Business Models to Advance the Reuse of Modeling and Simulation Resources

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Contents

Summary

Today, the military services continue to capitalize on advances in modeling and simulation (M&S) technology. M&S is employed throughout the acquisition process and in almost every acquisition program, by government and industry, and is an integral part of military training programs and defense analyses. These efforts have produced a rich infrastructure of valuable intellectual resources, including models, simulations, databases, scenarios, threat libraries, verification and validation histories, environmentals, and others.

Unfortunately, relatively few of the M&S resources developed in prior efforts are reused during the life cycle of an acquisition program or shared and reused by other programs, services, or organizations outside the original sponsor and developer. The reasons for this lack of reuse are many and can be grouped into six categories:

- Discovering existing resources that are available for reuse
- 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, reuse offers the possibility of reducing future M&S development costs, shortening the time to complete acquisition programs or prepare for training exercises that rely on M&S, and improving the credibility of M&S-based results by employing resources that have withstood scrutiny in prior programs, exercises, and analyses.

This paper investigates economic business models that could overcome these barriers and advance reuse. 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. An 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 consummate and savvy consumer of M&S goods and services, including understanding its property rights in M&S developed by industry, negotiating to obtain best value for M&S investment dollars, and ensuring that future users will be able to discover, assess, and use the M&S 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 sunk costs in the development of an M&S resource by "selling" the M&S resource to another government office—is precluded by current statute and DoD policy. Interservice and intra-governmental support agreements are designed primarily for business transactions that involve the delivery of services and not the exchange 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, 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 reuse of M&S resources include:

- Express the intentions to achieve reuse in the RFP (request for proposal) for new M&S and then negotiate with industry to obtain the required license rights. For M&S that have a high potential for reuse, 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 reuse the resource, but these costs should be significantly less than repurchasing the M&S 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 reuse 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 be exercised if and when a reuse opportunity is identified.
- Employ intragovernmental transactions to share (and reuse) 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 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 reuse. 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 reusers. 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 M&S.

- 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 IP law or 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 reuse.
- Establish a pilot program for an M&S intermediary to broker arrangements for the reuse of established M&S resources within and across government and industry. The concept of an IP 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 reuse. M&S reuse 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 reuse initiative is aimed at displacing industry's position in M&S. A senior government official, with a vision for reuse, can use his or her position and keynote addresses and articles in trade journals to inform industry about government's true aims in reuse 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 reuse today.

Finally, the current laws and regulations on intragovernmental 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 sunk costs in development of a model or database and to apply these funds to future program costs would provide an additional incentive for reuse beyond what we have recommended above.

Table 1. Mapping recommendations to problem areas

Actions to Overcome Barriers	Barriers to M&S Reuse: Discover resource	Assess resource	Acquire resource	Ensure inter-operability	Compensate developer	Avoid Misuse
Include reuse 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 reuse 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		X

Introduction

The future environment for the Department of Defense (DoD) will likely be characterized by high global tensions, continuous change, short timelines, tight budgets, and a measurable amount of uncertainty. These features are already apparent in the shift from traditional warfare and preparing for major contingency operations (MCOs) to a focus on irregular warfare against asymmetric threats. New hot spots and threats (e.g., piracy in the Indian Ocean and Gulf of Aden, terrorist attacks in Mumbai) are emerging monthly if not more frequently.

In establishing a new paradigm for planning these operations, time will be a limiting factor and the military must be capable of responding quickly to emerging events and adapting forces to new scenarios. The current financial crisis suggests a strong likelihood of stable or declining (in real terms) defense budgets and the military services will be pressured to do more with less.

Future military operations will be 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 becoming more interconnected with collaboration, sharing, partnerships, and reuse becoming dominant themes in all aspects of information technology, including modeling and simulation.

These factors suggest that the DoD Modeling and Simulation (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 applications or scenarios.

Tools developed with open standards will be preferred over tools with proprietary technologies or interfaces. New M&S resources must be built to be reusable, interoperable, and shareable with others. 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.

Evidence to support these propositions can be found in speeches by senior DoD officials at ITSEC 2007 and Systems Engineering conferences, in DoD planning documents, and in the Terms of Reference for a recent Defense Science Board (DSB) study (Enhanced OSD Acquisition Operations with Modeling and Simulation). For example, the Guidance for Development of the Force (GDF) (2010–2015) includes initiatives to facilitate reuse of data through data strategies that "implement authoritative sources" and "leverage the independent data efforts across OSD, the Joint Staff, and the military departments to improve data, integration, transparency and sharing" (and thus reuse).

A related issue is contractor-proprietary models that cannot be reused because DoD doesn't possess the necessary software licenses and data rights. The GDF tasks the Under Secretary of Defense (USD) Acquisition Technology and Logistics (AT&L) with developing Department-level guidance to: "manage the use of proprietary M&S tools and data in the Department's acquisition, analysis, experimentation, planning, training and testing activities."

In the face of a need to increase reuse of existing M&S resources, today most M&S development and application efforts begin without seriously considering the possibility of using outside resources. Unfortunately, relatively few M&S resources are reused—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 reused, including models, simulations, databases, scenarios, threat representations, post-processing tools, among others.

The reasons for the lack of reuse are many:

- M&S repositories are incomplete and not kept current.
- It's not easy to judge the capabilities and limitations of someone else's model.
- Commands are suspicious about releasing models and databases to other organizations.
- Some M&S resources are tightly controlled as proprietary.
- Existing models may require data that are either not available or not "model-ready" in the required format.

Another obstacle to reuse might be the absence of incentives, including incentives for potential consumers to consider reuse or for potential suppliers to provide their reusable M&S resources to others. A business model, with the right set of incentives, would educate and motivate Department managers to look first at existing M&S resources before contracting to develop new M&S and to obtain the necessary software licenses and technical data rights to permit others to use these M&S tools on new problems.

Likewise a business model would motivate M&S developers to make their resources attractive for reuse by others. For example, reuse can be facilitated by providing better documentation, putting the resources in a form to be more easily adapted to new problems, and addressing software and data rights issues in the original solicitation. Obviously, this will require additional compensation to the developers up front (or an option for additional compensation once an opportunity for reuse is identified); however, it might lead to more efficient use of DoD M&S dollars if it promotes increased reuse, shorter development time, faster turnaround of analysis products, and more "open" M&S.

We look at the factors that have combined to place significant barriers in the way of those who are striving to make M&S more cost-effective

by sharing and reusing resources and identify the actions that DoD can take to spur greater reuse of existing M&S resources. Most of these actions employ the concept of an economic business model. However, we also include actions that should strengthen the M&S "commons" (i.e., shared infrastructure) and improve the quality of information on which the Department makes future M&S investment decisions.

The results are based on review of the relevant statutes, regulations, and policies at the Federal, DoD, and Component levels that could affect DoD's ability to access and reuse software and technical data developed in prior contracts, and its ability to conduct intragovernmental business transactions between two DoD (or broader federal government) offices for the exchange of M&S resources [1], [2]. We also developed seven case studies on programs where reuse is occurring today and distilled the lessons learned [3]. Finally, we conducted a series of surveys and interviews with M&S developers and users from both government and industry. The survey instruments, questionnaires, and participants are provided in the appendixes.

The paper unfolds as follows:

The next section defines M&S reuse and discusses the benefits to achieving reuse and the barriers that make reuse difficult today. We begin our discussion of business models by developing a notional model — laying out the customers, suppliers, and the value proposition between them — and then relate the basic business model to M&S. M&S may contain valuable intellectual property (IP). Next we turn to a discussion of IP including the laws that protect IP and the rights associated with reusing, modifying, and sharing M&S IP.

Intra-governmental business transactions, including the exchange of M&S, are governed by a number of federal laws and DoD policies and regulations. The following section reviews these laws and policies to establish a foundation for an economic business model to support the reuse of M&S resources.

We use the background provided in the previous two sections to discuss two alternative business models: propietary and open source.

Next, we apply the concepts of a business model to two concrete examples in DoD: (1) Threat Modeling and Analysis Program (TMAP) and (2) Naval Aviation Simulation Master Plan (NASMP) Portable Source Initiative (N-PSI).

The final section explores a recent phenomenon, open business models, where firms collaborate and license internally developed technology to other firms positioned to capitalize on it. Several pharmaceutical companies have adopted open business models. We show how open business models might be extended and applied in DoD. We conclude with recommendations: a set of actions the Defense Department can take to increase the likelihood of achieving reuse of M&S resources.

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Modeling and simulation reuse today

What is modeling and simulation reuse?

We start by defining "modeling and simulation resource reuse" and distinguish it from the related and more common term "software reuse." We discuss the types of resources that are candidates for reuse and the benefits that should result from reuse. Finally, we discuss the current barriers to M&S reuse. The aim of this study is to develop a business model that will break down these barriers and provide incentives for reuse.

Definitions

Below we offer two formal definitions of "software reuse" and use these to form our definition of "modeling and simulation reuse."

(1) **Software reuse** is "the process of implementing or updating software systems using existing software assets" [4].

(2) **Software reuse** is "the practice of using existing software components to develop new applications. Reusable software components can be executable programs, code segments, documentation, requirements, design and architectures, test data and test plans, or software tools. Reuse also includes the knowledge and information needed to understand, develop, use, or maintain the component [5].

We define **modeling and simulation resource** reuse as the process of building, assembling or executing M&S systems and applications from existing components.

Although we usually associate software reuse with code, including macro libraries and "Numerical Recipes in C," in practice software reuse includes a broad set of resources. Likewise, modeling and simulation reuse can be extended to include more than the individual

models and simulations. Table 2 is a list of the candidate resources considered for reuse.

Table 2. M&S resources for reuse

Tools	Data	Environment	
- Models	- Input datasets	- Architectures	- Network resources
- Simulations	- Scenarios - CONOPs	- Interfaces	- SME expertise
- Federations	- Threat data - Algorithms	- Protocols	
- Utilities (post-processors)	- Environmental info	- VV&A templates	

The phrase "M&S resource reuse" applies to a wide variety of activities in the M&S development process, including:

- Inserting existing code or modules for algorithms, subroutines, modules, etc. in new programs under development
- Developing M&S applications that interface (using standards and protocols) with existing components or services (rather than creating these assets from scratch)
- Expanding the number and/or variety of users who have access to existing models, simulations, databases, scenarios, and related resources.

Reuse benefits

Reuse offers the possibility of reducing future M&S development costs, shortening the time to complete acquisition programs that rely on M&S support, and improving the credibility of M&S-based results by employing resources that have withstood scrutiny in prior programs.

In particular, to support spiral development and to enable acquisition activities to be executed in parallel require collaboration during spirals and across activities, including reuse of M&S tools, data, and lessons learned. Reuse could lead to a common, shared system description throughout the acquisition process.

M&S resource reuse should improve life-cycle cost estimation for acquisition programs and lead to fewer risks in downstream activities because the M&S that supports later stages of development, such as test and evaluation, will already be available in the form of reusable assets.

Moreover, many M&S resources exhibit the economic phenomenon known within the network industries as "network effects." Network effects cause the value of a product to individual users to increase or decrease, respectively, with the addition or subtraction of other users of the same product. Network effects have been cited with Instant Messaging systems (names and presence directory) and with computer operating systems (Microsoft Windows).

For example, in the case of the operating systems market, if more people use Windows, more software developers will write applications for Windows, which in turn will increase the value of the Windows operating systems to individual users and further increase the demand for Windows.

Likewise, the more a particular M&S resource is used (and reused), the more scenarios, threat behaviors, and input databases are developed for the resource, and the more verification and validation testing is performed. Users gain increased trust and confidence in the resource through shared experiences and see increased value for future applications due to the additional infrastructure available to support the resource.

In a similar way, M&S assets that are not reused may become unknown and lose support within the community. There is little reason to extend the capabilities of these resources, update user guides and other documentation, or develop interfaces linking these assets to other M&S assets.

Although our primary focus is on reuse within government-directed M&S activities, ideally both government and industry should benefit from M&S resources made available for reuse. In particular, industry would benefit from access to "government-approved" models, scenarios, and databases. Having access to "blessed" resources would not only reduce the time and cost of acquisition program activities that employ M&S, but also would add credibility to industry's use of M&S and provide a level playing field for government to review and compare M&S results from different contractors. The challenge is deciding which firms are eligible to receive materials that are often classified and source selection sensitive before the firm is under contract.

Incentives and barriers to reuse

The DoD procurement process shapes incentives for M&S users and developers to engage in reuse activities, including:

- Searching for existing assets that are likely candidates for reuse
- Creating M&S assets that can be reused by the next generation of developers
- Publicizing and sharing M&S assets once they have been created.

Unfortunately, today there are significant barriers to M&S reuse and few incentives. Tables 3 lists many of the barriers to achieving M&S resource reuse. The barriers fall into six categories:

- Discovering the resource
- Assessing the capabilities of an existing resource
- Acquiring (and perhaps modifying) the resource for a new application
- Interoperability with a new architecture (or application)
- Compensating the original developer
- Avoiding misuse of the resource and potential liability.

Table 3. Barriers to M&S resource reuse

- **Users lack awareness of reusable resources**
- **Insufficient details about reusable resources**
- **Hard to assess the true capabilities and limitations of existing resources**
- **Resources not in a form suitable for reuse**
- **Users lack trust in resources developed by others/ NIH**
- **Model is available but not the data**
- **M&S components don't work well together**
- **Repositories are incomplete and not current**
- **Little insight into how resources have been used in the past, including successfully and failures**
- **Difficult to access the actual resource**
- **Difficult to adapt existing resources to new problems**
- **No mechanism to compensate developer for resource investment and guidance on use**
- **No mechanism to protect developer from mischievous uses**

Prospective new users of an existing M&S resource need to be able to discover the resource from a pool of available resources, assess its capabilities with respect to a proposed application, and acquire or access the resource if it meets their needs.

Today, most users who are successfully reusing existing M&S resources learn about the resources through their community of interest (COI). For example, the staffs involved in the development of training systems that use visual terrain databases seem to know each other and share experiences using resources from the Naval Aviation Simulation Masterplan Portable Source Initiative (N-PSI) or the USAF Common Dataset Standard (CDS). Analysts involved in aircraft survivability studies are associated with the Joint Technical Coordinating Group for Aircraft Survivability (JTCG/AS) and access M&S resources in SURVIAC (Survivability Information Analysis Center). Newcomers working in an area for the first time or outside their community face challenges in identifying and assessing M&S resources suitable for their needs.

There are few incentives for resource providers to register their resources with a repository; as a consequence, resource repositories

are under populated. Open letters soliciting resource descriptions from Service components or developers often go unheeded.

The existing repositories make it difficult for users to identify appropriate resources for their problem sets or to compare the capabilities and limitations of alternative resources because the existing metadata is incomplete and/or insufficient to search the full range of holdings. Broad "key word" searches may produce a large number of "hits." But using advanced search capabilities often results in no hits because the critical metadata describing the details of the resource to help refine and narrow the search is simply not provided. Furthermore, the discovery metadata contains little or no insight into how the resource has been used in the past, including both successful and failed applications. The point of contact listed in the metadata may not want to reveal limitations or may not be sufficiently familiar with the resource.

Many resource providers don't update the metadata associated with their resources and thus the repositories quickly become outdated. Developers need an incentive (i.e., funding or a contractual requirement) to maintain metadata. The metadata also need to be screened through an objective filter to avoid false advertising by developers who may try to inflate the true capabilities of their resources.

If a suitable existing resource is located, often there is simply no straightforward way of accessing the M&S resource from another organization. The original user may have contracted for only "limited rights" to the resource (due to intellectual property) and be unable to transfer the resource to a third party.

When M&S resources can be freely exchanged between organizations, the organization providing the resource faces additional costs in making the resource easily reusable by others. For example, there is a strong likelihood of significant time and effort to educate and guide the new user in the application of the resource. Sometimes the available resource is simply not in the form, or format, required by the next user. For example, a database may not be at a sufficient resolution, or from the right spectrum (e.g., visual or IR), or with the required latency (real-time, non-real-time), or in the right standard (DTED, OpenFlight), or classification level. Additional work may be

required to convert the resource to meet the needs of new users. The mechanisms available to provide compensation for these very real costs are unclear.

Another consideration is that the resource provider is vulnerable to criticism if the resource is misused by others. For example, new users may apply the resource in applications that are outside of the limits for which it was originally developed. If the M&S resource provides spurious results, the user may levy criticism against the original developer. Worse, a mischievous user may attempt to "reverse engineer" study results produced by the model to discredit findings in the original study; for example, by showing that a weapon system doesn't perform as well as claimed by the sponsor. There is no mechanism in place to protect the developer or user from these mischievous uses.

Many existing resources are not interoperable with the architecture or analytical framework selected by the new user. The resource may not conform to established standards, may employ a standard different from the intended use, or the developer may have interpreted and implemented the standard in a different way. This resource won't work well with the other components in the chosen architecture. Aligning the existing resource with the chosen standard may require additional work and costs, even though significant savings may accrue in the end.

Finally, the SMEs manning the Help Desk of an M&S resource repository do not have first-hand experience with the M&S resources stored within the repository and cannot guide new users to the resources most appropriate to their problem. Thus users must rely on metadata, which is often incomplete or out of date.

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Overview of business models

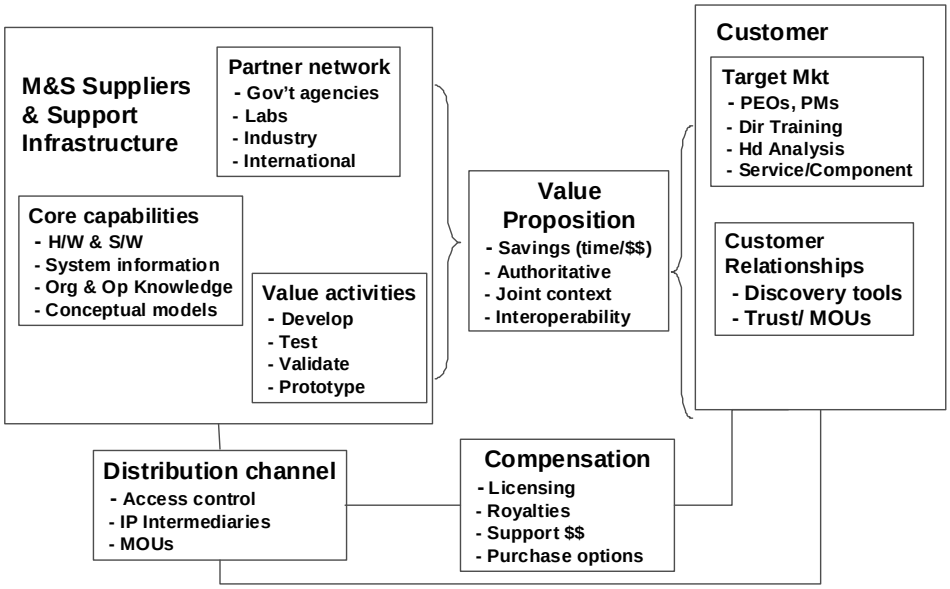
The objective of this study is to assess whether the barriers confronting reuse discussed in the previous section could be overcome with a business model. A business model would motivate program managers and other DoD decision makers to reuse existing M&S resources, either in their current form or by extending them to meet new requirements, before funding development of new M&S. Likewise, a business model would motivate M&S developers to put their resources in a form to be reusable and to share the resources with others.

A business model performs two functions: it creates value for customers (here M&S users), and it captures a portion of that value for the suppliers (here M&S resource providers) [6]. A business model creates value through a series of activities that yield a new product or service. It captures a portion of that value (usually referred to as profit) by applying a unique capability or resource within the series of activities in which the firm (or provider) enjoys a competitive advantage. The business model also includes mechanisms to distribute the product or service to users (here perhaps a repository or a registry) and to receive compensation from users (here perhaps through licensing agreements).

Figure 1 provides a template for an M&S business model. At the heart of a business model is a value proposition, which describes the products and services a business offers. For the M&S business model the value proposition is described in the cost or time savings available to the user from access to credible M&S tools and authoritative databases and scenarios. Other forms of value to prospective users might come from the capability to test their system or conduct their analysis in a joint environment through access to "approved" joint scenarios or a test and evaluation (T&E) infrastructure such as the Joint Mission Environment Test Capability (JMETC)[7]. In turn, this reuse can help to bring about improved interoperability by enabling the

user to test the integration and interdependency under conditions representative of the joint operational environment.

Figure 1. M&S resource reuse business model



The right hand portion of the figure shows the "target market" or potential customer pool that could benefit from reusable M&S resources, and the relationships and linkages that resource providers establish with different customer segments. Here, the target customer market is extensive and ranges from PEOs and program managers to directors of training and the head of the analysis directorates in each service. For example, within the Navy, the M&S section within OPNAV N81 would receive value from access to these resources.

The left-most box describes the M&S suppliers and their support infrastructure. This includes a partner network of government agencies and associated laboratories, industry, and an international component of both government and industry. Their core capabilities

include computer hardware (servers, desktops, networks) and software, including models, simulations, algorithms, etc. These partners also possess organizational and operational knowledge (subject matter expertise) and critical information on the systems being modeled. For example, this group might have developed the underlying conceptual models for various warfare phenomena. The conceptual model may represent a significant investment in time, energy, and creativity and serves as the foundation for a computer simulation. As such, it can be a valuable reusable resource.

The value activities from this group include developing, testing, validating, and prototyping the M&S resources made available for reuse. In the process of conducting these activities, this group often develops valuable intellectual property (IP). The protection of IP and the laws and regulations affecting whether the government can access, use, modify, and disclose IP is at the heart of a business model and a subject we return to later in this report.

The distribution channel defines how M&S users and resource providers become connected and how the relationships between providers and users are managed. This includes the "Discovery" mechanism by which users gain awareness of available resources, the physical location of the stored resources, and whether the distribution channel is supported through a registry or repository. The Discovery mechanism might include an "IP intermediary" or broker who can connect users with the resource providers best equipped to satisfy their requirements. This is another subject we return to later. The relationships between users and providers could be managed through MOUs (memorandum of understanding) that define the limits of acceptable uses or applications of the resource. MOUs are a way of establishing a trust relationship between users and suppliers.

Finally, the business model will generally include a compensation mechanism to return a portion of the value-added in creating the reusable resource to the organization performing the activity. This compensation may take the form of licensing fees or reimbursement for contractor support to either train a new user or modify the resource to fit a new problem or new modeling architecture. As we will see later, in open source software development, the compensation may be in the form of "status" or recognition as a contributor to an important work.

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Reuse of intellectual property in models and simulations

Intellectual property refers to creations of the mind such as inventions; literary and artistic works; and symbols, names, and images used in commerce [8]. Modeling and simulation resources may contain intellectual property. For example, an algorithm that produces faithful approximations of the performance of a specific real-world system or process within runtime constraints, represents original research and is considered to be intellectual property of the developer. Likewise, the developer's conceptual model of the mission space may also involve intellectual property. This abstraction of the real world systems and environment, including the developer's perspective on what aspects of the real world to include in the model and what aspects can be safely ignored; how the different warfare systems and processes should be represented in the model; how systems interact with the environment and with each other; and the set of embedded assumptions that govern the behaviors and interactions of warfighting systems, can involve a significant amount of creative expression. Conceptual models represent valuable opportunities for reuse.

The intellectual property in computer models and simulations is often encapsulated in the source code and technical data. DoD's access to the M&S intellectual property developed under contract is governed by copyright law, patent law, and the procurement regulations contained in the Federal Acquisition Regulation (FAR) and the Defense FAR Supplement (DFARS). These laws affect the government's ability to use, reproduce, modify, and release the software or technical data to other potential users and developers.

First we note the government has two, sometimes conflicting, roles with respect to intellectual property: it contracts for goods and services that contain intellectual property and is also responsible for the

laws that protect intellectual property. As a buyer of goods and services, the government strives to receive the maximum return on the dollar, but, as a maker of economic policy, it wants to provide incentives for private industry to innovate and develop better components, including better M&S software and related resources. The laws governing intellectual property attempt to balance industry's proprietary interests with the government's interest in having rights sufficient to permit third parties to reuse software and technical data in furtherance of government needs.

Before discussing the rights associated with reusing modeling and simulation intellectual property, we provide a few definitions [9]:

1. **Computer software** includes computer programs, source code, source code listings, object code listings, design details, algorithms, processes, flow charts, formulae and related material that would enable the software to be reproduced, recreated, or recompiled. Computer software does not include computer databases or computer software documentation. [In the updated (1995) DFARS, the definition of computer software now includes “object code,” a direct response to industry's concern of protecting against software being pirated.]

2. **Computer software documentation** includes owner's manuals, user's manuals, installation instructions, operating instructions, and other similar items, regardless of storage medium, that explain the capabilities of the computer software or provide instructions for using the software.

3. **Computer database** is a collection of data recorded in a form capable of being processed by a computer. The term does not include computer software.

4. **Computer program** is a set of instructions, rules, or routines recorded in a form that is capable of causing a computer to perform a specific operation or series of operations.

5. **Technical data** is recorded information (regardless of the form or method of the recording), of a scientific or technical nature. The term does not include computer software or data

incidental to contract administration, such as financial and/or management information.

The allocation of intellectual property rights for M&S software and technical data developed in performance of a contract for DoD is primarily determined by ascertaining which party funded the development.

Table 4 summarizes the relationship between funding source and allocation of rights.

Table 4. Allocation of Government rights and the source of the funding

	Noncommercial technical data	**Noncommercial computer software & documentation**	**Technical data – commercial items**	**Commercial computer software**
Developed exclusively at private expense	Limited rights	Restricted rights (software) & unlimited rights (documentation)	Limited rights	Customary license
Developed exclusively at government expense	Unlimited rights	Unlimited rights	N/A	N/A
Mixed funding	Government purpose rights	Government purpose rights	N/A	N/A

These rights affect the ability of DoD to share and reuse the M&S resources. Specifically,

Unlimited rights means rights to use, modify, reproduce, release, perform, display, or disclose technical data, computer software, or computer software documentation in whole or in part, in any manner and for any purpose whatsoever, and to have or authorize others to do so. These rights permit the government to use technical data and computer software without any limits, including offering the data to other companies for their competition with the owner of the data or software in the commercial marketplace as well as in the government marketplace.

Limited rights apply only to technical data and provide the right to use or disclose the technical data only within the government, but not for the manufacture, except for emergency repairs.

Restricted rights apply only to proprietary noncommercial computer software and mean the government's rights to:

> (i) Use a computer program with one computer at one time. The program may not be accessed by more than one machine at a time or time shared unless otherwise permitted by the contract
>
> (ii) Transfer a computer program to another government agency without further permission of the contractor if the transferor destroys all copies of the program and related computer software documentation in its possession and notifies the licensor of the transfer.
>
> (iii) Modify the computer software under very limited circumstances such as tactical situations or emergency repairs. Additionally, service contractors may be given access to the software if they sign nondisclosure agreements.

Government Purpose Rights means the rights to:

> (i) Use, modify, reproduce, release, perform, display, or disclose computer software or computer software documentation within the government without restriction
>
> (ii) Release or disclose computer software or computer software documentation outside the government and authorize persons to whom release or disclosure has been made to use, modify, reproduce, release, perform, display, or disclose the software or documentation for United States Government purposes. Government purposes include competitive procurement but not competition against the owner of the data or software in the commercial marketplace.

The Federal Government has recognized that there are obvious benefits to purchasing commercial items and has defined a separate category in the DFARS to cover commercial software and technical data.

Commercial computer software means software developed or regularly used for nongovernmental purposes which satisfies at least one of the following:

1. Has been sold, leased, or licensed to the public
2. Has been offered for sale, lease, or license to the public
3. Has not been offered, sold, leased, or licensed to the public but will be available for commercial sale, lease, or license in time to satisfy the delivery requirements of the contract
4. Satisfies a criterion expressed in 1, 2, or 3 and would require only minor modification to meet the requirements of the contract.

This definition is so broad that a vendor could assert that software developed at private expense for a specific military customer (e.g., flight simulator software or war gaming software) is commercial if the vendor has a good faith belief that when the version for DoD is delivered under contract, a slightly modified version will simultaneously be available for license to the public.

Having commercial computer software is significant because under the DFARS the government acquires only the standard commercial license rights. If the government has a need for rights not conveyed under the license customarily provided to the public, the government must negotiate with the vendor.

A significant fraction of DoD M&S could probably qualify as "commercial" under the DFARS. It is not clear from the definition of commercial computer software whether the software must be developed exclusively at private expense. The phrase "developed or regularly used for nongovernment purposes" suggests that software that is developed exclusively with government funds could still be commercial if the software is regularly used for nongovernmental purposes. Moreover, a stronger argument could be made that software developed with mixed funding falls within the definition of commercial computer software.

The government's rights in software are determined by evaluating when the software was developed and who paid for it, at the lowest practicable level (i.e., component level). Software is typically developed at discretely segregable levels. For example, software may be evaluated at the level of modules or subroutines, which in turn might be collections of algorithms, which in turn can be related to specific lines of source code. These are the levels at which M&S development can and should be analyzed by government contract and technical representatives.

Defining the moment that M&S software is "developed" will always be subject to some degree of uncertainty. The 1995 DFARS attempts to resolve these issues by using a definition of "develop" crafted specifically for software and software documentation. The basic clause for software states:

"Developed means that:

1. A computer program has been successfully operated in a computer and tested to the extent sufficient to demonstrate to reasonable persons skilled in the art that the program can reasonably be expected to perform its intended purpose;

2. Computer software, other than computer programs, has been tested or analyzed to the extent sufficient to demonstrate to reasonable persons skilled in the art that the software can reasonably be expected to perform its intended purpose; or

3. Computer software documentation required to be delivered under a contract has been written, in any medium, in sufficient detail to comply with requirements under that contract."

The definition of a "developed" computer program requires that the program has been coded and compiled into executable object code, not exist merely as flowcharts. However, the definition is flexible enough to suggest that the program doesn't need to be thoroughly debugged to be considered developed.

An interesting case arises when a contractor has developed an M&S resource at private expense, which DoD then wants to improve. Although DoD may take the position that it obtains unlimited rights

in the entire item as a result of funding improvements, this is typically too broad an interpretation. A company can continue to restrict or limit the government's rights even though the government funds improvements of the item.

Note, these data rights clauses do not specify the data (in terms of type, quantity, or quality) that is to be delivered, only the respective rights of the government and the contractor to use, disclose, modify, or reproduce such data. The DoD must ensure that the information necessary to reuse an M&S resource (e.g., software documentation, validation and verification (V&V) test results, user guides, etc.) is stated as a data deliverable in the contract. This is typically done through the Contract Data Requirements List (CDRL).

To protect the government's rights to access and reuse M&S software, government representatives must review the records of development and funding at the discrete levels of model, module, and subroutine. This audit should:

- Verify that the developer maintains separate development accounts for work done under company funds, IR&D, or other indirect accounts
- Examine the records of work claimed to be done at private expense and compare with contractual requirements to do the same development work
- Ensure that the government is not charged for any license fees for rights in technical data or software that the government has previously acquired with essentially unlimited rights.

Our assessment shows that the government enforces its rights in M&S software and technical data infrequently. This may be attributed to:

- Program managers lacking the knowledge of specific intellectual property rights and their value in achieving M&S resource reuse
- Complexity of the laws governing intellectual property
- Lack of guidance in how to obtain and employ these rights to achieve M&S resource reuse

- Lack of a supporting infrastructure including a database of existing rights associated with a specific resource and a mechanism to inform others of actions taken to obtain or extend data rights.

These concerns could be addressed with a training and education program for those involved in M&S procurement, including a 'best practices guide on contracting for M&S.' We discuss these issues further on in the recommendations section.

Analysis of laws and regulations affecting intragovernmental business transactions

Overview

Various statutes authorize federal agencies to enter into interagency agreements to obtain goods and services. However, the roles and responsibilities of each agency in such transactions are often a subject of confusion.

This section reviews the federal laws and DoD policies and regulations that govern interservice and intragovernmental support agreements and related business transactions between two DoD (or broader federal government) offices for modeling and simulation (M&S) resources. Within this framework of laws and policies we are looking for sufficient latitude to establish financial incentives to conduct these business transactions.

Specifically, we examine whether and under what conditions a DoD program manager (or other federal official) can authorize funding from its budget to make a computer model, database, or other M&S resource available and usable by other DoD programs (and government agencies) and be compensated by subsequent users in the exchange. The funds received would be reapplied to the original program or agency mission. Such laws and policies would provide the foundation for an economic business model to support the reuse of M&S resources.

This review is set in the context that a program manager or other government official from one M&S end-user organization foresees the longer term (reuse) potential for a particular M&S resource currently being developed or used within his or her organization and wants to make the resource available to other government offices. In the simplest case, the resource is government property and neither party

incurs a cost in sharing the resource. But, the situation becomes complicated when the existing M&S resource cannot easily be transferred to additional users because the government doesn't control the license rights or because the resource, in its current form, is inadequate to support additional users.

Obviously, if the M&S resource complies with approved information assurance standards and doesn't pose a risk to computer network security and if the action to make the resource available to other users does not obligate the government financially, then the government official is free to post the resource to a repository, such as the Defense Technical Information Center (DTIC) or the Modeling and Simulation Resource Repository (MSRR).

A more common situation occurs when a government office has to spend additional program or organization funds to make the resource reusable by others. For example, the initial user may have a rather narrow and short-term requirement for the M&S resource. To satisfy own program requirements, this user might fund a limited use software license, little or no user documentation, and focused verification and validation (V&V) testing sufficient to satisfy accreditation requirements for the current application.

In the course of developing or using this M&S resource, the original user (e.g., program office) may accumulate favorable experiences with the tool and recognize a longer term potential to support similar activities in this or other DoD programs. For example, different military service programs can use common modeling of threat system behaviors and visual databases. Investments by one Service in this infrastructure should be leveraged and made available to others. Also, activities in the latter stages of an acquisition program, for example test and evaluation, may be able to reuse some of the M&S resources developed during the concept development or design phases of acquisition.

In these cases, however, additional work (and funding) may be required to prepare the original M&S resource to be discovered and reused by others. These activities might include developing the discovery metadata, preparing additional user documentation, obtaining a software license for a broader set of user rights, conducting

additional V&V testing, implementing the application in a service-oriented architecture (SOA) framework, or developing a more "user friendly" model interface. The original user interface may be rather primitive. Its design may not anticipate the many uses and abuses that are likely to come with additional users. Finally, contractor support may be required to assist new users in training to use the model, setting up the model and developing input databases, and interpreting model results.

The issue we want to explore is whether a government official can legally spend the additional funds to provide the capabilities outlined above and, if so, what incentives beyond patriotism and altruism are available to encourage this investment.

Clearly it is in DoD's interest to identify promising M&S tools and make these resources available to others. Such actions support DoD's broader aims of achieving effective and efficient investments in M&S and improving collaboration and information sharing throughout the Department. But what do current laws and policy say about the ability of a DoD office to support these Department higher-level objectives and, at the same time, recoup some of its investment in making M&S tools reusable?

Relevant laws and regulations

The type of mechanism available to support interservice and intragovernmental transfer of modeling and simulation resources depends, in part, on these factors:

- Is the existing M&S resource government-off-the-shelf (GOTS) or commercial-off-the-shelf (COTS)?
- For M&S COTS products with license requirements, is the current license sufficient to support future users, or does it need to be expanded?
- Does a new user need government or contractor support to apply the M&S resource?

- Are existing M&S capabilities (and supporting infrastructure) sufficient to satisfy future users, or do they need to be expanded?
- Do the M&S assets belong to a working capital fund?

We start by examining the legal precedent. Any transfer of goods and services between government organizations for financial remuneration requires: (1) an explicit statutory authority (i.e., an okay from Congress) to create the entity, and (2) an explicit charter from an executive agency that indicates the entity's purpose and provides a citation to the relevant statute in order to establish the agency's legitimacy.

The sources of authority for transfers between federal agencies, including DoD components, are spelled out in the following seven documents:

- U.S. Code Title 10, Armed Forces, § 2208, *Working Capital Funds*
- U.S. Code Title 31, *Money and Finance*, Chapter 13 Appropriations and Chapter 15 Appropriation Accounting
- U.S. Code Title 41, *Public Contracts*, § 23
- DoD Financial Management Regulation 7000.14-R, Vol 11A, *Reimbursable Operations, Policy and Procedures*
- DoD Financial Management Regulation 7000.14-R, Vol 11B, *Reimbursable Operations, Policy and Procedures, Working Capital Funds*
- DoD Instruction 4000.19, *Interservice and Intragovernmental Support*
- OMB Circular A-130, *Management of Federal Information Resources*

DoD working capital funds are established by **U.S. Code Title 10** § 2208 as one means of encouraging one DoD activity to perform work, render services, or provide supplies for another, based on the Economy Act. The Secretary of Defense "may establish working capital funds to provide for such industrial-type and commercial-type

activities that provide common services within or among departments and agencies of the DoD."

The Economy Act, **U.S. Code Title 31** § 1535-1536 (commonly referred to as a Military Interdepartmental Purchase Request (MIPR)), authorizes the inter- and intra-departmental furnishing of materials or performance of work or services on a reimbursable basis. Section 1502 addresses what is called the "bona fide needs statute."

Project Order Law (**U.S. Code Title 41** § 23) together with the Economy Act contains legal authority and requirements for one U.S. Government entity to perform work for another.

The **Department of Defense Financial Management Regulation (DoD FMR) 7000.14-R** directs statutory and regulatory financial management requirements, systems, and functions for all appropriated and non-appropriated, working capital, revolving, and trust fund activities. These regulations define policy for using the authority granted by the U.S. Code to make transfers both directly through policy statements and indirectly through its definition of a hierarchy for other DoD policy documents.

Within that regulation, **Volume 11A** covers reimbursable operations, policy, and procedures. Within Vol 11A, Chapter 1 provides guidance on the costing of reimbursements that result from providing authorized services or materiel. This regulation applies unless a specific DoD issuance authorizes alternative reimbursement policies. The most significant of these alternative reimbursement policies is defined in **Volume 11B** on working capital funds.

DoD activities are encouraged to request support from other DoD activities when in-house capabilities do not exist or when support can be obtained more efficiently or effectively from other existing DoD capabilities. **DoD Instruction 4000.19**, provides the DoD policy for interservice and intragovernmental support agreements. Reimbursement for support is executed with a funds transfer instrument (e.g., MIPR). This instruction is written primarily for hosts providing services to tenants; for example, administrative services, custodial services, data processing services, fire protection, civilian personnel services, etc., where additional users absorb excess capacity within the

existing service infrastructure. But we are interested in examining the situation where additional work (and funding) is required to make the service available to others.

OMB Circular A-130, *Management of Federal Information Resources*, describes how the fees for services provided by data processing activities within the Federal Government will be determined.

Assessment

Title 31 U.S. Code § 1301 restricts the use of current funds to fund future anticipated, but not yet realized, requirements. Specifically, this statute states that funds may be used only for the purposes and programs for which Congress made the appropriation. Such an interpretation seems to prohibit a government official from spending program funds to provide additional documentation, V&V testing, or improved M&S capabilities to support the future needs of others. The bona fide needs rule (31 U.S. Code § 1502) places additional constraints by requiring that funds be used only for the needs or services within the life of the appropriation. It restricts this year's appropriated funds from being used to fund future and unspecified requirements beyond the life of the appropriations. This rule can be interpreted as prohibiting a government official from using current-year funding to develop M&S capabilities that may be used only in the future.

Furthermore, a program or agency cannot request appropriations for costs for which they are to be reimbursed through subsequent business transactions. Therefore, the program cannot request appropriations for costs associated with making an M&S resource reusable if it expects to be reimbursed later for those costs in business transactions with other offices.

This restriction could be overcome with a DoD policy on standards for reusable M&S resources and a requirement that all DoD-funded M&S resources comply with these standards. This policy could be used to justify the additional costs of developing more complete documentation, a more stable user interface, additional V&V testing, the creation of metadata, etc. However, unless the new policy is

accompanied by additional funding to make resources reusable, it will likely be viewed by programs as an "unfunded mandate."

DoD Instruction 4000.19 stipulates that an interservice support provider may not charge for any costs built into its budget. Therefore, if a DoD program or agency has been funded for the development of an M&S resource and it provides this resource to another government program or agency, it cannot recoup any of the costs for its development.

M&S resources can be exchanged between two offices, and the resource-providing office can be reimbursed for marginal or out-of-pocket costs. As set out in the Economy Act, reimbursement is to be made on the basis of "actual cost," as determined by the performing agency, 31 U.S. Code § 1535(b). Actual costs include all direct costs attributable to providing the goods or services ordered, as well as indirect costs funded out of the performing agency's currently available appropriations that bear a significant relationship to providing the goods or services.

For example, if the resource provider supplies a contractor (or government personnel) to assist the second organization in the use of the model, the cost of the contractor is a reimbursable expense. Labor support may be required to train the staff to use the model or to assist in developing scenarios and other inputs or in processing the model outputs. DoD Instruction 4000.19 sets forth the applicable policy and dictates that interservice support costs are reimbursed based on incremental direct costs, i.e., only those costs that are measurable and directly attributable to a support receiver may be recovered.

DoD 7000.14R, Volume 11A, Chapter 1, *General Reimbursement Procedures and Supporting Documentation*, further defines reimbursement of labor:

> The cost of direct civilian labor incurred in the performance of a service for, or the furnishing of materials to, another entity shall be reimbursed unless the performing entity has been provided appropriated funds directly to it for that purpose. Otherwise, the performing entity would be penalized to the extent that its funds are used to finance the

> cost of performing another entity's work, while the ordering entity's appropriations are augmented to the extent that they now may be used for some other purpose.
>
> As a rule, the applicable military personnel appropriations shall fund the cost of direct (and indirect) military labor incurred in the performance of a service for, or the furnishing of materials to, another DoD entity. Therefore, since a direct appropriation is provided for that purpose, the cost of military labor shall not be charged to another DoD entity except for the costs of military personnel assigned to DoD Working Capital Fund activities.

If subsequent users operate the M&S resource on computer facilities owned and operated by the providing government agency, the agency is authorized to charge an asset use fee. An asset use fee is levied for the use of DoD assets (facilities and equipment, or both) and is required to recoup depreciation and interest on investment. However, any amounts collected are expected to be returned to the U.S. Treasury as miscellaneous receipts, unless otherwise provided for by statute or other DoD guidance. Few, if any, existing M&S resources would benefit from an asset use charge.

DoD 7000.14R, Volume 11A, Chapter 4 provides policy for data processing activities. Specifically, paragraph 040402 states that fees for services provided by data processing activities shall be determined using guidance in OMB Circular A-130, *Management of Federal Information Resources*. This document lays out the policy of charging only for distribution costs for existing information resources. Specifically:

a. Avoid establishing, or permitting others to establish on their behalf, exclusive, restricted, or other distribution arrangements that interfere with the availability of information dissemination products on a timely and equitable basis

b. Avoid establishing restrictions or regulations, including the charging of fees or royalties, on the reuse, resale, or re-dissemination of Federal information dissemination products by the public

c. Set user charges for information dissemination products at a level sufficient to recover the cost of dissemination, but no

higher. They must exclude from calculation of the charges costs associated with original collection and processing of the information.

OMB Circular A-130 promotes the wide sharing of federal information resources such as databases without attempting to recoup any of the original costs of development. This policy appears to apply to GOTS products, but not to COTS where the intellectual property is protected.

Finally, we briefly address the role of working capital funds in providing incentives for reuse. DoD activities funded through working capital funds may play an important role in an economic business model for M&S reuse. By definition, a working capital fund is a revolving fund that is authorized by law to finance a cycle of operations where the costs for goods and services provided are charged back to the recipient. The funds received are available to continue operations and for future investments. Working capital funds typically provide for the centralized performance of common (e.g., administrative) services such as computer services, telecommunications, financial services, payroll, and personnel.

For example, the Department of Justice has a working capital fund that includes an operating account for computer services. These services include operating a data processing facility for both user-furnished and common enterprise applications. The costs for operating this business are recovered by billing customers through preapproved rates; for example, computer services are billed based on metrics such as CPU hours, storage (gigabytes per month), server use (transactions per minute), and printing (per thousand lines).

DoD also operates several working capital funds, including some shipyards, warfare centers, and major test and training ranges. These assets are expected to generate enough revenue to cover their operating costs and no longer receive appropriated funds directly.

Authorized customers of a DoD working capital funded activity may be:

- Any DoD command organization

- Non-DoD federal government agencies
- U.S. manufacturers authorized by Title 10 U.S.C. § 2208(h) [sold to contractors for use in performing contracts with DoD] and in accordance with Title 10, U.S.C. § 2563 [typically services that are not available from any U.S. commercial source] and § 4543.

A customer of a working capital fund receives appropriations from Congress and uses some of these funds to purchase support from a working-capital-funded activity; for example, a major test range. For contractors using a working capital fund, the fund is reimbursed by charges to applicable appropriations or payments received in cash. For example, JITC is operated as a working capital major test range and works closely with, and accepts resources from, industry for test and evaluation support.

A major test range or other activity operated as a working capital fund has standard business incentives to invest in M&S to the extent that it can charge for these services. (Some percentage of its funds can be retained for additional investments in M&S). For example, a working capital funded activity could recoup the costs to make an M&S resource reusable, including the costs of additional documentation and V&V testing. The relatively fixed overhead cost to accomplish this can be spread over more lines of business if the M&S services are in high demand. This would lower the average cost of the services of the test range and perhaps attract more customers.

The program manager (or original developer of the M&S resource) could transfer M&S resources to a test range operated as a working capital fund. But since the program manager's development cost of the M&S asset has already been paid out of appropriated funds, it's not clear what, if any, “transfer price” is legal. It is possible that the program could be given a credit balance at the test range in exchange for transferring the M&S resource to the working capital fund. The question of “fair price” is an issue. If this credit at the working capital funded test range could be used later by the contractor in conducting T&E activities at the range, perhaps the contractor would be willing to reduce its costs to the government program. But the timing remains an issue. The program manager will probably have moved on

to another job before the asset could be transferred to the test range and would not see any financial benefit, even though subsequent downstream activities within the acquisition program might see a return on this investment.

Summary

The existing statutes and DoD regulations on interservice and intragovernmental support are designed primarily for business transactions that involve the delivery of services and not the exchange of property such as software. Services, including payroll, personnel, computer, security, and travel may have excess capacity in one agency that can be sold to other agencies. Or, one agency uses the contracts and/or contracting services of another agency to obtain supplies or services from contractors. In most cases, the incremental cost of providing the service to additional customers can be measured in labor hours. Or, a capital investment, such as a computer server, added to an existing infrastructure can provide the service to a larger group of customers more efficiently than setting up a separate infrastructure.

Unfortunately, the concepts and procedures covered in these laws and policies do not appear to extend to information resources such as software and databases. If an M&S resource has been funded through Congressional appropriations, it cannot be resold to another government program office. A government office can bill only for the incremental cost of providing the M&S resource to another office.

For GOTS products, the M&S resource is government property and should be shared at no additional cost unless subject matter expertise support is required to use the tool. Here, the additional labor may be billed at incremental cost to the provider.

For COTS products, the second user may negotiate with the commercial vendor for an expanded license, including a Government Purpose Rights or perhaps an enterprise license. Any additional labor required for training, database development, etc. can be negotiated directly with the vendor.

The issue of timing (when the investment is made and when costs are recouped) is an added complexity in an M&S reuse business model. In most typical interservice and intragovernmental support agreements, costs that are incremental and not built into the provider's budget can be passed on to existing customers as soon as the cost is incurred. In the M&S resource case however, the incremental costs to make the resource reusable need to be passed on to future users who would benefit from the investment today. But the number of those future users is unknown at the time the investment must be made. Therefore, future users cannot be charged in a timely fashion.

Working capital funded activities are allowed to bill fully loaded costs to both government and industry customers. They are also allowed to invest some of their working capital to develop and renew the infrastructure used to provide services. These activities could be an important element in a business model. For example, a DoD acquisition program could transfer an M&S resource with reuse potential to a major test range operating as a working capital fund. The test range would make any additional investment needed to make the resource reusable, including documentation, V&V testing, etc. and then bill acquisition customers for the use of this resource in providing test and evaluation support. The program office that made the original M&S investment and provided the resource to the test range might receive a credit from the test range toward future testing on its program (e.g., major aircraft system) as a transfer payment in exchange for the resource.

The implications for interagency acquisition of M&S are summarized in table 5.

Table 5. Implications for interagency acquisition of M&S

Servicing agency	Requesting agency
(1) Existing GOTS or COTS with Gov't Purpose Rights	(1) No compensation allowed – Congress has appropriated funds to servicing agency – No increase in support supplier's costs
(2) Same as (1) + Gov personnel or contract support	(2) Fund incremental cost of labor
(3) Same as (1) + model enhancements	(3) Fund model enhancements
(4) COTS M&S with license requirements	(4) Fund incremental license fees
(5) New M&S with joint requirements	(5) Jointly fund new M&S

M&S reuse is best achieved through standards, software license agreements, and open business models that encourage collaboration and make partnerships worthwhile endeavors for both government and industry. But the concept of government-to-government business transactions that would allow one government office to receive a return on its investment in M&S by selling the resource to another government office is not a viable option under current statute and policy.

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Business models for proprietary and open source

Proprietary business models

Proprietary M&S resources are software and technical data for which the developer has set restrictions on use, modification, copying and distribution. Developers can enforce restrictions by technical means, such as restricting access to the source code, or by legal means, such as software licenses. Most commercial-off-the-shelf (COTS) software, such as Microsoft Windows is proprietary software.

In the traditional business model for proprietary M&S software, the developer generates revenue through sale of the software (e.g., object code) and associated documentation (e.g., user guide), and perhaps an annual maintenance agreement. The DoD (or any customer) receives a license to use the software on one or more machines depending on the terms of the license agreement. The license provides the right to use the software but does not transfer full ownership of the resource. The source code remains proprietary property of the developer and the DoD cannot copy, modify, re-engineer, or transfer the software to another government agency or third-party contractor.

The license agreement is similar to what a user receives with the purchase of Microsoft Windows. A user can use the software on his/her computer but cannot reproduce it, modify it, improve it, and redistribute a new version of Windows to others.

Another increasingly common business model for proprietary M&S resources in DoD is for the developer to sell services to customers that use the M&S resource. For example, the developer's firm may use the M&S to design a weapon system, or analyze the forces and capabilities of a Service component for the QDR, integrate the M&S into a training curriculum, or design and execute an experiment supported by

the M&S. Here the primary product is the service in the form of analysis or training, and the M&S resource is an intermediate good.

Both of these business models typically rely on a single firm to develop the M&S resource. The firm provides its customers with either the rights to use the resource or services (and the resulting products) that use the resource in delivering the service. The key basis of comparative advantage for this firm is control of the intellectual property, usually in the form of source code, as proprietary to the firm.

Business models based on proprietary technology have been the norm in the information technology industry until recently.

The first online network services such as CompuServe, America Online (AOL), and Prodigy functioned as proprietary network models. They gave subscribers access to content and services deployed solely by the network providers themselves.

For example, CompuServe subscribers could read an Associated Press news feed, chat with other CompuServe subscribers, and send private e-mail to fellow subscribers. The CompuServe business model was based on the connect charge, a per minute fee for access. Subscribers or third party companies were not allowed to develop new services that might appeal to CompuServe subscribers without CompuServe approval.

These proprietary networks severely constrained innovation and were eventually supplanted by the open Internet. The architects of the Internet had little concern for controlling the network or its users' behavior. The network's design was made publicly available and, as a result, innovation on the Internet has flourished.

As experience in the telecommunications industry has shown, proprietary technologies can threaten interoperability. When it approved AOL's merger with Time Warner in 2001, the FCC expressed concern that AOL had dragged its feet in designing an interconnection mechanism that would enable the subscribers of other services to use AOL's proprietary names and presence directory and communicate with AOL's subscribers as freely as with each other. Some believed

that AOL's reluctance to interconnect was evidence of its desire to achieve a monopoly in the instant messaging market [10].

In a similar way, the early business computing companies like IBM maintained a controlling, proprietary paradigm for their business model: customers leased computers on a monthly basis and the lease covered everything— hardware, software, maintenance, and training. As a result, businesses developed little in-house talent for programming or operating computers because everything was included as part of the package deal. Moreover, it became very difficult to switch vendors because all of the software was bundled with the machine as part of the business model.

A similar situation exists today with proprietary M&S. The original developer provides a license to use the M&S resource and contracts with users to make model improvements and to provide analytical services that use the M&S resource.

An opposing and more favorable view of proprietary technologies and innovation was offered by the economist Joseph Schumpeter. He argued that the best way to induce entrepreneurs to take risks in developing revolutionary technologies is to present the prospect of above-competitive profits and a short-term monopoly when those technologies succeed. Under this theory, the most significant competition takes place not within the market in the form of price wars but for the market itself, i.e., in establishing the next great innovation that will displace the old monopoly with a new one. If the incentives (i.e., potential profits) are significant, the resulting monopolies should be only temporary as new companies attempt to displace the insurgents. Modern-day Schumpeterians argue for strong intellectual property protection[11].

Evidence of the Schumpeterian view can be found in some of the COTS M&S products. These products provide the Department with access to leading-edge technologies that otherwise might not be available.

For example, proprietary video game technology has spawned several technologies useful to M&S, including graphical processing units (GPUs) and a class of algorithms called "physics engines." Graphical

processing units are microprocessors dedicated to rendering computer graphics and are considered the workhorse of modern graphics processing. GPUs perform calculations in parallel, making them better suited than central processing units (CPUs) for the complex calculations involved in graphics rendering. Physics engines perform the calculations needed to approximate real-world behavior in simulations. Proprietary physics engines provide the speed and precision required in many M&S applications.

COTS products support a broader market than DoD and thus their capabilities are likely to continue to improve over time. Future versions of COTS products will incorporate technological advances from other products, customers, and markets of the original developer. This is particularly true with products from the commercial gaming industry that reach DoD.

That said, however, COTS products can limit follow-on innovation by in-house government staff and by third party vendors unless DoD obtains a license for the source code. Optimal M&S reuse occurs when a broad range of users can access the resource, experiment, and adapt the resource to new problems and applications. Reuse leads to more reuse as additional scenarios, behaviors, databases, and CONOPs are developed for the original M&S, which, in turn, create additional opportunities to reuse the resource. And user confidence continues to grow as more users gain and share their experiences with the resource.

DoD may also require access to source code or other documentation simply to "look under the hood," i.e., to examine the details of the model and understand how it really works. This includes reviewing the underlying assumptions embedded in the model and the relationships for converting inputs to outputs. Such an assessment will enable prospective users to establish confidence and trust in the model and to understand, interpret, and use the model results.

Intellectual property protection does not prevent DoD from obtaining a license for source code or technical data rights. Rather, the laws provide the commercial developer with a bargaining chip to negotiate these rights with DoD and other users.

Assuming that it is possible to "decouple" the M&S resource from the original developer and that a third party could, in practice, use, improve, and extend the original M&S resource without support from the original developer, then DoD might want to negotiate to obtain these "rights." A source license and/or tech data rights would encourage DoD to develop in-house talent and would promote competition to sustain and/or extend the original M&S resource.

The decision on whether it is in DoD's interests to negotiate for these rights depends, in part, on the potential of the resource to support a number of applications and/or users, for example to be reused throughout a single acquisition program or across several programs.

Even when a source license is infeasible, if the M&S resource has the potential to support a number of applications and/or users, the Department should have an option to purchase an enterprise license or negotiate for Government Purpose Rights. A "Best Practices Guide for M&S Contracting," describing the laws protecting intellectual property, the rights that convey with various licenses, and the situations where broader rights might benefit DoD would be extremely helpful in guiding contract officers and program managers in M&S procurement decisions.

Open source business models

An emerging alternative business model is based on open source software and open source licensing. This business model is built around the concepts of a cooperative and collaborative approach to software development, sharing, and reuse.

Whereas the conventional notion of property is the right to exclude others from freely using something that belongs to someone else, property in open source software is configured around the right to disclose and distribute.

Here are the essential features of open source software:

1. Source code must be distributed with the software or otherwise made available for no more than the cost of distribution.

2. Anyone can redistribute the software for free, without royalties or licensing fees to the author.
3. Anyone may modify the software or derive other software from it and then distribute the modified software under the same terms [12].

Open source projects include office suites such as Open-Office, database systems such as MySQL, operating systems such as Linux, and web servers such as Apache.

Large parts of the U.S. Government, including DoD, the Department of Energy, and the National Security Agency (NSA) are using open source software. For example, NSA is using a version of Linux with added security features. The M&S software environment (OneSAF) was developed under the open source software paradigm. Several combat systems are built on top of open source systems and designed as open architectures. Last year the Navy published guidance on the use of open source software within the software acquisition process, which acknowledged that open source software should be treated the same as any COTS product [13].

Open source licenses define the terms of use and the conditions under which the software code will be released to others. About a dozen open source style licenses are in general use. Although each license has subtle differences, the common characteristic is to encourage the end user to copy, modify, and redistribute the software.

The contractual terms within the license agreement distinguish open source software from shareware (where the object code but not the underlying source code are made freely available) and public domain software (where no restrictions are placed on subsequent users of the source code).

Until recently, the General Public License (GPL) was the dominant open source licensing agreement. Under terms of the GPL, all enhancements to the code, including any code that is proprietary that might be bundled with the cooperatively developed open source software, had to be licensed on the same terms. The GPL is

considered "viral" in that it "infects" all code that is bundled with the open source software with the requirement that it be covered under the license agreement as well. More flexible licensing arrangements, including the "Open Source Definition," and the "Debian Social Contract," do not place such restrictions on other software that is distributed along with the licensed software, hence these licenses do not "contaminate" other software.

The open source software development environment is typically characterized by a group of individuals from different organizations at different locations, perhaps separated by time zones and connected primarily via network technologies, working in collaboration, and sharing code to develop, test, and refine software programs.

Where proprietary M&S development is usually characterized by the single firm working alone to produce a product whose use (and reuse) is tightly controlled by copyright and other IP laws, open source software development is symbolized by collaboration and partnerships, including peer review by outsiders to produce M&S resources whose use (and reuse including derivative products) is encouraged.

In addition to fostering reuse, open source M&S software offers these potential benefits:

- The collaborative nature of open source should make it possible to leverage the creative talents of a broad and diverse open source development community to reduce software development time and solve some of the hard M&S problems such as the modeling of human decision making and the modeling of information operations.
- By endorsing a "collaborative open source environment," the Defense Department might stem the loss of software developers from DoD work. Open source can provide the opportunity for a rich set of software projects that use a diverse set of skills. For example, open source might free up the innovator to move on to develop the next "killer application," while leaving others in the community to maintain and extend his or her original work.

- Ready access to the source code makes it possible to customize the M&S to meet unique user requirements.
- Open source software will increase the pool of developers and analysts who understand the inner workings of the M&S resource, which, in turn, should lead to stronger peer review of M&S and higher quality software. Peer review is at the heart of the scientific method and is the most effective means of finding and correcting faults.
- DoD would not be locked into a monopoly supplier for M&S resources developed as open source.

There are also several challenges to DoD adopting an open source approach to M&S development:

- For complex M&S systems, one firm may dominate the original development effort, even in an open source environment. This firm may command a premium to make the resource open source and still it may not be possible to decouple the resource from the prime developer and reuse without support. The benefits of open source would still arise in the testing and peer review of the resource.
- The costs of training a secondary source of developers (i.e., an open source development community) can be significant, especially if the system is unfamiliar to new prospective developers. Thus the benefits of open source are more likely to be achieved with general purpose and common use elements of the M&S infrastructure such as the Run Time Infrastructure, and less so on narrow purpose M&S systems such as mission-level simulations.
- Open source development often brings forth visions of a community of developers, perhaps hundreds or thousands in number, many working as hobbyists without monetary compensation but with a passion for the software project, who are able to coordinate their activities, sustain the collaboration over time, and then essentially give away the product. It's difficult to envision how this model would work in DoD.

For example, the notion of an army of altruistic volunteers pursuing open source development in DoD is largely a myth. The vision that users will pile on to test and debug the code when a new version of open source software is released won't be realized unless the users are under contract for this or a related open source project. Most companies will not allow employees to contribute to open source development projects unless the company plans to use the software in something else the company is producing.

- Government leadership will be critical to open source M&S development. Although there is a perception that open source software projects lack a "central authority," just the opposite will be true here. In the absence of volunteerism, the government will need to provide an overall vision for where the open source project is heading, decide how many and which firms to bring under contract to form the open source community and which tasks to assign to whom, and coordinate the activities and monitor progress. A simple business model would be for government to contract for open source with one firm and allow the firm to populate the open source development community through subcontracts. Once the initial open source product is developed, additional contracts can be let for testing and integration. Evidence from commercial open source development shows that the frequency and quality of contributions to open source projects is highly skewed with a few individuals accounting for a disproportionate amount of the contributions, especially the high quality contributions. Such data suggest that DoD should be able to keep the size of the open source community for any one project relatively small, which will reduce the management challenges [14].

- Open source software tends to be geared to the more sophisticated user. In fact many programmers are attracted to open source development for the opportunity to solve challenging software problems and to have their contributions and performance recognized by their peers. The typical commercial software development effort with proprietary code includes less glamorous tasks such as documentation and doesn't afford

outsiders with visibility into the programmer's clever solutions and elegant code. Government leadership will have to step in to ensure that user documentation, easy-to-use interfaces, and technical support—tasks that may not appeal to the open source developer—are funded and completed if the open source software is to be reusable by the larger DoD M&S community.

- Ready access to source code for the M&S resource can lead to a proliferation of derivative works as users add functionality and customize the resource to meet unique requirements and tastes. Who owns the baseline? Who decides if "forked" capabilities should be folded into the baseline? There may be confusion in understanding which version of the M&S resource was used for a particular study. Government leadership and a strong central authority are essential to prevent the open source project from becoming needlessly forked in unproductive directions. Moreover, government must be proactive about configuration management of the baseline and decide which versions of the open-source resource are approved "official" for government work. For example, a registry for M&S resources should include the baseline version and other extensions approved for use in DoD studies. The metadata in the registry should also acknowledge peer review, by name, performed by members of the open source community.

The commercial software business is becoming a service-oriented business with maintenance, training, and customized applications providing the bulk of the revenue for software developers. As evidence, the price a customer will pay for a software product quickly goes to zero once the vendor goes out of business.

Likewise, M&S support in DoD is beginning to be dominated by service oriented firms whose revenue depends on a continuing exchange of value between the M&S provider and user, and not a one-time sale of software.

The commercial world has shown that a traditional open source business model that relies solely on technical support of the software and add-on features is unlikely to generate sufficient revenue. Companies

must look for ways to add value beyond supporting the open source kernel. Within DoD, any open source business model will need to focus on providing application services including use of the M&S resource to support analysis, training, experimentation, etc. Companies that are more familiar with the code than others and can use this knowledge to customize the software for different applications will have a comparative advantage. Another potential source of revenue in an open source business model is to provide training on open source software to enable others to use the resource on their own and to customize it for their setting.

M&S firms that provide highly differentiated services; for example, firms that develop efficient algorithms or creative approaches to conceptual modeling or behavioral modeling, may command a premium for making their software open source. Their business model may remain one of providing the software as a standalone final product, albeit open source.

The Federal Government's M&S business is becoming increasingly connected as departments and agencies within government face similar problems (e.g., DoD and DHS). There is increased collaboration and partnerships across the agencies as a result. DoD's endorsement of open source and open source business models for M&S products and services could lead to increased sharing and reuse across wide sectors of the government.

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Two examples of DoD M&S business models

This section applies the concepts of a business model and the previous discussion of IP, intragovernmental business transactions, and open source to two concrete examples.

Threat Modeling and Analysis Program

The Threat Modeling and Analysis Program (TMAP) is a Defense Intelligence Agency (DIA) effort to combat some of the drawbacks of the traditional approach to threat modeling and simulation (M&S). Before TMAP, a given threat representation often resulted in multiple models, rather than a single, authoritative model. TMAP solves this problem and fosters reuse of models, both within and outside of science and technical intelligence (S&TI) centers.

Five S&TI centers take part in TMAP: DIA's Missile and Space Intelligence Center (MSIC), the Office of Naval Intelligence (ONI), the Armed Forces Medical Intelligence Center (AFMIC), the National Air and Space Intelligence Center (NASIC), and the National Ground Intelligence Center (NGIC). To understand TMAP's business model we spoke with a few of the centers. The discussions fell into five categories, corresponding to the components of a business model:

- Suppliers and support infrastructure
- Customer relationship
- Value proposition
- Compensation
- Distribution.

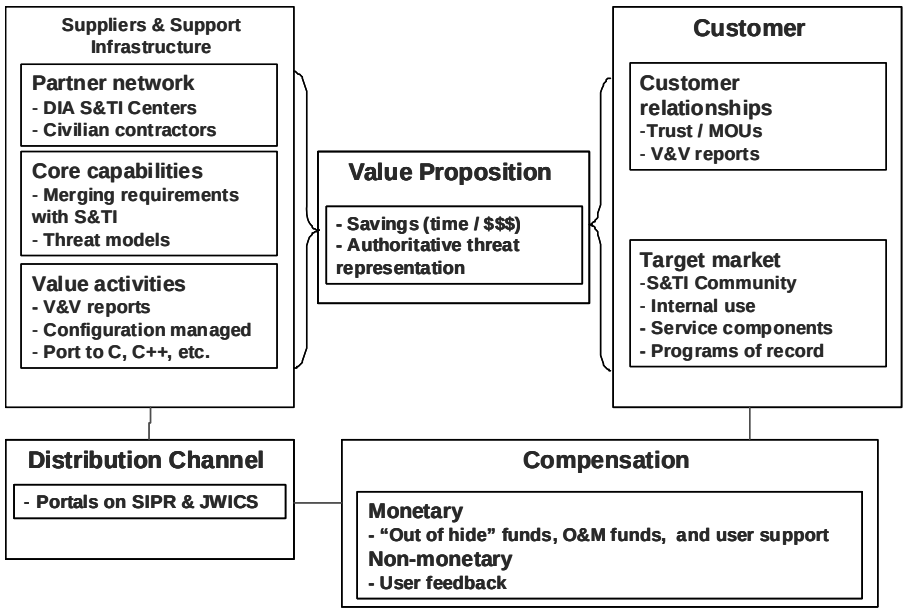
TMAP's business model is nearly identical to that of open source software. Open source is typically created by a group of programmers (or

an individual) and the source code is distributed at no additional cost. Users submit feedback and may modify the source code themselves. Like with open source, users can also modify a TMAP model to fit their needs. Unlike open source, however, a user cannot redistribute a TMAP model. The S&TI centers are the only source of their models, since national security is involved. TMAP models are only releasable to government entities or authorized contractors (at the request of a government sponsor). In addition, if a user makes extensive modifications to a model, it will no longer be "approved" by TMAP and won't be supported by the issuing S&TI center. This business model is, in part, responsible for TMAP's success.

TMAP business model

TMAP has an atypical business model—it doesn't focus on profit. Instead, it converts funding and S&TI into an analytic tool, which is then given away. TMAP's main similarity with a business is in its structure, as shown in figure 2.

Figure 2. TMAP business model



The business model is simple: the S&TI centers build models and give them away, in exchange for user feedback and occasional funding for model improvements.

Suppliers and support infrastructure

Core capabilities

TMAP's strength is in merging intelligence regarding a threat with the common requirements of that threat's community of interest (COI). The needs of the S&TI center developing the model weigh more heavily, since the primary purpose of the models is to support the center's S&TI analysis.

Value activities

The S&TI centers add value to their models in three ways. First, the models undergo a validation and verification (V&V) process, and the V&V reports are readily available. Second, the models run in the Simulink environment, which is a part of MATLAB, a common, commercial numeric/symbolic computing and modeling environment. MATLAB use introduces a degree of standardization into the models. Lastly, a model usually comes with a "readme" file that includes information a user ought to know before running the model. Typically, the readme file includes the threat name and type, model version, classification level, date created, creator, description, known issues, previous issues, installation and verification instructions, a point of contact, the MATLAB version, and Simulink model build number.

Partner network

Though TMAP comprises a collection of S&TI centers, each center works with users and contractors to verify and validate and improve its models. The users provide the S&TI center with feedback on the model, similar to what open source users provide for the software developers. The feedback usually takes the form of bug reporting and suggestions for improvements. In addition, users sometimes fund the improvements.

Customer relationships

Customer relations sit at the heart of TMAP's business model and closely relates to the partner network. Here, a model's users are subject matter experts regarding a threat, so their feedback is the currency the S&TI centers receive for sharing their models. User expertise increases the feedback's value.

Value proposition and compensation

The TMAP business model is unconventional in that the value proposition doesn't necessarily involve monetary exchange. Using a TMAP model brings two advantages: (1) cost savings from users not having to build their own model, and (2) knowledge that their model uses an authoritative threat representation shared by other members of the S&TI community. S&TI centers don't collect revenue, but they are indirectly compensated by the user feedback. The feedback helps the S&TI center improve the model, and the improved model furthers the center's intelligence mission.

Distribution channel

Accessing a model

Unlike some M&S efforts, none of the S&TI centers has a repository of models. Instead, the centers have a portal on JWICS and/or SIPRNet listing the available models and a mechanism to request them. Models are released to government entities and to contractors at the request of a government sponsor. Many of the requests come from outside the S&TI centers.

Sharing models across the government

The intent underlying TMAP is to use the models for S&TI analysis in support of a variety of government organizations. TMAP doesn't distinguish between internal and external use, since all users come from the COI for that particular threat. While the internal/external distinction may not be important for TMAP model usage, it does become important if one considers a wider class of M&S resources. For instance, sharing an M&S resource between the Navy and Air

Force could be a very different situation if the government doesn't control the intellectual property rights to the M&S resource. All the TMAP models are government-owned, so sharing isn't an issue.

Non-S&TI center users include the Joint Warfare Analysis Center and the Joint Aircraft Survivability Program, both of which have provided funding. Other users include USAF 412th Test Wing, USAF 96th Communications Group, John Hopkins University-Applied Physics Laboratory, and the Department of Energy's Oak Ridge National Laboratory.

Potential utility of TMAP across DoD

The TMAP structure would be useful to the DoD in two cases:

1. The DoD component owns the M&S resource
2. The DoD component has sufficient intellectual property rights to distribute within the DoD or to appropriate contractors.

TMAP's utility in both cases hinges on having the rights to freely distribute in one's organization. Another aspect of TMAP's business model that could work for DoD is the pooling of requirements within a community of interest. The M&S resource could be developed to meet the common requirements, and then the recipients could add functionality as necessary. This approach would work best if the resource were designed and built in a “joint” context. Here, “joint” means “within the M&S resource's community of interest.”

NASMP Portable Source Initiative

The Naval Aviation Simulation Master Plan (NASMP) Portable Source Initiative (N-PSI) is an effort to provide reusable high fidelity visual and sensor databases to aircraft simulators and other fleet training systems. The goal of this initiative was twofold. N-PSI planned to (1) standardize the methods used to construct and deliver databases and (2) develop new policy and contractual language to enable reuse across Services and training platforms. To realize either goal, N-PSI needed to acquire data in a suitable form, with suitable intellectual property rights.

N-PSI reached the first goal by realizing that over 80 percent of the effort in building a database from source data could be stored in open, industry standard formats. It then divided the database development process into two parts. The first step constructs a "dataset" from source data, which typically includes satellite imagery and terrain elevations. This first step in the process is perhaps the heart of N-PSI. The remaining step converts a dataset into a runtime database, optimizing it for a specific visualization platform.

N-PSI's first goal also introduced an open metadata format for the datasets. The metadata format can be modified over time. The format was borne of collaboration between government and industry.

N-PSI business model

The key to understanding N-PSI's success lies in understanding its business model. Stated another way, we wish to understand the structure of N-PSI's business, not just the content of its business. The N-PSI business model is depicted in figure 3.

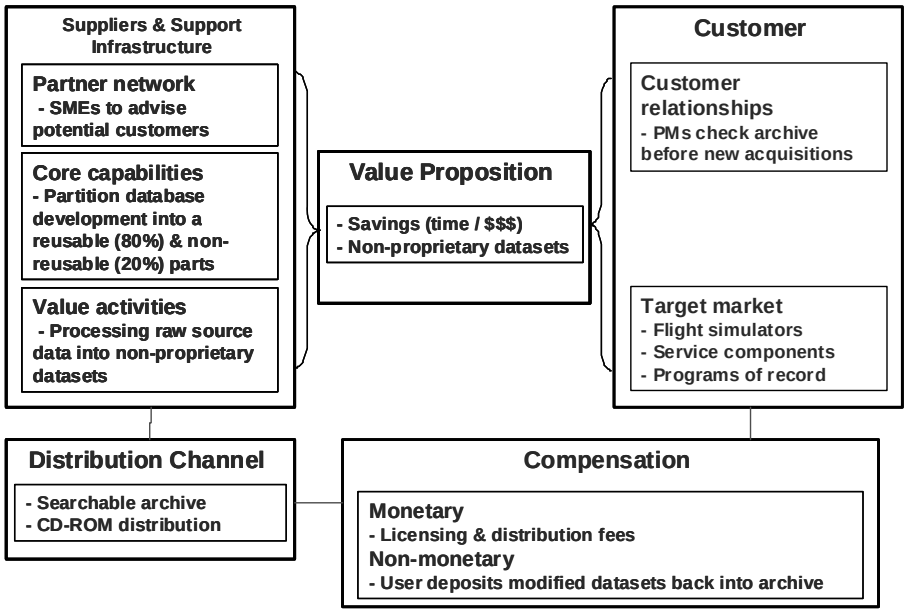
Supplier and support infrastructure

N-PSI's core capability lies in partitioning the database development process into two steps and producing optimized, runtime databases for a variety of platforms and several military services. The first part involves obtaining raw data from public sources, processing the data (i.e., filter, color balance, etc.), and then storing it as a non-proprietary dataset. This first step represents about 80 percent of the work needed to build a runtime database from source data. The remaining 20 percent of the effort comprises the second part of the database development process. By splitting the development process into two parts and storing the intermediate dataset, N-PSI is saving money and time and explicitly reusing a modeling and simulation resource.

Distribution channel

Part of N-PSI's business model is its infrastructure, the main part of which is the dataset archive. The dataset archive is also an important part of how N-PSI connects the customer with the datasets. Unlike the

Figure 3. N-PSI business model



Modeling and Simulation Resource Repository (MSRR), N-PSI's archive is updated on a regular basis and is focused solely on the datasets, which are narrowly defined. From here, datasets are distributed to customers via CD-ROM, which alleviates certain security concerns associated with running applications on the Navy-Marine Corps Intranet (NMCI). Potential customers include government entities and approved government contractors.

Value proposition

N-PSI's process is described above, but the value generated from the process and how that value is passed on to the customer haven't yet been made explicit. In short, N-PSI has revolutionized acquisitions of visual and sensor databases. Before N-PSI, training systems had to purchase the databases with a specific vendor's image generators (IG). This was because the databases were generally proprietary and there was a lack of suitable archived source data. Usually, the database requirements were included in the request for proposal (RFP). The

database was purchased as a line item from the IG vendor as part of procuring a new training device. These factors contributed to the high cost of running a visualization system because switching vendors often meant buying a new database. There was little chance of database reuse, let alone cost savings. N-PSI overcomes these problems by using open source data to build a dataset, as an intermediate step on the way to a database. N-PSI stops there and stores the dataset for later reuse.

Customer relationship

This portion of the business model describes the relationship between N-PSI and the customer. N-PSI affords certain advantages to its customers. For instance, it provides subject matter experts to advise potential users on the current availability of various data types. The use of subject matter experts could also be considered part of the infrastructure, particularly as partners in N-PSI's enterprise. Another facet of the customer relationship is the customer's non-monetary contribution to N-PSI. If customers update a dataset, they must redeposit the modified dataset into the archive, made available for future users.

N-PSI datasets are shared and reused across a number of training systems in the Navy, Marine Corps, Air Force, Army, and Coast Guard.

Compensation

Since N-PSI is a Navy program, and not a business, it doesn't turn a profit. However, customers do pay for N-PSI datasets, via licensing and distribution fees. N-PSI also receives two kinds of non-monetary compensation from it customers: (1) redeposits of modified datasets from current users, (2) recognition that before authorizing new development, program managers must search N-PSI's archive for existing datasets that might fit program requirements.

Potential utility of N-PSI across DoD

N-PSI's structure could be extended and used by the DoD for databases that fulfill the same criteria as N-PSI's. The databases would need to fulfill the following conditions:

1. They must be derived from mainly open source data, or data that DoD has Government Purpose Rights to.
2. A large portion of the effort needed to construct the database could be done once, with the resulting dataset archived for later reuse. The products of this process would be stored in an open, industry-standard format.
3. Dataset requirements are set by the community of interest.

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Open business models

In recent years companies have realized that to be more productive and to make effective use of all available resources, they need to be open to external ideas and, at the same time, be more willing to share internally developed ideas, technologies, and other resources with outside firms. Given the rapid scientific and technological advances (especially true in M&S), no one organization can do it all. Instead, companies realize that knowledge and productive capability are disbursed across many organizations. The resources available through a broad network of participants can be mobilized to accomplish much more than one firm acting alone. This phenomenon has given rise to open systems and open source software as companies collaborate and work together by taking ideas and resources that originate in one firm and matching them with complementary resources from other firms.

The business model that harnesses the power of collaboration and takes advantage of the sharing of resources is called an "open business model." Whereas the conventional business model strives to control and protect proprietary resources, especially intellectual property, through patents, copyrights, and trademarks, an open business models looks for opportunities to share some proprietary resources with other firms that are better positioned to capitalize on them. For example, by partnering with a firm that enjoys a competitive position in a value-adding activity (e.g., marketing) not available to the firm that developed and controls the proprietary resource. Likewise companies operating open business models look for opportunities to apply their unique capabilities to exploit the proprietary resources of other firms that lack advantages in these areas. These firms manage a balanced portfolio of proprietary assets, some that are protected and some that are shared.

Open business models allow companies not only to apply the firm's unique resources, assets, or position in that organization's own operations but also to link them into other companies' businesses. In open

business models, ideas and technologies are bought, sold, licensed or otherwise transferred, changing hands at least once before they can be converted to an end product.

Several pharmaceutical companies have adopted open business models by licensing some basic IP through open collaboration with other companies that are better positioned to exploit the IP. This collaboration has resulted in drug products reaching market sooner than otherwise possible. Information technology professionals are also collaborating on a wide range of open systems including Linux operating systems, Apache web servers, and MySQL databases.

The military services are attuned to the need to share information and collaborate with mission partners through the network centric warfare concept. The DoD has made investments in a supporting infrastructure to enable net-centric op-rations, including Network Centric Enterprise Services (NCES) and the DoD Data Strategy. Thus DoD has taken the first steps to adopt open business models.

Likewise, within the M&S domain, DoD has produced a number of M&S innovations, including distributed interactive simulation (DIS) protocols, the High Level Architecture (HLA), and semi-automated forces (SAF), among others. None of these were produced by a single organization working alone. Rather, these innovations were the result of an open process with a division of labor among tens if not hundreds of companies working in consort with the military services and government research labs.

The future business model for DoD M&S may have to extend this concept by encouraging the Services and industry to open their business models by actively searching for and exploiting outside ideas while making internal ideas and resources available for others and identifying opportunities for collaboration and partnerships across government and industry.

When sharing and collaboration don't occur on their own, the government may need to use policy or set up a separate organization to foster collaboration and reuse among constituent groups. This is exactly what the U.S. Army did when it established the Cross-Command Collaboration Effort (3CE). The 3CE functions as an "enabler"

for collaboration across the three organizations supporting the Army's Future Combat Systems (FCS) program: U.S. Army Training and Doctrine Command (TRADOC), U.S. Army Test and Evaluation Command (ATEC), and U.S. Army Research, Development, and Engineering Command (RDECOM).

The Army recognized the overlap in some activities associated with the three commands, including M&S, but that each organization was too busy with day-to-day activities to pursue opportunities to collaborate. Moreover, collaboration often requires negotiation and compromise and setting aside one organization's priorities for the betterment of the whole, and there was no incentive for this collaboration to happen. Recognizing that collaboration would not happen on its own without some prodding, the Army set up the 3CE.

The 3CE is able to step back and look across the three organizations and identify opportunities for collaboration and reuse that the individual communities don't see themselves. This includes common needs across the three organizations as well as overlapping activities that can be contracted or made more efficient. For example, 3CE can recognize when one of the three organizations is developing a resource or scheduling a test event that might be useful to the others. Then 3CE might provide some seed funding to jump-start the collaboration or take some action that enables one of the organizations to adjust its schedule or modify the effort so that it can also satisfy the requirements of the other organizations.

The 3CE can provide funding for the development of common tools and data to ensure a consistent representation of the FCS through the program's lifecycle or funding to integrate “common” M&S tools and data across the three commands. The 3CE functions as an independent broker with no vested interest in the selection of one model or database over another. Rather it can recognize opportunities for synergy in the activities and investments of the three organizations and act as an intermediary to bring the parties together.

We return to the concept of open business models and the role of an “M&S intermediary” in the “Recommendations” section of this report.

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Recommendations

This section outlines the steps that DoD should take to increase the reuse of M&S resources throughout the department. These actions will enable users to discover the set of M&S resources available for reuse, assess the capabilities of each and decide if one or more is well-suited or can be extended to match their needs, and ensure that sufficient license rights are in place to access and apply the resource to a new problem. Although most of the actions are focused on an underlying business model, they also include steps that should strengthen the M&S "commons" (i.e., shared infrastructure) and improve the quality of information on which DoD makes future M&S business decisions.

The recommendations are broken into five categories: (1) Training and Education, (2) Contracting Practices, (3) Common Infrastructure, (4) Leadership, and (5) Open Business Models.

Training and Education

Recommendation: Develop a best practices guide for M&S contracting.

The results from this project need to be expounded and illustrated in a guidebook for government decisionmakers. A best practices guide will enable decisionmakers to make more cost-effective investments in M&S, including reuse of models, simulations, and associated data from prior procurements and a preference for non-proprietary M&S resources when these actions are in the government's best interest. The guidebook should inform decisions on the procurement of M&S goods and services, supporting tools that allow more efficient use of M&S, and larger acquisition and training programs in which M&S is but an element. The guidebook should include advice on:

- Conducting the "Discovery Process" to determine whether existing M&S resources are available for reuse and well-matched to the problem at hand. If so, how to contract for any additional licenses and technical support required.
- Selecting between government funded new development and existing commercial or other non-developmental items (e.g., existing GOTS) as M&S resources. The issue of acquiring proprietary vs. non-proprietary products is of particular concern.
- Relevant government laws, policies, and regulations affecting the procurement of M&S goods and services.
- Assessing the long-term reuse potential of an M&S resource under development and, when warranted, the steps required to make the resource accessible and reusable by future users, including stating reuse intentions in the RFP.
- Assessing the technical data "rights" needed to support current, and perhaps future, applications of the M&S resource, and matching these rights with the software licenses and technical data rights available through the DFARS. What does it mean for government to own these rights and how to inform prospective new users of their availability?
- Market value of M&S goods and services, including intellectual property. Negotiating with industry to obtain the rights to use, modify, reproduce, disclose, etc. to others in government and industry, as required.
- Monitoring the contractor software development process to protect the government's rights to reuse the resulting products.
- Specifying contract deliverables including the form of soft-ware deliverables (source vs object code) and the types of documentation required to support current and potential future applications. Criteria for acceptability of contract deliverables.
- Assessing situations where the reuse potential is limited and the data rights should be focused solely on gaining sufficient access to examine the inner workings of the M&S to understand and verify capabilities. Some proprietary M&S fall into this category

Recommendation: Strengthen the training and education programs on M&S contracting for contract officers, program managers, and other DoD decision makers.

Program managers face budget and schedule pressures but have little formal training or first-hand experience with M&S, including investment decisions and timelines for M&S contracting and development. Often, they rely on an M&S program lead to make decisions on the selection of M&S tools and investments in new and existing M&S. Both groups require more training on these issues.

The continuous learning modules (CLM) provided by the Defense Acquisition University (DAU) on Modeling and Simulation in Systems Engineering (CLE 011), and Naval Open Architectures (CLE 012) provide a good overview of top-level considerations in planning to contract for M&S, including property rights and source selection considerations. These modules are good starts, but they need to be expanded with additional details and real-world case studies.

What is needed is more details about how to go about the process of discovering whether existing M&S resources can satisfy new problem sets, working through the complex regulatory structure associated with IP law, negotiating to obtain or extend the license agreement, and ensuring that future government users can access and reuse M&S resources developed today. These decisions involve trade-offs among alternatives; each decision must take into account multiple criteria, and the decisions are often supported with limited or worse, conflicting data about the M&S capabilities, downstream reuse opportunities, existing rights, etc.

Contract personnel need additional training on software technology, including the form and function of alternative deliverables (source code, object code, user manual, analysts guide, etc.), the types of documentation needed to understand and modify software, and the lifecycle management of software systems.

Program managers, government M&S lead staff, and other DoD staff responsible for M&S investment decisions need additional training on the complex data rights provisions contained in the FAR and DFARS. They need real-world examples and case studies to bring to

light the difference between proprietary, open-source, commercial, and GOTS systems and the data rights associated with each. The training issues include: the minimum rights required to reuse an M&S resource—by government or shared with industry (for software components, interfaces to COTS components, or algorithms); conditions under which government should be willing to pay a premium to obtain these rights; how to negotiate for these rights; and actions a government agent can take to protect these rights for future users? Much of this information could be packaged in a Best Practices Guide, but some training is best provided in a classroom setting, especially case studies from real-world experiences.

Recommendation: Establish M&S reuse goals at PEO and program levels. Provide enabling mechanisms and reward progress.

Program managers are ultimately responsible for the expenditure of government resources and need to balance time, schedule, budget, and performance. The program managers must make trade-offs in the use of existing (off-the-shelf) resources that can be applied as is or modified to support their needs (albeit perhaps with somewhat less than a perfect fit) versus the alternative of building new M&S from scratch that can be tailored to their program's needs. As stewards of government funds, program managers must be incentivized to take a longer-term perspective, including managing the life cycle costs (LCC) for their program. Such an attitude will lead to investments in M&S resources that can be reused throughout the acquisition program and shared with others to support additional requirements.

Within the Acquisition Community, the existing culture focuses almost entirely on the next milestone, forsaking a longer term perspective. Changing the culture is hard but attempts to do so could pursue either a “pull” or “push” strategy. The “pull” strategy would require program managers (and similar DoD decision makers) to report efforts to reuse existing resources (for example by searching registries or exploring contacts) before contracting to develop new M&S resources. Obviously, this would require the standup of a DoD M&S registry (and formal registration process) accompanied by a search engine to enable managers to quickly screen available

resources. The "push" strategy would encourage program managers (and similar DoD decision makers) to report efforts to create reusable resources (e.g., by funding additional documentation or V&V testing) and would provide budget supplementals to accomplish this work.

The John Warner Defense Authorization Act for 2007 (Section 802) contains language requiring program managers of major weapon systems to assess the long-term technical data needs of their systems with respect to maintenance and sustainment and to follow strategies that provide DoD with the necessary rights to pursue in-house maintenance or a secondary source for spare parts. This language should be extended to include data rights to enable reuse of M&S resources developed during the acquisition of the weapon system.

Recommendation: Identify DoD working capital funded activities that use M&S resources and facilitate the transfer of M&S resources from acquisition programs to these activities.

Working capital funded activities, such as test facilities and shipyards, are allowed to bill fully loaded costs to both government and industry customers. They are also allowed to invest some of their working capital to develop and renew the infrastructure used to provide services. These activities could be an important element in a business model for M&S reuse.

For example, a DoD acquisition program could transfer an M&S resource with reuse potential to a major test range operating as a working capital fund. The test range would make any additional investments needed to make the resource reusable, including documentation, V&V testing, etc. and then bill acquisition customers for the use of this resource in providing test and evaluation support. The program office that made the original M&S investment and provided the M&S resource to the test range might receive a credit toward future testing on its program (e.g., major aircraft system) as a transfer payment in exchange for the resource.

Contracting Practices

Recommendation: Negotiate with developers up front to obtain sufficient rights to reuse high-potential M&S resources.

Government needs to obtain the technical data rights to M&S resources that it intends to make available for reuse and then broadcast the availability of these rights and the resource to potential users.

For new M&S resources that have a significant potential for reuse and where the source of funding is either entirely private or mixed, to include private and government funding, the DoD will need to negotiate for sufficient rights to reuse the resource. These negotiations will usually result in Limited or Government Purpose Rights. For M&S resources developed exclusively with public funds, the DFARS regulations vest the government with Unlimited Rights, and no additional negotiations should be necessary.

In many cases, without support from the original developer, it will not be possible to decouple the M&S resource from the original developer, release the details (technical data) to a third party, and expect that a third party will be able to use, improve, and extend the original M&S design or integrate it with one of their own products. In these cases, negotiating for Limited or Restricted Rights should be sufficient.

In cases where it is possible to decouple the resource from the developer and where the government wants to promote competition and innovation by third parties, the government may want to negotiate for Government Purpose Rights.

Recommendation: Implement stronger oversight of the M&S development process to protect government's rights in these resources.

The 1995 DFARS assigns rights to software (including M&S) solely on the basis of the funding source used to develop the software. A contractor is required to identify all software products to be delivered to the government with less than unlimited rights and to produce records showing the sources of funding for each module or

component. Unfortunately, the government does a rather poor job of tracking the funding source and the work that was accomplished under each source.

The government should verify (and challenge if necessary) the claims of the developer by reviewing the developer's accounting records for tracking the allocation of private and public funds and the developmental work that is accomplished with those funds. The government rarely will have independent evidence of how the contractor funded the development activities and in most cases must rely on the contractor's records. The government should verify that proprietary data and software have been properly marked as such by the developer with the appropriate protective legend.

Recommendation: Develop a methodology and support tools to estimate the true long-term value of an M&S resource that reflects the potential for reuse and the intellectual property of the developer.

Not every M&S resource has the potential to be reused. Some M&S resources have a narrow focus and fulfill a one-time requirement, some are difficult for anyone other than the original developer to reuse, and others contain intellectual property that the developer may not be willing to disclose.

Furthermore, there is a cost associated with converting a resource to a form where it can be easily reused by others. This cost may include license rights, documentation, additional V&V testing, training for prospective users, and a more intuitive (user-friendly) interface. Obviously DoD does not want to make this investment in every M&S re-source. At present, however, DoD lacks the tools necessary to inform these decisions on when to invest to make an M&S resource reusable.

A methodology is required to assess the likelihood of an M&S resource being required in future DoD activities; for example, downstream within the acquisition program or in a subsequent activity for the organization that developed (and funded) the M&S, or across acquisition programs and analysis activities, including perhaps in the other Services and defense agencies. The opportunities must be

identified and the capabilities of the M&S resource to satisfy each of these opportunities evaluated.

The methodology will have to assess the nature of the M&S capabilities (i.e., robust or narrow focus), the availability of input data for a range of possible scenarios and applications, ease of use, and other factors. Obviously M&S that satisfy a broad range of problems have a higher likelihood of satisfying future requirements and thus of being reused than M&S resources that have a narrow or specialized focus.

The methodology would also attempt to segregate the software to examine the government's and contractor's contributions to the development of the resource and resolve the rights associated with the resource. This approach will include verifying software markings, when the resource (at the lowest component level) was developed, and who paid for it.

The methodology would enable DoD to decide which M&S resources have a strong likelihood of being reused and what steps need to be taken to make the resource reusable. Armed with this information, DoD personnel could decide when it is in the government's best interest to fund reuse up front during initial development, when to employ an “options” strategy to fund some initial actions to maintain the M&S (and associated expertise) and perhaps exercise the option later when the reuse opportunity arises, and when to contract for one-time M&S support.

An options strategy for M&S resources could function similar to a stock option. These options would convey the right, but not the obligation, for the government to procure an expanded license or rights at some point in the future. The government would not exercise the option until it was assured of the continuing need for the M&S resource. In the interim, the developer might need a small amount of funding to sustain the resource, including maintaining in-house expertise.

Common Infrastructure

Recommendation: Centrally fund the common M&S infrastructure.

There exists a core common infrastructure of GOTS M&S resources that supports the needs of broad communities of interest. Today, in the absence of central funding, the programs or organizations with the largest budget available for M&S have the greatest influence over setting priorities for improved capabilities and other upgrades to this core set of resources. However, upgrading the capability of an M&S resource in response to one program may not support the needs of the broader user community. This is especially true for reuse, which requires funding for user documentation, additional V&V testing, and configuration management. A source of central funding should be made available to support the life cycle management of a few of the most widely used M&S resources. This funding must reach, and be administered by, the group of long-term subject matter experts/ users of these M&S resources. These users have a broader perspective and can foresee and coordinate needs for multiple programs.

The resulting products should be registered in a "commons" (shared workspace) and made available to all users as GOTS products. Candidate areas for central funding are the set of survivability M&S resources within the Joint Aircraft Survivability Program (JASP); the visual database initiatives co-sponsored by the Navy and Air Force (N-PSI and CDS); the Threat Modeling and Analysis Program (TMAP) sponsored by the Science and Technology Intelligence centers within DIA, and the resources managed by the Joint Data Support (JDS) program, including scenarios, CONOPS, order of battle information, threat lay-downs, and similar databases supporting the analytic agenda.

Recommendation: Establish a resource registry for all government-funded M&S resources. Include license rights in the metadata.

Users need better awareness of the M&S resources that are available for reuse, the capabilities and limitations of existing resources, and how they have been used in the past. Likewise, DoD managers need a mechanism to inform the broader community about M&S resources

they have already funded, their experiences with these resources, and the license rights in place to make these resources available to others.

The existing M&S repositories are incomplete, not kept up-to-date, difficult to search, and they contain resources of mixed quality for the reasons cited in this report. Moreover, a single central physical repository that satisfies the needs of a variety of users from different communities and different experience levels is unnecessary to achieve reuse. These objectives can be accomplished by registering M&S resources in a DoD-wide registry and maintaining a few M&S resource repositories, with each serving a small community of interest, such as aircraft survivability. The repositories might be linked electronically to enable a community to search beyond its borders.

DoD should establish a formal registration process and require that any M&S resources developed in performance of an M&S contract be registered with sufficient discovery metadata about the resource to enable a cataloging of the resource and subsequent identification and retrieval by potential reusers. The registration process must be user-friendly with a web-based tool.

Additional actions to stand up an M&S registry include: (1) complete a taxonomy for metadata, starting with the DoD Discovery Metadata Specification (July 2008) but expanded to include license rights associated with the tagged resource, (2) define requirements for a search engine and architecture, (3) develop a schema for cataloging entries, (4) work with industry to ensure that the requirement to register an M&S resource becomes part of future contracting practices.

The registry should be supported with a user-edited wiki where users' could post comments about their experiences with the resource. The wiki would function in a way similar to the way the ratings system used by Amazon.com works. The registry might also include answers to frequently asked questions (FAQs), which would help to narrow the search and reduce the administrative burden on the developer or resource point-of-contact to answer questions.

The M&S wiki should not have to be actively policed by an independent and objective reviewer. DoD would decide who has the authority

to modify an entry and users would have to judge the quality of the information themselves, based on external factors.

Recommendation: Continue standards-setting efforts between government and industry.

Standards can increase the prospects for reuse by making it easier to use the M&S resource in multiple programs and different settings. Government and industry should work collaboratively to establish and publicize standards that ensure reusability of M&S assets. Future contracts should specify that deliverables meet these standards and government should use V&V testing to certify that deliverables comply with the standard.

Due to multiple existing standards, unique user requirements, and disagreements over the most efficient standards, it's unlikely that DoD users will agree on a single standard – either for distributed simulations (HLA, TENA, DIS) or terrain databases (SEDRIS, N-PSI, OpenFlight, Shape, GeoTIFF). In the interim DoD will need to support multiple standards. For example, DoD will need to ensure that source data continue to be provided in multiple formats to meet unique user requirements. But even multiple standards can facilitate reuse by encouraging new users to adopt one or another, and to develop their resources to be compliant with the chosen standard.

Leadership

Recommendation: Recruit a senior government champion and use the bully pulpit to articulate goals for DoD M&S reuse and maintain a drum beat on expectations.

To achieve increased reuse of M&S resources will require a champion—a senior government official to advocate for reuse. This individual should continue to stress the need for program managers and other stewards of government M&S funds to search for and apply existing M&S resources before developing new resources and call attention to both success stories and missed opportunities. This includes taking the lessons learned from niche groups that are achieving reuse today (e.g., Naval Aviation Simulation Master Plan Portable

Source Initiative (N-PSI), USAF CDS, JASP/SURVIAC) and pushing them to a wider audience. The M&S reuse champion should articulate policy and guidance on the responsibilities of government officials, to include sharing M&S resources with others while protecting the intellectual property rights of industry.

The reuse champion should use keynote addresses and other speeches at engineering, M&S, and other trade conferences and articles in professional journals to set out DoD's expectations for reuse and a strategy to achieve the desired results. These forums can reach the widest audience and the one most affected by changes in DoD management, contracting, development, and use of M&S. Conferences should include the DoD M&S Conference and the Annual Systems Engineering Conference. Publications should include: (1) *Journal of Defense Modeling and Simulation*, (2) *Military Simulation and Training*, and (3) *Military Operations Research Society (MORS) Phalanx*.

The community from which the champion is drawn (Acquisition, Test and Evaluation, Training, etc) is less important than that the individual cares passionately about the importance of reuse and be willing to invest personal time and energy to make it happen.

Recommendation: Make DoD authoritative M&S resources available to industry partners.

M&S resource reuse cuts both ways and DoD should share authoritative M&S models and databases with industry partners to achieve additional benefits of reuse. Environmental databases (weather and terrain) and threat models would be especially useful to industry. Unfortunately, current policy prevents sharing of many government supplied resources with industry unless the company is already under contract for the program or a related system. These policies should be reviewed.

Once a new policy is in place, contractors should be required to demonstrate why they cannot reuse existing government-provided M&S tools and facilities before building their own.

Open Business Models

Recommendation: Provide seed funding to encourage partnerships and teaming arrangements to jointly develop M&S resources that support multiple programs and offices.

The current statutes and policy preclude the possibility of recovering sunk costs in M&S development through intragovernmental transactions, where one government office sells the M&S resource to another government office. Once an M&S product becomes GOTS, or licensed to the government, only new and current costs can be recovered; for example, the costs to extend the license to additional users or to provide contract support to train new users.

Given these constraints, the most promising scenario for reuse on new M&S development is for two or more acquisition programs (or other M&S user organizations) to come together and form a partnership to jointly sponsor M&S that supports both programs. Open business models using an M&S intermediary or a similar approach such as the Army 3CE effort can help to identify and broker arrangements for jointly developed M&S.

Recommendation: Establish enablers for open business model transactions—intra-government, across industry, and between government and industry partners.

Each of the military services and defense agencies have M&S resources (models, databases, studies) that could be leveraged by other Services and agencies. Likewise most private sector companies have M&S (including proprietary M&S) resources that are not being fully utilized in house. The Services and defense agencies need to become more open to accessing and using established M&S resources developed by others and more willing to collaborate and share their M&S resources with other partners. Likewise, industry must become more open to external ideas, including becoming aware of M&S resources controlled by other companies and be willing to collaborate and license each other's M&S technology when one company can extend the M&S resource beyond what the developing company can do on its own. This recommendation requires breaking down the “Not-Invented-Here” syndrome.

DoD could facilitate open business models by organizing a registry of M&S assets and resources, including conceptual models, semi-automated forces, algorithms, databases, and others. These resources could be matched and licensed with M&S resources from other companies and government organizations. The discovery metadata should include the license rights associated with each resource and previous applications of the resource (both independent and in prior partnerships with other government organizations or industry).

Recommendation: In support of open business models, establish a pilot program and provide seed funding for an M&S intermediary to broker arrangements for the reuse of established M&S resources between users and developers.

Virtual collaboration through electronic registries alone probably will be insufficient to achieve the desired levels of reuse within DoD. Instead, DoD will need to take proactive steps to identify and bring together users and providers of M&S technologies in business transactions.

One way to accomplish this is through an intellectual property (IP) (here M&S) intermediary. The concept of an IP intermediary, or innovation intermediary, was first proposed in the private sector as a means of pursuing an open business model. The initial attempts employed IP intermediaries to manage the R&D organizations in the pharmaceutical industry. The concept of an IP intermediary is designed to help companies identify and manage the IP involved when working with ideas that originate outside the firm, and to manage a company's IP when letting others license and use the ideas in their firms.

An IP intermediary functions as an honest broker, independent from developers and users, and therefore is in a good position to sign a non-disclosure agreement (NDA). Some IP intermediaries are agents for the developer to create a market for the IP, and others act as a broker to match IP developers with other organizations that can use the idea in their business. In the M&S world, the IP intermediary would help program managers and other M&S users identify and locate suitable existing M&S resources and help developers find a market for established M&S resources.

The M&S intermediary would also document the legal status of each M&S resource within the DoD and maintain awareness of what license rights convey with each resource and the options for enterprise, facilities, volume, or source licenses. It would facilitate license agreements between developers and new users.

The M&S intermediary would build and maintain a knowledge base of how existing resources have been used in the past, including V&V histories. This knowledge base and V&V history would grow over time to include the experiences of new users. Finally, the IP intermediary would negotiate a memorandum of understanding (MOU) between the resource developer/provider and the new user to guide the appropriate future use of the resource and avoid liability if the resource is used out of bounds. All of this information about the M&S resource would be captured in the registry. An FFRDC that is independent of M&S developers could function as the M&S intermediary and provide this service to both government and industry.

Recommendation: Designate select M&S resources as open source and continue to incorporate open source products in DoD systems.

Open source software presents significant opportunities for M&S reuse if government leadership provides a vision for the open source project and if a viable business model for industry is put forward.

Open source software, by definition, overcomes one set of obstacles facing reuse today, specifically the license rights to use and modify software and share the derivative work with others. The collaboration inherent in the open source paradigm should also improve the quality of M&S resources by opening the set of research problems and resulting products to many potential contributors.

Government leadership will be essential to establish a vision for an open source project to cultivate a community of open source developers and testers/integrators who are "willing participants" but agree to adhere to the vision to prevent unproductive forking of derivative products.

Unfortunately, a business model has yet to be proposed that can compensate members of the open source community for their individual

contributions to the project and generate sufficient revenue. Industry's current business model for open source is largely dependent on providing support services (e.g., training) to open source users and add on features, or incorporating the open source software in one or more of its products. The former business model is broken Therefore, within DoD, open source software may be more practicable for common use, general purpose elements of the M&S software infrastructure such as a run-time infrastructure (RTI) or a Geographic Information System (GIS) and less appropriate for a complex simulation system with relatively few users. Industry can be expected to participate in an open source project to the extent that it can use the products in its government lines of business, so M&S systems with a broad user base are attractive candidates for open source.

DoD should continue to seek opportunities to use legacy open source software in DoD systems and to encourage industry to do the same. Sponsoring new open source development projects with the vision of a large and robust open source community at the start is problematic at this point due to the difficulties of capturing and rewarding individual contributions when the contributors work for different organizations, and the skills and knowledge employed extends to intellectual property controlled by the participant's firm.

DoD should contract for open-source software for systems where the expected user-base is broad, even if the original development community is small (including a single prime developer). Here, the upfront costs of training and growing an open-source community should generate a significant return in software quality and in the follow-on costs of software test and integration, and software upgrades.

Appendix A: Modeling and simulation resource reuse survey

The following is the set of detailed questions posed to a group of M&S professionals (appendix B) regarding their experiences attempting to reuse M&S resources developed by others or to provide resources to another organization for their reuse.

Discussion Issues:

Based on your experiences as an M&S professional, please consider the following issues in reusing a variety of M&S resources (ranging from simulations to databases to scenarios):

1. As an M&S resource consumer, what visibility do you have into resources that are available for reuse? Do you use M&S resource repositories or rely on recommendations from others to guide you to available resources? What could be done to improve M&S resource repositories?
2. As a resource provider, what incentive do you have to make your resources available for reuse by others?
3. How easy (or difficult) was it to adapt the resource to a new problem? Was the "savings" in development time or turn-around of analytical products sufficient to justify compensation to the resource provider?
4. Were you able to decouple the M&S resource from the original developer and "re-use" the M&S without support from the original developer?
5. If not, what type of support did you receive from the resource provider (or make available to the resource consumer) in adapting the resource to your problem?

6. What mechanism did you use to compensate the provider for his or her time in answering questions about the resource, guiding the new user in its application, and for the intellectual property and other investment in the resource? How did you negotiate a "fair" value for the provider's support and for a copy of the resource?
7. Was there any formal memorandum of agreement (MOA) on how the resource could be used to prohibit out-of-range or inappropriate applications?
8. What understanding existed between the resource user and provider regarding the user's responsibilities to report any deficiencies discovered while using the resource?
9. If the user made changes to the original resource were these reported back to the resource provider?
10. As a consumer of M&S resources, what could be done to make existing M&S resources attractive to you—to motivate decisions to reuse before buy and buy before build? As a resource provider, what could be done to incentivize you to make your resources attractive and available for reuse by others?
11. What does your typical M&S support contract look like? Do a software license and/or rights to the source code or databases developed as part of the M&S effort convey to the government as a deliverable?

Appendix B: Survey Participants

Table 6 lists the organizations of M&S professionals who participated in the discussion about their experiences with the reuse of M&S resources, based on questions listed in appendix A.

Table 6. Survey and Discussion Participants

Northrop Grumman	Boeing
Aegis Technology	Soar Technology
MAK Technologies	Lockheed Martin
PM FCS AD M&S	MOVES/NPS
NGA	Metron
NAVAIR Portable Source Initiative	NAVMSMO
OSD-JDS	JSF M&S
BreakAway, LTD	IWS M&S
MSIC, DIA TMAP	USN IWS SHARE
USJFCOM J9	SAF/XC
USAF Common Data Set	OPNAV N814
M&S EA (Ocean, Air & Space, Terrain)	NRL
IWS General Council (SEA00)	JASP
Pitch Technologies	MSIAC
MMA M&S	

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Appendix C: Naval Aviation Simulation Master Plan Portable Source Initiative: Discussion issues

The following is the set of detailed questions posed to developers of the Naval Aviation Simulation Master Plan (NASM) Portable Source Initiative (PSI). The NASMP PSI is an initiative to develop reusable terrain and sensor databases for use in aircraft simulators. Key to the business model are the use of open standards and government purpose license rights. The USAF and U.S. Special Operations Command have adopted a similar business model and are working with the Navy on this initiative.

Discussion Issues

1. The application of the N-PSI to terrain (visual) databases seems relatively straight-forward because there is little or no controversy over "authoritative," i.e., ground truth data. But your papers suggest that this approach has also been applied to develop "sensor" databases. Here there are opportunities for obvious differences in opinion over whose database should be considered an authoritative sensor database. What type of sensor databases have been addressed by the N-PSI? How have you resolved the issue of "authoritative?"

2. Do the N-PSI sensor databases deal simply with "numbers" of sensors and their characteristics, or do they also address sensor performance? Databases on sensor performance will always trigger debates on issues of "authoritative."

3. If you have solved the "authoritative" issue with respect to sensor databases, could this initiative to extended to other databases (e.g., intelligence, threat order-of-battle, weapons effectiveness, kill probabilities, and similar databases used in M&S)?

Here again, there is often controversy over whose database to consider as "authoritative."

4. How much and what type of "infrastructure" are involved in sustaining the N-PSI; for example, to make prospective users aware of these resources and to run a help desk to field questions, to house and manage the archive in Orlando? Within our project for OSD we can envision the need for management of this "infrastructure" to answer user questions, to guide users in the reuse of existing M&S resources, to manage software licenses and MOUs, etc. We assume there are some "infrastructure" management costs associated with maintaining the N-PSI. We would like to learn more and whether these costs are funded from a central pot or shared among all programs that use PSI resources. (See 8–12 below).

5. What limitations are placed on the vendor's use of the dataset? Are derivative works allowed? For example, can the vendor include the dataset in another product to be later sold to the government or other entities?

6. If a vendor downloads a dataset and modifies it in some presumably useful way, what mechanism, if any, is in place to test and potentially incorporate the changes?

7. What is the best way to think about and characterize the mission of the N-PSI (originally in 2004 and today)? Is the N-PSI largely about:

   a. Developing policy and standards and providing the education and awareness for programs to make use of these resources

   b. sponsoring "proof-of-concept projects, or

   c. developing and managing the actual infrastructure (i.e., datasets) that are made available to vendors?

8. Is there any funding associated with the N-PSI initiative and, if so, how is this funding employed, for example:

a. Did N-PSI fund the original development of the standards that defined datasets or did these standards come about through some other process/activity (e.g., SISO)?

b. Does it sponsor/fund database development projects (to develop content or to translate raw source data to datasets?

c. Does it sponsor/fund database maintenance (and archive) at NAVAIR Orlando?

d. Does it primarily fund policy development?

e. Does it fund demonstration projects (to illustrate how proposed policies would work in practice)?

9. Assuming there is an N-PSI budget, what is the nature of N-PSI funding?

   a. Does it receive a line-item Congressional appropriation?

   b. Or, does funding come "out of hide" from the NAVAIR budget (or from PMA 205 budget)?

   c. Is the funding from the RDT&E budget? O&M budget?

   d. How has the funding pattern changed over time?

10. How has the scale of recurring N-PSI expenses evolved over time?

    a. Staff compensation

    b. Contractor expenses for out-sourced activities

    c. Non-labor expenses (both RDT&E and O&M).

11. What has been the N-PSI staffing mix? (i.e., is N-PSI work done primarily by civilian and military government employees or does N-PSI funding include money for a significant proportion of private sector IT contractors?)

    a. Military

    b. Civilian civil service

c. Civilian contractor, cost-plus contract

d. Civilian contractor, fixed-fee basis.

12. What is the current mix of N-PSI responsibilities?

    a. Defining standards and guidelines

    b. Creating databases consistent with these standards

    c. Maintaining repository

    d. Facilitating distribution of existing assets

    e. Other.

13. What are the most recent N-PSI success stories?

14. How well will the 80/20 split approach work in a world dominated by proprietary third party source data (rather than free NGA data)?

15. Where will N-PSI be in 5 years?

16. How could we obtain a copy of contracting language recommended by N-PSI (whether used by N-PSI itself or recommended as standardized terms for other DoD agencies)?

17. What limitations are placed on the vendor's use of the dataset? Are derivative works allowed? Can the vendor include the dataset in another product to be later sold to the government or other entities?

18. If a vendor downloads a dataset and modifies it in some presumably useful way, what mechanism, if any, is in place to test and potentially incorporate the change within the government's archive or reusable datasets?

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List of figures

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List of tables

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