments

There are impediments to an effective and automated discovery process. These include the resources required to produce, maintain and support access to metadata. Policies, priorities and leadership direction are critical to ensuring the paradigm changes required to establish the business models to support discovery. The balance between information assurance protections and the Net-centric vision of automated access to information throughout the DoD enterprise is another potential barrier. As the discovery process is developed and implemented, impediments will be revealed that will have to be overcome through governance (policies, direction and priorities established by leadership). Impediments noted include:

1. No one has the responsibility of overseeing metadata creation or accuracy
   a. Funding responsibility can be difficult to assign to a search tool in an enterprise effort
2. There is insufficient motivation to create the metadata
3. The creation and maintenance of this metadata can require a level of effort that is often not adequately resourced
   a. Tagging of the individual metadata elements or the actual instance of the metadata
   b. The manual mapping of the search tool search elements to the metadata files

c. Manually transition into a specific XML format

d. Collecting the latest metadata for products that have imbedded metadata

e. Maintaining a website

f. Maintaining documentation and configuration management

4. Products that are not electronic have no automated means to create and link metadata

5. The metadata schema may not include the metadata element that best describes the unique aspects of the product

6. Information assurance designed to protect the data and extra level of precautions will serve as an impediment to connecting the source sites and search tool, and also preclude non-established individuals (US Government Agencies, partnering academic institution, off-site contractors and non-CAC enabled locations) access to the metadata

   a. New firewalls or other information assurance measures can block previously established permissions

   b. Tendency will be to assign a higher level of access to all metadata instantiations

   c. Hesitancy to accept other PKI identification

   d. Additional resources may be required to allow access by authorized but unregistered personnel

7. Concern about miss-use of their products outside of a controlled group of users

8. Logistical impediment due to networks for each classification level

9. Collection of unclassified metadata that reveals classified information

4.6 Future Efforts of the M&S Catalog Project

In the coming months, efforts in the M&S Catalog project will be aimed at improving the capabilities of the tool itself, improving the data model used by the M&S Catalog, continuing outreach to sources (both new and current), development of metadata creation and transformation tools to enable source organization metadata efforts and search federation with other search engines.

DoD-relevant taxonomies were important in previous search tools because of the rigid structure of the search capability. The facetted search capability (presented in Figures 5 and 9) allows the user to develop their own path to the resources that meet their requirements. In essence, it allows the user to develop their own tailored taxonomy that is relevant to the particular resource requirements that guide their search. The complex taxonomies found in each community are driven by search criteria or different descriptions. As the organizations providing metadata and user search criteria increase, the number of facetted search categories may grow significantly. Placing all supported facetted search selections on one screen would reduce the usability of the M&S Catalog. These facets will roll up under specific headings which will enable more searches.

Different user interface pages can be developed with subsets of the facetted search options. The community taxonomies will be used to guide the determination of what facetted search selections will be listed on each user interface page.

In the search for pedigree, often the best input is from other experienced users who have used a resource. The M&S Catalog is considering adding a capability that allows users to rank and comment on resources. Additionally, experienced users often can be a great resource for new users to determine the best methods with which to access or use a particular tool, data source or service. In order to take advantage of sharing ideas and experiences, a forum capability can possibly be added to the M&S Catalog.

As stated earlier, the expansion of sources and users may increase the metadata elements necessary to accurately differentiate between resources. In order to be able to develop tools and processes to integrate with the M&S Catalog effectively, a data model that defines the metadata elements reflected in the M&S Catalog will be developed. The metadata elements will be aligned with the MSC-DMS metadata elements where applicable. New metadata elements that cannot be mapped to the MSC-DMS will be submitted for addition to the MSC-DMS.

The number one priority of the M&S Catalog for the remainder of 2011 is increasing participation by sources. Our efforts include outreach to the sources themselves, recruitment of senior leadership of the DoD communities enabled by M&S, and assistance to sources that want to participate. Such assistance includes development of tools

to assist in metadata creation and maintenance, mapping to the M&S Catalog data model and electronic interface with the M&S Catalog.

Finally, currently slated work includes federation with other search engines. The DoD Data net-centric Vision established the DDMS as the common discovery metadata for federated searches. The M&S Catalog metadata must be exportable in a DDMS identifiable format. Additionally, the M&S Catalog must be capable of accepting DDMS formatted search queries.

5. SUMMARY

Visibility into the resources available across the DoD enterprise has become a high priority. This is not just in the communities supported by M&S but throughout senior leadership as indicated by the DoD Data net-centric Vision [1], [2], and [3]. At the core of that vision is the creation and electronic access to key information about organizations and their products or their services. In order to achieve the DoD enterprise net-centric vision, a discovery process must enable visibility into that key information or metadata. The M&S Catalog has been developed as a discovery search service that will provide visibility into the communities that are supported by and support M&S efforts.

The M&S Catalog is in an initial operational capability level of maturity as it continues to gather metadata from new sources and refines the metadata that is being collected from current sources. Tools will be developed to minimize the level of effort required on the part of the source sites to create, present and maintain metadata for their products and services. During the process of integrating more sources sites, there will also be improvements in the user interface presentation of the metadata element navigational search and the user feedback pertaining to individual resources.

The resulting visibility into the M&S world will provide significant benefits throughout DoD. Resource owners can use the catalog to identify their own inventories as well as to identify new customers. Resource seekers can rapidly find what they need and identify potential cost avoidances by learning of existing efforts. The department will achieve better resource management by ensuring resources are not applied to create existing capabilities, but instead focused on those areas where capabilities are lacking.

The M&S Catalog is available to anyone with a DoD-approved CAC or External Certificate Authority (ECA) security certificate at **https://MSCatalog.osd.mil.**

6. REFERENCES

[1] Department of Defense Net-Centric Data Strategy, DoD CIO Memorandum, May 9, 2003.

[2] DoD Directive 8320.02 "Data sharing in a Net-Centric Department of Defense", December 2, 2004 , ASD(NII)/DoD CIO.

[3] DoD 8320.02-G, "Guidance for Implementing Net-Centric Data Sharing", April 12, 2006, ASD(NII)/DoD CIO.

[4] Department of Defense Discovery Metadata Specification (DDMS) – Version 2.0 – 16 July 2008, Deputy Assistant Secretary of Defense (Deputy Chief Information Officer).

[5] Modeling and Simulation (M&S) Community of Interest (COI) Discovery Metadata Specification (MSC-DMS) – Version 1.2, February 20, 2009.

NOTE:

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