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TECHNICAL REPORT

Live-Virtual-Constructive Common Capabilities: Asset Reuse Mechanisms Implementation Plan

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The Johns Hopkins University
APPLIED PHYSICS LABORATORY

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Live-Virtual-Constructive Common Capabilities: Asset Reuse Mechanisms Implementation Plan

April 2010

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EXECUTIVE SUMMARY

The reuse of software, data, and other assets in Department of Defense (DoD) Modeling and Simulation (M&S) development is neither as frequent nor as effective as it could be, and as a consequence, the potential benefits of reuse to the DoD enterprise are not being fully realized. Improvements in the enterprise culture and processes supporting reuse are needed to increase the frequency of reuse. Three alternative approaches to accomplishing those improvements were defined and evaluated. Enhancements to the capabilities and coordination of DoD M&S asset repositories are needed to increase the effectiveness of reuse. An assessment of multiple existing repositories using a carefully developed set of M&S-oriented evaluation criteria was conducted to identify where those enhancements are needed.

The LVC Asset Reuse Implementation study team examined thirteen (13) existing M&S catalogs, repositories, and registries of interest to the Live-Virtual-Constructive (LVC) Architecture Roadmap Implementation effort and evaluated the applicability of these and other reuse initiatives. A detailed model of LVC asset reuse mechanisms based on twenty-two (22) comprehensive reuse use cases tied to the DoD Net-Centric Data Strategy and commercial standards for repositories was developed and used to facilitate the research and analysis conducted. Consideration of the state of these LVC asset reuse mechanisms, together with feedback from stakeholders within all communities enabled by M&S in the form of questionnaires, workshop discussions, and interaction in the government-industry profession, informed this study and recommendations.

Three complementary approaches to improve LVC Asset Reuse mechanisms were examined. The Transactional Approach focuses on enhancing the discovery and acquisition of reusable M&S assets through a set of distributed, interconnected M&S catalogs, registries, and repositories**.** The Social Marketing Approach addresses the long term improvement of behaviors that promote reuse of M&S assets**.** The Process-Based Approach encourages more frequent reuse by enhancing reuse guidance within standard DoD M&S systems engineering process models. These three approaches were evaluated in terms of desirability, achievability, and affordability, as well as the likely barriers to their success.

The Transactional Approach was rated as the most affordable due to existing investments and is roughly equivalent to the Process-Based Approach in terms of desirability. The Process-Based Approach was rated as the most easily achievable based on its compatibility with ongoing standards initiatives in M&S systems engineering processes, and also an emerging impetus towards Service-Oriented Architectures (SOA). A Social Marketing Approach was rated as the least mature in all three indices of desirability, achievability, and affordability, but it offers some unique methods to increase reuse frequency. Barriers to the success of the Social Marketing and Process-Based Approaches are rated as equal in difficulty.

Although these approaches were defined and evaluated in such a manner as to be separately executable, the study team's consensus was that all three approaches had merit, were synergistically combinable, and should be pursued together in the next phase of the LVC Architecture Roadmap Implementation Project in a twenty (20) staff-month effort.

1. INTRODUCTION

Live-Virtual-Constructive (LVC) communities can achieve greater efficiencies by better storing, discovering, and reusing assets stored in repositories, as well as by using standards for conceptual models, meta models, or interface agreements. This activity is designed to address the design-area problem that interfaces and other required integration assets (i.e., gateways, bridges) are often built anew each time they are required. This effort complements other efforts that are converging capabilities and agreeing on common tools, formats, and procedures. In general, modeling and simulation (M&S) asset reuse is lower than desired. The DoD M&S Steering Committee has recognized reuse as a corporate requirement and has several initiatives to improve visibility of resources.

1.1 PROJECT DESCRIPTION

This effort is divided into three tasks as listed below. This document addresses the first two tasks and provides a plan for the future completion of the third task.

1.1.1 Examine Existing Repositories and Registries

Examine existing repository and registry capabilities for M&S reuse, and compare these capabilities to the required mechanisms for sharing and reuse described in the LVC Architecture Roadmap.

1.1.2 Evaluate Applicability of Other Reuse Initiatives

Evaluate applicability of other M&S Steering Committee sponsored reuse initiatives (catalogs, metadata discovery specifications, etc.).

1.1.3 Develop a Recommended Implementation

Develop a recommended implementation based on government review of registry, repository and reuse initiative analysis.

1.2 LVC ARCHITECTURE ROADMAP CONTEXT

The Live-Virtual-Constructive Architecture Roadmap (LVCAR) Study made recommendations with respect to three important dimensions of simulation interoperability:

- Technical architecture
- Standards
- Business model

Within technical architecture, a specific recommendation was made to “direct efforts towards creating and providing standard resources, such as common gateways, common componentized object models, and common federation agreements” [Henninger, 2008].

1.3 RELATED EFFORTS

The Asset Reuse task is one of several investment recommendations directed at meeting this need. Specifically, this task was designed to examine existing infrastructure capabilities for M&S reuse, compare these capabilities to the required mechanisms for sharing and reuse described in the LVCAR, and develop and implement a plan to ensure the appropriate discovery and distribution mechanisms are available in the future. The plan must address more than just infrastructure. It must also include processes for reuse and possible incentives to improve reuse. This implies analysis of what causes programs to build new rather than reuse existing capabilities, and requires that processes and incentives address these tendencies. The resulting product will be an improved on-line repository that addresses the distribution aspect of all LVCAR products.

1.3.1 LVC Architecture Roadmap Efforts

The Convergence, Bridges and Gateways and other Common Capabilities LVCAR efforts are being done concurrently with this project. Although all of the LVCAR implementation tasks are interrelated, two of the other LVC Common Capabilities subtasks are most closely related to the Asset Reuse task: these are the Systems Engineering Process and Reusable Tools and Common Data Storage Formats subtasks.

1.3.1.1 Systems Engineering Process

Systems engineering, in general, refers to a body of knowledge and practice to apply structured processes for developing large and complex systems in a reliable and repeatable way [Kossiakoff, 2003][1]. Systems engineering processes typically feature organized reviews of interim products, comparative evaluation of alternatives, and structured refinement of designs [Blanchard, 1998]. The development of M&S systems, such as large models and distributed simulation systems can also benefit from the use of systems engineering processes. The Federation Development and Execution Process (FEDEP) and the Distributed Simulation Engineering and Execution Process (DSEEP) are systems engineering processes customized to the development of High Level Architecture (HLA) federations in particular (FEDEP) and distributed simulation environments in general (DSEEP). Each consists of a hierarchically organized sequence of tasks and subtasks for those purposes, with task descriptions, inputs, and outputs provided to assist developers in creating distributed simulation systems.

One effort within the current LVCAR Implementation effort is the Systems Engineering Process task. In this task, an "overlay" (an application-specific addendum) to the DSEEP is being developed, focusing on the development of distributed simulation environments that integrate more than one distributed simulation architecture [Distributed Interactive Simulation

[1] References may be found in Appendix A.

(DIS), HLA, Test and Training Enabling Architecture (TENA), and Common Training Instrumentation Architecture (CTIA)]. Within the current DSEEP document [DSEEP PDG, 2008], asset reuse is recommended in Step 2 - Perform Conceptual Analysis (Activity 2.1), Step 3 - Design Simulation Environment (Activities 3.1, 3.2, 3.3), Step 4 - Develop Simulation Environment (Activities 4.1, 4.3), and Step 7 - Analyze Data and Evaluation Results (Activity 7.2). Reuse within the DSEEP is often assumed, either explicitly or implicitly, to be at the level of a member application (in HLA terminology, a federate), but reuse of other assets such as simulation data exchange models (in HLA terminology, object models), planning documents, and scenario databases is also mentioned. Specific reuse mechanisms are not discussed in any detail in the DSEEP. Generic archives of reusable assets are mentioned, but specific repository contents and procedures are only identified in connection with TENA.

1.3.1.2 Reusable Tools and Common Data Storage Formats

Practitioners rely on utilities and tools for requirements development, conceptual and object modeling, scenario development, design, networking, testing, and after action review. This effort will improve reuse of tools and associated data by:

- Examining the various business model options associated with efficient, effective sharing of tool resources for DoD simulation applications,
- Identifying the most beneficial approach,
- Examining different data storage formats used across the various architectures to determine the feasibility of creating a set of architecture-independent formats for storage of classes of data, and
- Building a library of cross-community reusable tools.

The Asset Reuse solution must support the reuse of these tools and data by providing an effective mechanism for their discovery and sharing.

1.3.1.3 LVC Convergence, Bridges and Gateways Tasks

The LVC Convergence task, as well as the Bridges and Gateways task, offers an emerging community of LVC producers and users of M&S assets that will benefit from improved asset reuse mechanisms. This mechanism must be flexible enough to accommodate the software development practices adopted by the LVC Convergence team, facilitate collaboration between LVC stakeholder roles, and provide for seamless interaction across organizational boundaries. Existing LVC repositories for such programs as TENA and CTIA should be incorporated either directly or indirectly into the emerging LVC asset reuse mechanism, in order to leverage existing investments in their capabilities, to expand existing M&S communities of interest (based on these architectures), and to ensure that the reuse solution remains compatible with all architectures.

1.3.2 Other Efforts

A number of other efforts are explicitly or implicitly relevant to this effort. Modeling and Simulation "repositories" currently exist on several levels: DoD, Service component, and many DoD programs of record offer the means to search for, identify, describe, and in some cases to store, and forward, M&S capabilities to end users. Of particular interest to this effort is the M&S Catalog effort as described in the 2008 M&S Corporate and Crosscutting Business Plan [DDR&E, 2009]. The M&S Catalog's scope covers the entire DoD M&S enterprise and is focused on discovery mechanisms that are immediately relevant to M&S asset reuse. Previous related studies include three studies conducted in 2009. The first of these is the Center for Naval Analyses (CNA) Study, "Business Models to Advance the Reuse of Modeling and Simulation Resources" [Shea, 2009], which noted that "M&S repositories are incomplete and not kept current." The Joint Data Alternatives Phase II project prototyped a data catalog (DataCat) which focused on tools and data used to initialize simulations, with links to other repositories owned and operated by simulation programs of record (e.g. Cross Command Collaboration Environment (3CE), OneSAF). [Browning,2009]. Also in 2009, the Naval Surface Warfare Center Dahlgren Division (NSWCDD) commissioned a study of engineering repositories. Many of the lessons learned from the NSWCDD study are applicable to LVCAR reuse mechanisms. Moreover, this effort identified five reasons why repositories fail: (1) lack of funding, (2) insufficient metadata, (3) non-intuitive search, (4) inability to easily access resources, and (5) lack of incentive. [SimVentions, 2009].

As part of the assigned scope for this effort, the DoD-level Modeling and Simulation Information System and the major Service modeling and simulation resource repositories were examined. Although the information and resources stored in these repositories often consists of metadata descriptions of M&S assets stored and distributed through program-of-record mechanisms, this was not found to be universally true. In order to gain a more complete picture of asset reuse mechanisms currently used by LVC M&S producers, users, and integrators, a selection of available and accessible repositories was examined, both government and (in one instance) commercial resources. These included the following program repositories:

- Cross Command Collaboration Environment Knowledge Repository
- TENA Repository
- Live Training Transformation (LT2) Portal (used by CTIA)
- MATREX Integrated Development Environment (IDE)
- Forge.mil

In addition to these, the TurboSquid repository was examined from a commercially-based reuse perspective. Access to the Synthetic Environment (SE) Core repository was requested but not received in time for this report. Although the Joint Composable Object Model (JCOM) effort might in the future prove relevant to LVCAR reuse mechanisms, its prototype object model repository was not available for inclusion in this study.

1.3.3 M&S Community of Interest (COI) for Discovery Metadata

The mission of the M&S COI is to make M&S data and services visible to the Global Information Grid (GIG) user community, integrate M&S services into the GIG, and provide a forum for the M&S community to work within the COI to influence, advise, and educate the more global community with regard to M&S. Like other COIs, M&S will manage its metadata registry, establish taxonomies and ontologies to enable discovery and retrieval services, and conduct prototype experiments or demonstrations exploring the most appropriate services to enable GIG users in the key tasks of planning, training, sense-making, and decision making. The M&S COI will promote Service and Joint collaboration in the use of emerging technology to adapt services for the GIG and recommend standards and architectures that will best support M&S as an Enterprise Service. Coordination across other COIs will be critical as M&S has roles that span several domains. The final shape of M&S services will depend upon the design and execution of near-term proof-of-principle demonstrations.

1.4 GROUND RULES AND ASSUMPTIONS

The ground rules and assumptions of this study are described below. Previous studies have established the relevance of M&S registries and repositories to asset reuse. The analysis in this study addresses the alternatives associated with the following:

- Processes necessary to improve M&S reuse mechanisms,
- Capabilities and limitations of online M&S asset reuse mechanisms,
- Rationale for and barriers to collaboration between M&S producers, consumers, and integrators, and
- Incentives and disincentives to M&S reuse.

1.4.1 Assumptions

Based on coordination with LVCAR stakeholders, including the Reusable Tools and Common Data Storage format and LVCAR Business Model task leads, it is assumed that the overarching business model for DoD M&S Reuse is evolving and will evolve. It is further assumed that long-term support for shared infrastructure among the Office of the Secretary of Defense (OSD), Services, and the Program Executive Offices (PEOs)/Programs of Record will be enabled, with support from secure online technology available within the DoD M&S enterprise and the GIG. While no concrete assumptions are made for how the M&S COI within the GIG will be structured, it is assumed that LVC Asset Reuse mechanisms to be initiated under this effort need to be agile enough to progress the enterprise from its "as-is" through to its "to-be" state and also need to be synchronized with a subset of the activities described in Section 1.3.2. Finally, it is assumed that discovery mechanisms are an essential element of the "to-be" state, in order to complete the transactional chain from discovery to delivery of reusable assets and address relational issues involving M&S providers, users, and integrators.

1.4.2 Constraints

Constraints on this effort include the related efforts described in Section 1.3. LVCAR efforts as Convergence, Reusable Tools, and Common Data Storage Formats, and Bridges and Gateways describe the substance of reusable M&S assets that may require direct or indirect support from the LVC asset reuse mechanisms to be initiated and reinforced under this effort. M&S Systems Engineering processes also represent a set of needs to be addressed by these mechanisms. DSEEP provides the standards mechanism that captures proposed process improvements and associated documentation. Compliance with the DoD Network Centric Data Strategy and related standards must also be addressed, particularly when and where discovery and structural metadata standards and processes are involved.

These constraints are consistent with the fundamental precepts of the LVCAR tenets established during Phase I, which are:

- Do no harm
- Interoperability is not free
- Start with small steps
- Provide central management

1.5 KEY TERMS

In order to clarify concepts used throughout this document, a short summary of key terms and how they are used is provided in this section. Figure 1-1 depicts the relationships among these terms. Appendix E contains formal definitions for the terms discussed in this section and other reuse-related terms.

An Asset is a collection of associated artifacts from which a system or subsystem is composed. Assets have the following attributes:

- Have capability or content useful beyond their original application;
- Have been developed or enhanced to be of sufficient generality and quality to support reuse;
- Have been approved for reuse;
- Have been documented with pertinent metadata; and
- Have been placed into a repository.

By contrast, a Resource is an asset that has been recognized as reusable by communities enabled by M&S.

Reuse is defined as using a previously developed asset again, either for the purpose for which it was originally developed or for a new purpose or in a new context. Reuse may save

time, effort, or cost for development or testing. Reuse may add credibility to the new application if the asset underwent verification, validation, and accreditation for its previous use.

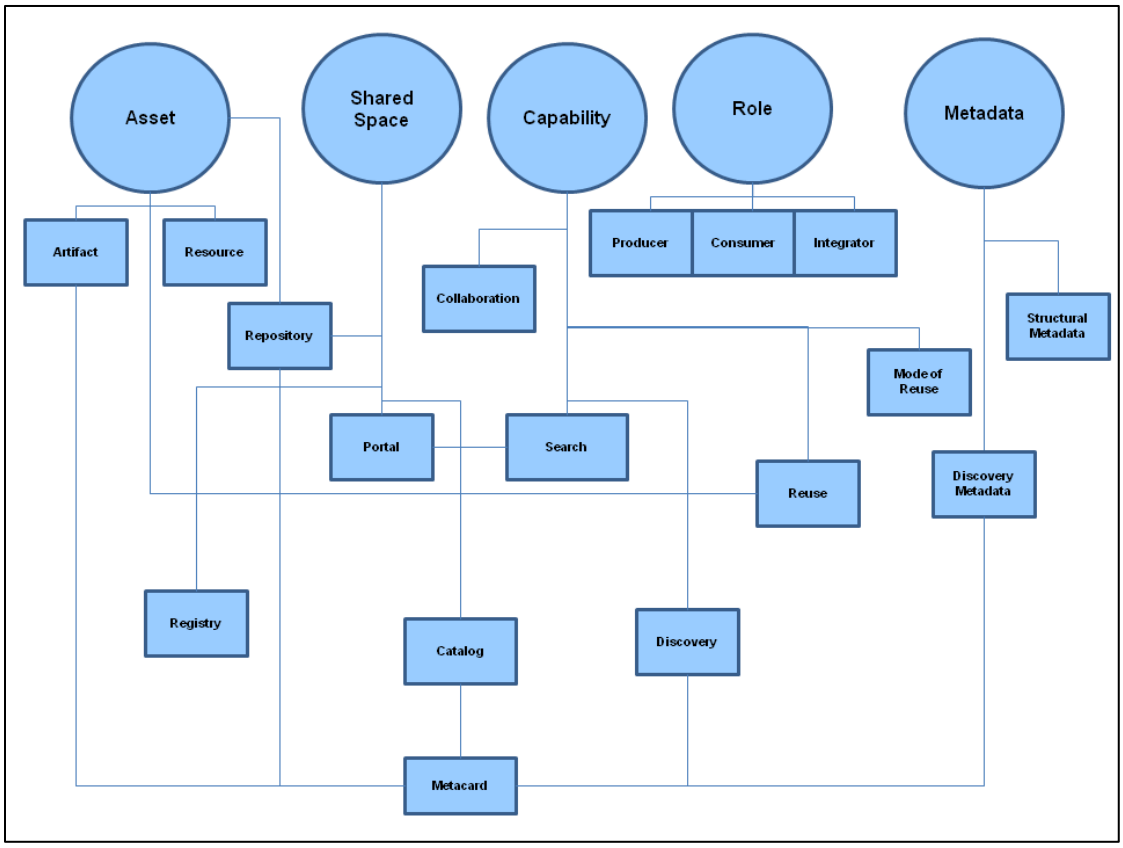

Figure 1-1: LVC Asset Reuse Terms and Relationships

Generally speaking, Metadata is data about data. It specifies the content, meaning, structure, and use of the data and provides information describing its characteristics. Metadata that describes the function and use of an artifact may often be searchable. Discovery is the process of searching, identifying, and selecting assets for reuse. It is enabled by discovery metadata and facilitated by user interfaces with features that support the discovery process. Discovery metadata aids in the recall and retrieval of an artifact (e.g., makes the artifact visible). A Metacard is discovery metadata for a particular asset and is often stored in a catalog (or metadata catalog). Structural metadata documents the internal characteristics of an artifact and may include name, description, data constraints, and tag relationships.

A Shared Space is a mechanism that provides data storage and access capabilities for users within a given network space and provides virtual or physical access to any number of data sets (e.g., catalogs, Web sites, registries, classification networks, document storage, or databases). Examples of shared spaces include catalogs, repositories, portals, and registries. While a Catalog is a system that accepts, stores, and provides access to discovery metadata for

assets, a Registry is a system that accepts, stores, and provides access to schemas or templates for metadata (discovery metadata and/or structural metadata), but not the metadata itself. A Metadata Catalog combines the functions of a catalog and a registry by accepting, storing, and providing access to both discovery and structural metadata for assets. A Portal provides (1) a human-machine interface that enables users to search and explore content assembled from one or more sources; and (2) personalized capabilities to a site's visitors, providing a pathway to other content. A portal presents the user a single web page that brings together or aggregates content from a number of other systems or servers. A Repository accepts, stores, and provides access to assets that may be reused. Assets that may be stored in a repository include software (components or modules), artifacts, metadata, data, or other assets.

For the purposes of this effort, three primary roles have been identified. A Role is a related and coherent set of actions, responsibilities, and authorities which a person or organization may undertake as part of the overall process of developing a simulation environment and/or reusing assets. These are the Consumer who pulls (e.g., acquires) a resource of interest, based on producer registered metadata, and shares experiences with respect to that resource. A Producer develops assets which are tagged and stored in shared space. Producers are generally responsible for adding Metadata to a catalog based on the registered format. An Integrator builds systems and applications from data components.

2. FINDINGS AND RECOMMENDATIONS

2.1 FINDINGS

The reuse of software, data, and other assets in DoD M&S development is neither as frequent nor as effective as it could be, and as a consequence, the potential benefits of reuse to the DoD enterprise are not being fully realized. To increase the frequency of reuse, improvements in the enterprise culture and processes supporting reuse are needed. To increase the effectiveness of reuse, enhancements to the capabilities and coordination of DoD M&S asset repositories are needed. An assessment of multiple existing repositories using a carefully developed set of M&S-oriented evaluation criteria was conducted to identify where those enhancements are needed. Three alternative approaches to accomplishing those improvements were defined and evaluated. These alternative approaches included (1) a Transactional Approach, which addressed the utilization of store-and-forward mechanisms and associated discovery processes to foster reuse of LVC M&S assets; (2) a Social Marketing Approach, which emphasized cultural barriers to LVC M&S reuse and the means to overcome those barriers; and (3) a Process-based Approach, which addressed the adequacy of M&S systems engineering processes and standards in addressing reuse in conjunction with the lifecycle support and event-driven utilization of LVC M&S assets. The Transactional Approach centers upon the discovery and acquisition of reusable M&S assets through a set of M&S catalogs, registries and repositories. The Social Marketing Approach focuses on the long term improvement of *behaviors* that promote reuse of M&S assets. These approaches are discussed in greater detail in Section 3-3. The Process-Based Approach is based on enhancing existing standard development process models, or defining and implementing new standard development process models for M&S development so as to emphasize opportunities, methods, and advantages for reuse.

Exploration of these alternatives in relation to the state of the M&S catalogs, registries and repositories reveals that:

- No single mechanism provides all the necessary functions to support end-to-end reuse of LVC assets;
- Ongoing efforts that are progressing to improve the utility of existing M&S catalogs, repositories, and metadata registries should be continued;
- Otherwise excellent repositories have yet to be integrated to enable enterprise-wide services for discovery, configuration control and acquisition of reusable LVC assets;
- Well-defined, high quality discovery metadata is essential to successful LVC asset reuse;
- Use of shared spaces should be expanded to improve collaboration among LVC stakeholders; and
- Programmatic aspects of LVC asset reuse demand further attention.

For details on the study methodology used to develop these findings, see Section 3.2.

2.2 RECOMMENDATIONS

In order to address the findings noted in Section 2.1 above, the following actions are recommended for the continuation of this effort in Phase II of the LVCAR project:

1. Execute a phased implementation plan, primarily focused on the Transactional Approach, that leverages existing M&S asset reuse mechanisms into a seamless federated capability. Specific actions to be done in conjunction with this recommendation include the following:

    a. Vet requirements with LVCAR stakeholders;
    b. Establish process for make-buy-reuse decisions for LVCAR assets;
    c. Define Relationship between the M&S Catalog and LVCAR asset repository for Phase II;
    d. Establish agreements among candidate stakeholder repositories;
    e. Establish distribution mechanism for LVCAR solutions (e.g. Open Source licensing);
    f. Implement federation of discovery and update among selected repositories; and
    g. Publish results of the LVC Common Capabilities and other LVCAR tasks to relevant M&S catalogs and registries.

2. Complementary mechanisms should be explored to apply the Social Marketing Approach and Process-based Approach to augment the Transactional Approach in order to further reuse. Specific actions to be done in conjunction with this recommendation include the following:

    a. Explain what new reuse capabilities and practices are available (e.g. MSIAC Journal);
    b. Utilize Wiki, RSS feeds, blogs, social networks;
    c. Adopt reuse mechanisms early through respected individuals within the community;
    d. Establish and disseminate message through social networks for communities enabled by M&S;
    e. Obtain feedback from stakeholders on how the message is perceived;
    f. Adapt social marketing technique based on feedback received;
    g. Invite repository owners to advertise through social networks;
    h. Initiate awards for successful reuse;
    i. Increase the emphasis on reuse in M&S systems engineering processes;
    j. Identify improvements to DoD system development and acquisition processes that facilitate M&S reuse;
    k. Leverage emerging M&S discovery processes and repository capabilities to help developers;

l. Examine communities where software repositories, product line frameworks, and development processes lead to reuse"; and
m. Identify, define and propose policies to facilitate LVC Asset Reuse.

3. The use cases and related criteria developed as part of this study should be utilized to derive more detailed technical requirements related for LVC Asset Reuse Mechanisms, including:
    a. User Interface / Portal Needs;
    b. Various levels of metadata needed for discovery metadata;
    c. Mechanisms needed for discovering structural metadata (to understand resource assets); and
    d. Policies to help facilitate LVC System Engineering Process.

4. Policies should be defined to ensure that the capability described by Use Cases and Criterion are subsequently considered by the organizations and services that produce, integrate or use LVC assets stored and distributed through a repository.

5. Feedback mechanisms need to be systematized for LVC transactions, social marketing and process improvement pertaining to reuse.

Resources and schedule supporting these recommendations are located in Section 4.

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3. IMPLEMENTATION STRATEGY

3.1 OVERARCHING GOALS

This section describes the key features of the recommended implementation strategy for LVC asset. From the LVC Common Capabilities workshop conducted in November 2009 at JHU/APL and online questionnaires, a number of critical challenges were repeatedly identified. These were:

- Build communities of trust by advertising real successes. This and related studies point to the need to improve expectations for successful utilization of online resources, including catalogs, registries, and repositories, to improve the reuse of M&S assets. Questionnaire results and subject matter expert discussions revealed that successful reuse involves trust within M&S communities of interest. Repository assessments also confirmed these assertions. Moreover, when repository owners put mechanisms in place that enable sharing of M&S assets across programs of record, successful reuse is achievable. The challenge is to extend these viable communities of trust, advertising success to improve the broader M&S community's understanding of what works best. In the short term, this involves leveraging existing initiatives and investments, acknowledging self-formed communities, and enabling these communities to interact with one another. A longer term goal is to overcome barriers to trust within the larger M&S community where these impede successful reuse.
- Model success to the M&S Community. It is essential that LVC Architecture Roadmap efforts adopt the best current practices with respect to asset reuse mechanisms. In the short term, this involves the use of catalogs, registries, and repositories to support M&S development initiatives adopted in Phase II. In the longer term, these mechanisms should be expanded throughout the DoD M&S enterprise to address a broader range of challenges with respect to LVC asset reuse, which transcend the scope of LVC multiple architecture simulation environments.
- Build critical mass based on local sharing. As greater awareness of successful LVC asset reuse spreads across the M&S community, the challenge becomes how to use this awareness to improve the utilization of asset reuse mechanisms, achieving a critical mass that modifies habitual practices and relationships. The immediate goal is to continue to identify Phase II stakeholders and obtain buy-in for the initiatives proposed as part of this implementation plan. In the longer term, the goals desired are to expand the collaborative reuse of LVC assets, both horizontally and vertically, across the DoD M&S enterprise and to ensure long-term institutional support for successful LVC asset reuse practices.
- Establish and capture metrics on reuse. In order to reinforce successful asset reuse, it is essential to measure the progress of both short-term and long-term initiatives. This

involves both subjective and objective assessments obtained by a combination of quantitative and qualitative methods. User feedback must be solicited and obtained in the context of a broader community that involves producers, users, and integrators of LVC assets. This information must be accessible in a form that enables M&S decision makers to understand the impact of resource and investment decisions.

- Set up incentives based on measurable progress. A final critical challenge is to incentivize successful LVC asset reuse mechanisms. These rewards are not limited to monetary resources – they also include policy advocacy within the M&S community and the reinforcement of reuse as a community value within the DoD M&S enterprise.

3.2 STUDY APPROACH

This study has employed a hybrid methodology to identify and assess alternative approaches to LVC asset reuse. This analysis is based on quantitative and qualitative data collected from:

1. Solicitation of experiences and expectations from the M&S community, which was done using the workshop and the questionnaires, and
2. An assessment of existing repositories.

Initial data collection during the workshop utilized qualitative methods using focus group exercises in combination with the results of a free-form questionnaire. These instruments were used to examine attitudes, beliefs, and norms held by representative M&S stakeholders. Follow-up analysis utilized quantitative methods to administer a discrete answer questionnaire and a battery of repository assessments derived from the team's engineering analysis, which defined twenty-two (22) use cases and associated capabilities. These use cases were used to frame the assessment of key M&S registries, repositories, and catalogs. A further discussion of the repository assessment methodology is contained in Section 3.4 and Appendix F.

Three approaches were examined to determine what actions might be undertaken to address the issues identified by the analysis. While these approaches were defined so as to be distinguishable for the purpose of resource allocation, they were also designed to complement one another, addressing different aspects of the problem space that the others could not fully address and enable synergies not achievable by adopting a single point solution within the scope of the implementation plan.

3.2.1 Related Research

The related research described below includes a survey of M&S reuse literature as well as more general research into social marketing and commercial business practices relating to strategic reuse cited below.

Survey of M&S Reuse Literature

M&S system development (for computer-based models and simulations) is, in large part, a special case of general software system development. Reuse is a major issue in general software engineering and is documented in a vast literature that includes both emerging results for researchers and practical advice for developers. At considerable peril of oversimplification, the software reuse literature can be partitioned into three broad topical areas, each with its own extensive literature, of which only representative examples can be identified:

1. Methods for making software components reusable, i.e., code-level software engineering practices such as structured programming [Jensen, 1979], object-oriented development [Meyer, 1988] (which both enables reuse by producing reusable classes and depends on reuse in the form of inheritance [Cox, 1986]), and software testing [Deutsch, 1979] [Beizer, 1983]. The additional cost of producing reusable, as compared to single-use, software has long been recognized [Brooks, 1975] [Enos, 1979] [Royce, 1998].
2. Technical capabilities enabling software reuse, such as software architectures [Jacobson, 1997], component repositories [dos Santos, 2009], class libraries [Mili, 2002], and discovery mechanisms [Hummel, 2004].
3. Management practices enabling and exploiting software reuse, including software development processes [Royce, 1998] [Mili, 2002] and business case incentives [Jacobson, 1997].

Reuse has, of course, been a major goal within M&S development as well. The work on general software reuse applies to M&S development precisely to the extent that M&S development is software development, which is clearly considerable, especially in large M&S systems. In addition, there are M&S-specific aspects of M&S development that relate to reuse. Four examples will be given:

1. The development of distributed simulation interoperability protocols, such as DIS, HLA, and TENA have all been motivated in part by the express expectation that they would increase reuse [Hofer, 1995] [Dahmann, 1998] [Noseworthy, 2008].
2. M&S standards of various types (other than interoperability protocols) have been defined with the intent of increasing reuse of the standardized assets [Henninger, 2009]; examples include natural environment data [Mamaghani, 1999], simulation data exchange models [SISO, 1999], asset discovery metadata [M&S CO, 2009], and aerodynamic models [Hildreth, 2009]
3. Systems engineering processes for development of M&S systems have been produced that explicitly encourage reuse at various steps within the process (e.g., the Federation Development and Execution Process (FEDEP) [SISC, 2003] and the Distributed Simulation Engineering and Execution Process (DSEEP) [DSEEP PDG, 2008]).

4. Composability is an M&S-specific form of reuse concerned with assembling new models by composing existing (i.e., reusable) models [Petty, 2003a] [Davis, 2003]. Composability research has studied the validity of the resulting composite models [Weisel, 2003], and the computational complexity of the composition (i.e., reuse) processes [Petty, 2003b].

Reuse has been used, supported, and advocated in a variety of ways in M&S development; some selected interesting examples are mentioned. Reuse of M&S assets is seen both as a goal [Funaro, 2009] and as an essential technology [Bizub, 2009] in developing integrated Live-Virtual-Constructive simulation systems. Successful reuse and schedule risk mitigation were demonstrated using a configuration-controlled repository in a large M&S experiment [Kleinhample, 2009]. Open architecture, object oriented development, and product line techniques produced a library of reusable M&S assets in the context of developing naval training applications [Belanger, 2009]. Source-code level issues specific to reuse based on class libraries have been incorporated into programming languages for discrete-event simulation [Garrido, 2009]. Recent research into applications of conceptual models has considered reuse of conceptual models, which are claimed to be more easily reused than implemented models [Asaduzzaman, 2009]. Finally, reuse must be considered not only from technical and management perspectives; legal issues associated with reuse, such as copyright, intellectual property, and licensing must also be taken into account [Joshi, 2009].

Attributes of Social Marketing to Support M&S Asset Reuse

- Low barriers to engagement usually via low cost, web-enabled communications
- Trust developed through sustained discovery and reuse of M&S assets across communities

3.2.2 Social Marketing: Concepts and Applicability

While there are numerous examples of social networks in the commercial sector, the concepts and techniques that make them such powerful tools to influence behavior are no less applicable to the DoD enterprise. A Social Marketing Approach recognizes that it is people who develop, manage, and reuse M&S assets. For the purpose of this study, Social Marketing is defined as identifying and leveraging the social relationships between Communities of Producers, Consumers, and Integrators to influence their behavior in order to improve the reuse of M&S assets within the DoD enterprise. Through their activities, they either explicitly or unknowingly affiliate with each other into social networks. It should be noted that while Social Marketing is the name of the approach, this is distinct from social networks which are a cultural phenomena that can exploited to perform social marketing.

Figure 3-1 is a conceptual graphic illustrating a few of the DoD communities enabled by M&S. The Shared Spaces, which in the aggregate are generally thought of as part of the GIG,

are more specifically "the mechanisms providing data storage of and access to data for users within a bounded network space" [DoD CIO, 2003]. Types of shared spaces include repositories, catalogs, and registries, all of which contain information about and access to various categories of assets, such as software components, data models, interface specifications, and document artifacts.

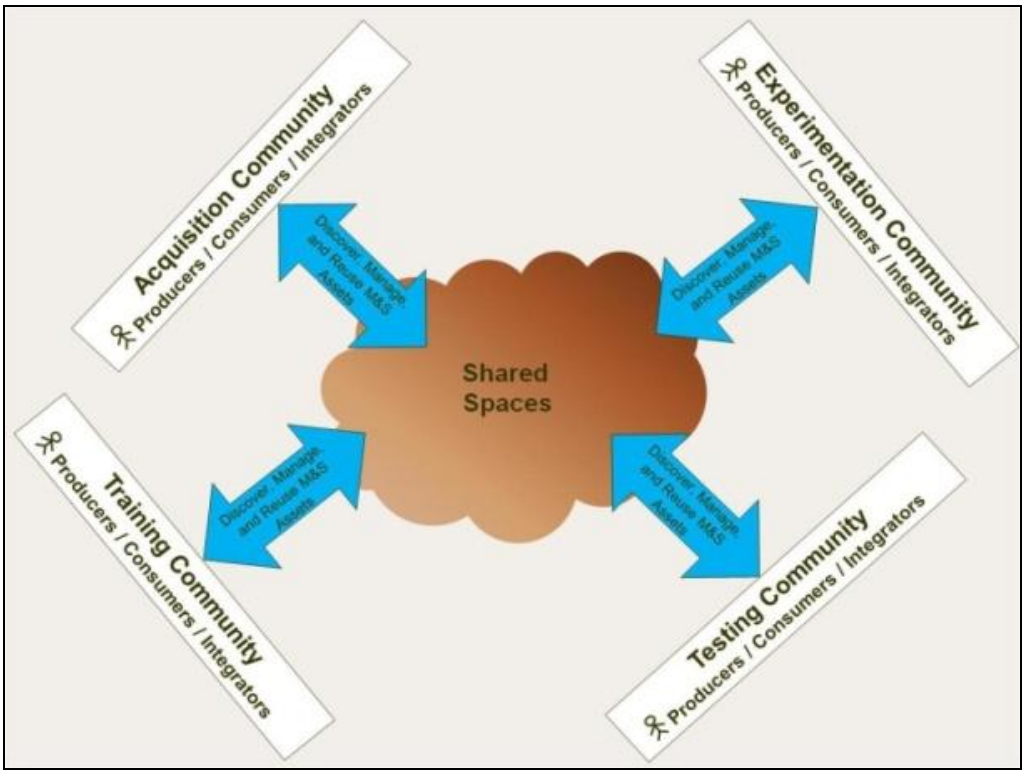


Figure 3-1: Conceptual Graphic of Some DoD Communities as Social Networks

Two of the hallmarks of social networking are its low barriers to engagement, usually through low-cost, web-enabled communications, and the development of trust between participants, who frequently may not have ever interacted on a personal level. These attributes enable the means of collaboration among producers, consumers, and integrators within the context of communities of interest, which fosters new opportunities for discovery and reuse of M&S assets. The sustainability and strength of these networks can be impacted by factors such as classification of the M&S assets and user authentication mechanisms [e.g., Common Access Card (CAC) requirement].

Further investigation into social marketing principles will likely reveal additional factors and means to foster long-term behavior change of producers, consumers, and integrators to emphasize sharing and reuse of M&S assets across the DoD enterprise.

3.2.3 Enterprise Based Reuse: Concepts and Applicability

Software reuse mechanisms are common within the commercial world as well as within military modeling and simulation. Prominent among these techniques is the software product line, a concept formalized by the Carnegie Mellon University (CMU) Software Engineering Institute (SEI). A software product line is defined as "a set of software-intensive systems that share a common, managed set of features satisfying the specific needs of a particular market segment or mission and that are developed from a common set of core assets in a prescribed way" [SEI, 2010]. Within DoD, a software product line may be implemented within a program of record, or across related programs. In the M&S community, this methodology has been employed within a number of LVC-related programs, including OneSAF and the Live Training Transformation (LT2) programs, which include CTIA and whose M&S assets are accessible through the LT2 portal.

Software product lines are distinct from opportunistic reuse and are more frequently employed in software development organizations with a high degree of software maturity. Reuse considerations come into play in this model, which outlines processes for establishing make-buy-reuse criteria within a structured software engineering process. Reusable work products include software libraries, databases, organizational resources, product components, identification of reuse needs, and reusable components.

An alternative view of managed software reuse emerges from the Agile software development community. The IBM Rational Unified Process has been extended into an "enterprise" process model that explicitly takes software reuse into consideration. (Ambler, 2005). This model defines nine activities that relate to software reuse:

- Plan Reuse Program
- Harvest Existing Asset
- Obtain External Asset
- Develop Asset
- Evolve Asset
- Publish Asset
- Retire Asset
- Support Reuse
- Measure Reuse Program

This model defines four roles that relate to reuse: (1) A "reuse manager" who defines the vision for the reuse program and creates a reuse plan that incorporates reuse metrics, organization, and staffing resources; (2) a "reuse engineer" who develops asset criteria, evaluates and selects assets, creates, generalizes and tailors assets (where appropriate), conducts validation and testing, redeploys robust assets to a repository, develops and supports reuse guidance, configures deployed assets for specific uses, and supports the enterprise by providing training

and assistance in reuse methods; and (3) a "reuse registrar" who registers assets and communicates their availability. Many of the LVC asset reuse mechanisms explored in this study possessed elements of this model, which was used to assist in verification of the conceptual model developed as part of this task and described in Section 3.2.4.

3.2.4 Conceptual Model

The engineering analysis conducted under this task developed and revised a conceptual model for LVC asset reuse. The key elements of this model:

- Describe the operational context for LVC asset reuse mechanisms;
- Establish a taxonomy for LVC asset reuse mechanisms; and
- Enable a functional analysis of LVC asset reuse mechanisms.

Figure 3-2 depicts a conceptual overview of LVC asset reuse mechanisms in the form of an Operational View – 1 (OV-1) diagram. Producers, integrators, and consumers collaborate within shared spaces through portals to M&S catalogs, registries, and repositories. Asset producers utilize repositories to store and forward M&S resources, and post metacards to M&S catalogs that describe those resources. When the producer defines structural metadata as well, this information is posted to the appropriate metadata registry. M&S integrators and users discover and retrieve M&S assets made visible by the M&S catalog and stored in a repository; they also provide feedback to users through these mechanisms.

Figure 3-3 further elaborates this conceptual model according to five functional areas:

- Ingest functions include mechanisms to distribute and tag assets with metadata as well as develop online artifacts linked to M&S assets and resources
- Manage functions pertain to storage and update of both asset data and associated metadata used to support asset discovery and acquisition
- Access functionality enables users and integrators to search for and discover M&S assets, as well as obtain and provide feedback about these assets
- Repository Infrastructure includes functions pertaining to access, security and enabling tools that facilitate collaboration and reuse among producers, developers and integrators
- Organizational Framework pertains to management and support functions that are necessary to make these mechanisms viable and usable to the respective community of interest

These functions and roles were further elaborated into use cases described in Section 3.2.5.

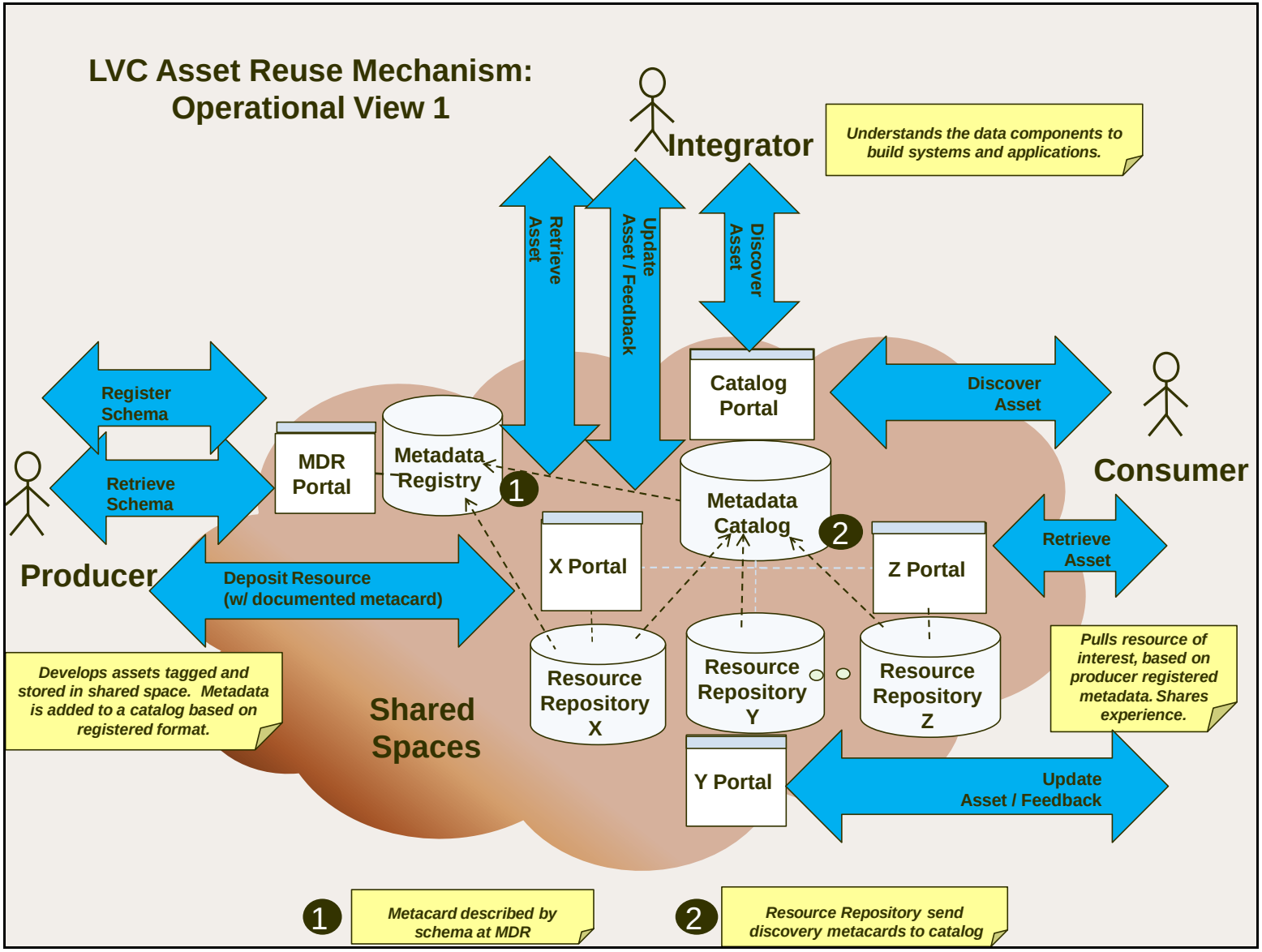


Figure 3-2: LVC Asset Reuse Mechanisms: A Conceptual Overview

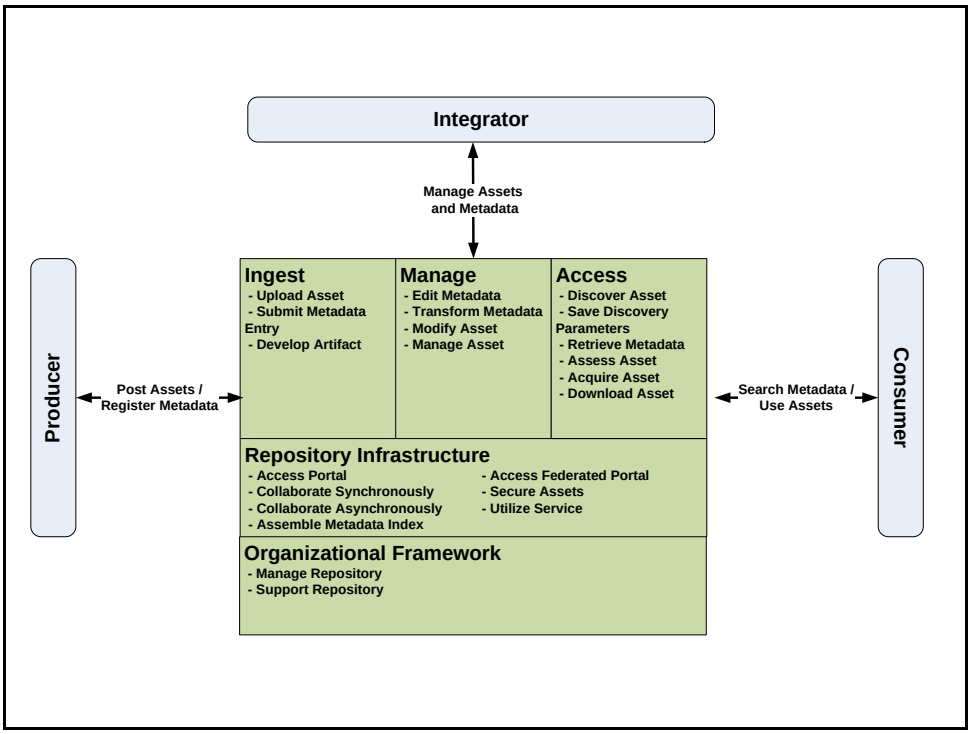


Figure 3-3: LVC Asset Reuse: A Context Diagram

3.2.5 Use Cases

The LVC Asset Reuse Mechanism team developed twenty-two comprehensive use cases depicted in Figure 3-4 as part of the engineering analysis supporting this effort. The relationship between these use cases and the LVC roles they support is depicted in Figure 3-4. These LVC roles are defined in the M&S Lexicon in Appendix E. Table 3-1 maps the roles in the use case diagram in Figure 3-4 to the higher level roles previously described:

Table 3-1: Use Case Roles and Mapping

High Level Role	Use Case Role
Producer	Federate Developer/integrator
Integrator	Federation Engineer/tester
Integrator	Federation Manager
Consumer	Federation Tester
Producer Consumer	Program Manager
Producer Consumer	Sponsor
Consumer	User/operator
Consumer	Verification and Validation Agent
Consumer	Accreditor

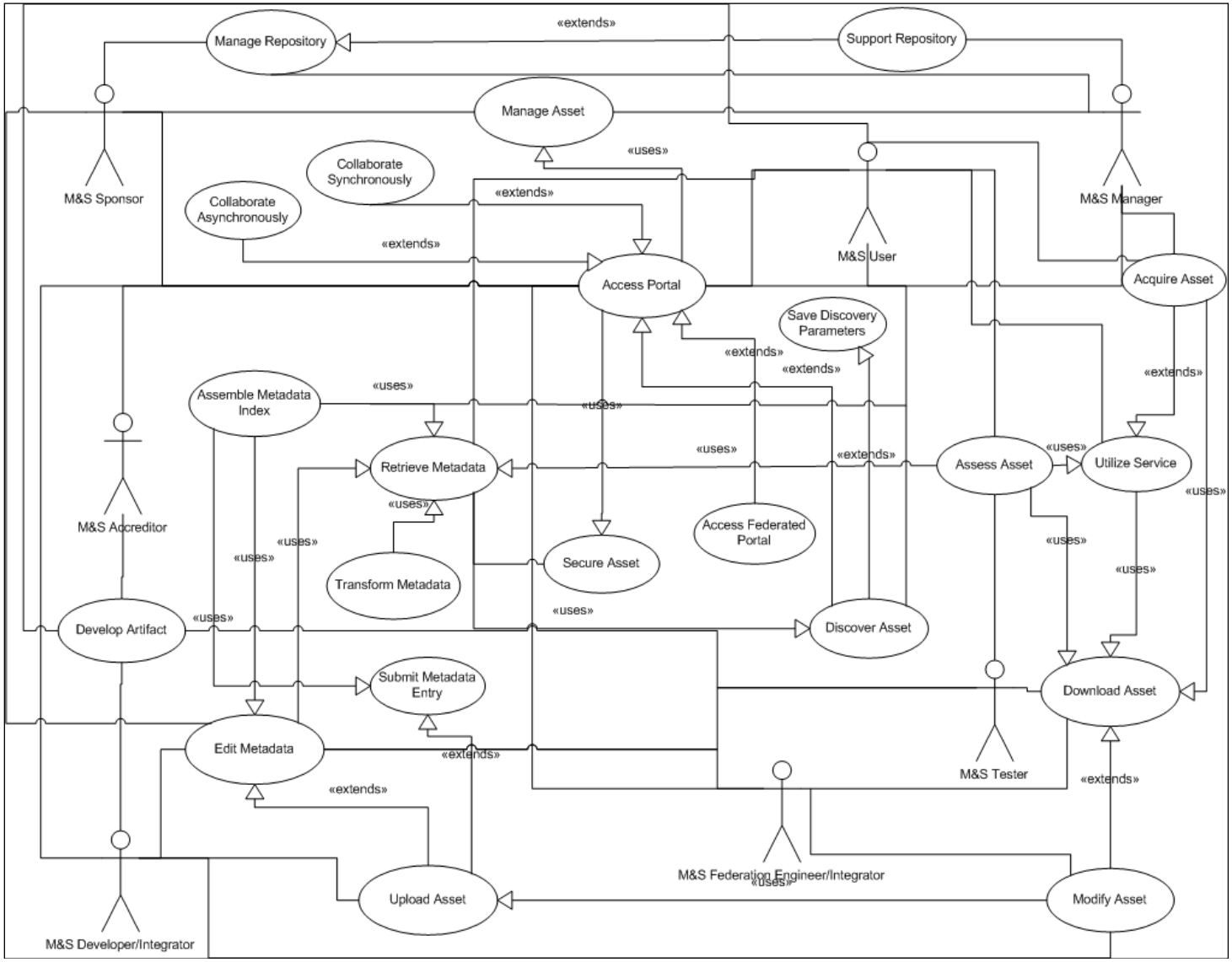


Figure 3-4: Use Cases for LVC Asset Reuse

The various roles described in Table 3-1 have diverse needs for information, data and services provided by M&S registries, catalogs and repositories. A comprehensive mechanism for LVC asset reuse must address the varying needs of these stakeholders consistently, and without excessive overhead or redundancy. Although it is not necessary to store and forward all the data pertaining to an LVC product or event from a single repository, a useful asset reuse mechanism will enable all classes of users to navigate seamlessly across system boundaries, on an "authorized user, need to know" basis.

These use cases were developed as architecture-neutral views to describe necessary functions performed by M&S registries, catalogs and repositories, independent of their organizational context or sponsorship. These use cases are fully described in Appendix B, with definitions and activity diagrams representing each use case.

1. Access Portal. All roles access Asset Reuse Mechanism services through one or more portals. The Asset Reuse Mechanism provides a single entry point to core services and federated M&S COI portals through the GIG, with information assurance, secure access and transport services.
2. Collaborate Asynchronously. The Asset Reuse Mechanism supports asynchronous collaboration services to include bulletin board, email, document storage, access subscription, and display. This use case is an extension of Access Portal capabilities.
3. Collaborate Synchronously. The Asset Reuse Mechanism supports synchronous collaboration services that include chat, desktop collaboration, and limited video conferencing. This use case is an extension of Access Portal capabilities.
4. Assemble Metadata Index. The Asset Reuse Mechanism enables the assembly of a searchable M&S catalog and associated taxonomy from registered metadata tags.
5. Discover Asset. Asset Reuse Mechanism discovery services provide extended search capability for M&S assets stored in core and federated repositories using extensions to the DoD Metadata Specification for the M&S Community of Interest. These extensions will be documented in the M&S COI Discovery Metadata Specification (MSC-DMS).
6. Save Discovery Parameters. The Asset Reuse Mechanism enables the user to save search parameters used during M&S Asset discovery.
7. Submit Metadata Entry. The Asset Reuse Mechanism enables M&S Sponsors and other authorized roles to register metadata entered into the core and federated repositories.
8. Retrieve Metadata. The Asset Reuse Mechanism enables the retrieval metadata on M&S assets from repository data stores using discovery/search and browse functions. Retrieval may be filtered using MSC-DMS categories.

9. Edit Metadata. The Asset Reuse Mechanism provides utilities enabling role-based editing of M&S asset metadata stored in the core and federated repositories.
10. Transform Metadata. The Asset Reuse Mechanism provides the ability to convert M&S asset metadata from one schema to another.
11. Assess Asset. The Asset Reuse Mechanism provides services to facilitate role-based assessment of M&S assets described by the core and federated repositories.
12. Utilize Service. The Asset Reuse Mechanism provides the capability to execute selected M&S services in a Web 2.0 environment over the GIG.
13. Acquire Asset. The Asset Reuse Mechanism provides utilities and services that enable online requests for access to M&S assets stored in the core and federated repositories. These services include online initiation and processing of government-furnished equipment (GFE) request and distribution agreements, distribution of access and download instructions, and M&S sponsor information.
14. Download Asset. The Asset Reuse Mechanism provides secure download of M&S assets stored in core and federated repositories once the M&S Sponsor has authorized the M&S asset to be acquired.
15. Modify Asset. The Asset Reuse Mechanism provides the capability to modify an M&S Asset for an intended use.
16. Upload Asset. The Asset Reuse Mechanism provides secure upload of M&S assets into the core or a federated repository using GIG services.
17. Manage Asset. The Asset Reuse Mechanism provides supporting tools, software configuration management, and versioning capabilities to enable role-based modification of M&S assets.
18. Develop Artifact. The Asset Reuse Mechanism provides online templates and supporting tools to develop role-based artifacts associated with M&S assets.
19. Secure Assets. The Asset Reuse Mechanism provides information assurance, data rights, and distribution controls to ensure that only authorized personnel may access data according to DoD policy processes.
20. Access Federated Portal. The Asset Reuse Mechanism enables the user to access a federated repository either directly based on a set of credentials or through the target repository's native portal.
21. Manage Repository. The Asset Reuse Mechanism enables M&S Managers to establish and enforce practices/processes to fulfill the repository's goals.
22. Support Repository. The Asset Reuse Mechanism provides accessible and reliable resources to assist users in utilizing repository services and maintain repository infrastructure.

3.2.6 Capability Decomposition and Assessment

The use cases listed above were decomposed into the activity diagrams located in Appendix C. These use cases were further linked to aggregate assessment criteria for M&S catalogs, registries and repositories. These criteria were derived from the DoD Network Centric Data Strategy and the *Framework for Evaluation of Digital Repository Software* utilized by the University of Illinois Urbana-Champaign Exploring Collaborations to Harness Objects in the Digital Environment for Preservation (ECHO DEPository) project, a five-year effort funded by the Library of Congress National Digital Information Infrastructure and Preservation Program (NDIIPP) [UIUC, 2009]. The ECHO DEP criteria originated from a joint task force study conducted by the National Archives and Records Administration and Research Libraries Group (RLG), Inc. from 2003 to 2005 [RLG 2009]. RLG later merged with the Ohio College Library Center (OCLC) in 2006 [Childress, 2010]. Appendix B describes the trace of these assessment criteria to the use cases described in Section 3.2.7 above and in Appendix C. A variety of existing criteria for assessing repositories of different types were examined in the process of developing M&S asset repository assessment criteria for our analysis. Two of those sources are the Net-Centric Data Strategy criteria, developed for assessing repositories storing data in the context of net-centric warfare [DoD CIO, 2003] and the ECHO DEPository Framework, a set of criteria for evaluating library digital repository software systems, intended for use as part of an audit instrument for the certification of trusted digital repositories within the Library of Congress National Digital Information Infrastructure and Preservation Program [UIUC, 2005].

3.2.7 Human Factors Considerations

The Common Capabilities Workshop sessions and supporting questionnaires were developed to obtain information about the perception of M&S stakeholders with respect to LVC asset reuse mechanisms. Both the preliminary questionnaires and workshop sessions were designed to maximize voluntary input and to encourage an efficient and candid expression of attitudes, beliefs, and desires with respect to LVC asset reuse and supporting mechanisms. This data was reduced and analyzed to assist in refining the use cases, assessment criteria and alternative approaches. The results of this analysis are summarized in Section 3.5.3 and Appendix D.

3.3 ANALYSIS OF ALTERNATIVE APPROACHES

Three approaches were defined for the purpose of analyzing alternatives. Although each approach was defined as a stand-alone course of action that could be executed on its own merits, the alternatives were formed as a means to establish resource priorities and to elaborate short-term and long-term goals.

3.3.1 Transactional Approach

The Transactional Approach centers upon the discovery and acquisition of reusable M&S assets through a set of M&S catalogs, registries and repositories, which may or may not be federated. The OV-1 illustration provided earlier depicts the functional components used for the

Transactional Approach. Metadata information resources, such as schemas and specifications, are registered in a Registry. These metadata information resources are used to document and define the resources that are built and used, including metacards, which represent the discovery metadata. Metacards and resource assets are deposited by publishers in one or more repositories. Each repository may allow its metacards to be collected by a Catalog. A Catalog provides a common portal for Integrators and Consumers to search for resource assets of interest without the need for having to go to each available repository and perform repeated searches. Once a resource asset of interest is discovered, an authorized user should be able to retrieve that resource asset through access of the repository for which it is stored. However, a Catalog and the repositories that it represents may be federated. A federated environment would allow discovery to occur either through the Catalog or a repository node, which is connected to other repositories. In addition, a federated environment may also allow the ability for an authorized consumer to retrieve a discovered resource asset directly based upon the federated interoperability that is provided and the sharing agreements that have been made among the federated repositories and catalog.

The Transactional Approach is desirable because it leverages existing investments in discovery of M&S assets. Rather than having to design and build new repositories, existing repositories can be utilized and come on-line via a Catalog offering reflection of each repository's metacards.

The adoption of this approach among existing repositories is achievable because it represents an incremental change to current practices. In other words, repositories, as they exist, are still able to function independently if necessary. The steps to increase the transactional capability are fairly straightforward. Repositories, as they exist now, must simply provide to one or more catalogs access or a listing of its metacards, which describe the available asset resources. These repositories can then evolve to allow further real-time mining and search by other connected nodes (either catalog or like repositories) thereby establishing a federated environment. The registries, which are also part of the infrastructure, provide a means to quantify (i.e., validate) metacards and their resource assets and can be utilized immediately by existing repositories with little to no impact simply through the use of Uniform Reference Identifier (URI) reflection and namespaces, which is already employed by the majority of repositories.

The Transactional Approach is also affordable because the solution can be designed to cost. This is in large part due to the achievability aspect discussed above. An incremental change to current practices yields minimization of cost. However, adequacy of services may be difficult to assess without proactive and continuous feedback.

The major benefit is clear; the Transactional Approach supports improved visibility of M&S reuse across the enterprise, but there are a few barriers. Just knowing that a reusable asset exists does not guarantee that it will be (re)used. Additionally, a lack of trust among users, communities perhaps among a competing industry, may prevent collaboration among members of the M&S community especially if they have not successfully worked together before or are concerned of protecting intellectual property (IP). The Transactional Approach therefore assumes the "kindness of strangers" [Williams, 1947, 11] (e.g., that M&S assets exist in a form that can be reused to fulfill one's own needs).

The Transactional Approach allows visibility to be assessed, but assessing reuse is more difficult. In other words, it is fairly straightforward to determine what metacards pertaining to a resource asset have been viewed and how often, and even how many, what downloads pertaining to the resource asset have occurred, which is indicative of a resource' visibility. However, the number of metacard views and downloads does not report on the reuse value of a resource. Although benefits can be measured objectively by recording transactions relating to use of online M&S reuse mechanisms, it may be difficult to form conclusions as to the actual benefit of some services. Moreover, if the repositories and catalogs provide a means to collect user experience and augment an asset's metacard with such usage information, then the opportunity exists to garner better visibility of reuse pertaining to a resource.

The incentive for the Transactional Approach is that it offers a highly functional way to advertise, promote and share resources. Such visibility may be beneficial (a) politically for an organization in socializing their work and (b) financially for a producer who may be looking for "buyers" of the resource asset or in developing similar resource assets. For some, though, this visibility can be a disincentive if the resource assets are misunderstood, misused, or misappropriated. This may result in either a negative effect pertaining to an organization's image or a producer's loss of IP. Typically, however, these issues are based upon perception. A repository or catalog seeks to protect the M&S resources by limiting only those authorized to access it. A repository, registry, or catalog allowing producers and integrators to have some control on the metacards that describe such resource assets should help reduce adverse perceptions; as use increases, the incentives for a Transactional Approach gain in value.

Therefore, to implement this approach, these actions are recommended:

1. Vet requirements with LVCAR stakeholders. Collaboration with LVCAR stakeholders should be ongoing throughout the duration of Phase II. These include internal stakeholders on the Common Capabilities, Convergence and Bridges, and Gateways teams, as well as external stakeholders, particularly the M&S Catalog project and other federated repositories whose capabilities may be leveraged.
2. Establish process for make-buy-reuse decisions for LVCAR assets. A standard template for make-buy-reuse should be developed to create a protostandard for

transaction-based reuse. This template should take into consideration alternative development approaches and should be exposed to shared spaces as part of the LVC emerging LVC asset reuse mechanism.

3. Define the relationship between the M&S Catalog and LVCAR asset repository for Phase II. Current M&S Catalog access policy limits portal access to US Government and contractor personnel. Because the strategic objectives of this effort are to model success, it follows logically that M&S assets developed in Phase II will be exposed to the M&S Catalog through metacards. However, for dissemination to government and commercial stakeholders, a separate distribution mechanism is required. Appropriate agreements should be made for the process and procedures used to expose LVCAR project assets to the M&S Catalog. This will require direct technical collaboration as well as a consideration of releasability and distribution licenses. There should be a common understanding as to what level metadata input should be supported into the M&S Catalog in metacard form.
4. Establish agreements among candidate stakeholder repositories. A set of candidate federated repositories should be identified for the purpose of expanding shared spaces for LVC asset reuse. This process may involve reduction of replication of redundant assets, within a framework agreed upon among the respective stakeholders.
5. Establish distribution mechanisms for LVCAR solutions (e.g., Open Source licensing). In order to achieve LVCAR goals, it will be necessary to disseminate core assets developed in Phase II to both government and commercial partners. Distribution licenses will need to be established and enforced by the LVC asset reuse mechanism.
6. Implement better federation among repositories. Active measures should be undertaken to utilize social networking and other media to provide continuous updates on repository contents. Likewise, feedback mechanisms should be shareable among repositories.
7. Publish results of the Reusable Tools study and other LVCAR tasks (e.g., Convergence, Bridges and Gateways) to relevant M&S catalogs and registries. In addition to the M&S Catalog metacard upload and discovery mechanisms noted above, it may be necessary to publish structural metadata to the DoD metadata registry and other metadata catalogs as transaction-based reuse mechanisms mature.

3.3.2 Social Marketing Approach

The Social Marketing Approach focuses on the long term improvement of *behaviors* that promote reuse of M&S assets. By its nature, this approach advances social and public goods associated with reuse of LVC assets. It does not address financial incentives directly, but rather influences M&S producers, integrators, and users to adopt practices which extend the boundaries of shared spaces in the context of evolving institutional frameworks. Investments in social marketing activities orient M&S stakeholders to support LVC asset reuse objectives by

encouraging voluntary exchange of information about M&S assets within social networks. Accompanying these efforts are "social marketing" campaigns designed to spread a coherent and positive message about LVC asset reuse and analyses of the results of these campaigns to determine what changes in attitudes and behaviors have resulted from these efforts.

This approach differs from the other two alternatives in several respects. It is particularly desirable because it directly addresses the disincentives that have caused M&S reuse mechanisms to fail in the past. If properly executed, the results of this study indicate that it is achievable because both workshop and questionnaire feedback indicate that there is a broad desire for improvement of M&S reuse mechanisms with the DoD community. It is also affordable because investment can be made in increments that accelerate return on investment rather than suffering from diminished returns. This is the point made in Malcom Gladwell's [2002] *The Tipping Point: How Little Things Can Make a Big Difference*. A successful social marketing campaign makes desirable behaviors habitual, with positive and long-lasting results.

Despite these advantages, a number of barriers have been identified that inhibit the potential success of this alternative approach. In the first place, ingrained habits are not easily changed. For example, DoD-specific Wikis have been built within the DKO/AKO environment, but not exploited to facilitate reuse of M&S assets. If M&S stakeholders do not share the same commitment to LVC reuse as a community value and a common good, then the impact of social marketing is lessoned, desirable behaviors not enforced by the M&S community, and undesirable behaviors may not only not be penalized, they may be rewarded. Finally, in the expert opinion of the study team, if immediate short term results cannot be assessed, then leadership may prematurely judge this approach to have failed.

To implement this approach, these actions are recommended:

1. Explain what new reuse capabilities and practices are available (e.g. the Modeling and Simulation Information Analysis Center (MSIAC) Journal). Mature M&S professional journals and networking events should be utilized to highlight the importance of asset reuse and to identify new trends and practice, both pertaining specifically to DoD M&S, as well as with the broader fields of education and training, systems and software engineering and information technology. Feedback received from these efforts should be collected and analyzed.
2. Utilize Wiki, Really Simple Syndication (RSS) feeds, blogs, social networks. Use of existing shared spaces should be expanded in a creative fashion that enables key stakeholders to collaborate both synchronously and asynchronously. While DoD-specific media appear to be well developed and useful for these purposes, utilization metrics should be collected and assessed periodically to determine their overall value in furthering LVC asset reuse and to determine whether service gaps exist across the communities enabled by M&S.

3. Adopt reuse mechanisms early through respected individuals within the community. Early adoption of social networking methods should be advertised by respected technical and management professionals across the communities enabled by M&S.
4. Infect the enterprise with a viral rather than controlled message. As part of the long-term strategy associated with LVC asset reuse in Phase II and beyond, the adoption of reuse themes should be monitored, analyzed, and reported in conjunction with participation in professional conferences and networking events associated with the communities enabled by M&S. Consideration should be made as to how reuse messages are symbolized in these media and how those symbols penetrate across the larger DoD enterprise into neighboring communities.
5. Obtain feedback from stakeholders on how the message is perceived. Periodic assessments should be conducted at least annually to determine how messages and symbols pertaining to LVC asset reuse. Such assessments may utilize a combination of qualitative and quantitative methods to collect data upon and measure stakeholder perceptions.
6. Emulate successful use of social marketing techniques. Additional research should be fostered on the utilization of social marketing to further software and systems reuse within the commercial sector. Where scientific evidence points to proven successful practices, these efforts should be documented and provided to DoD asset reuse mechanism sponsors for adoption where and as appropriate.
7. Invite repository owners to advertise through social networks. Independent social media should enable LVC asset sponsors to advertise their efforts through an expanding set of social networks. Where government-owned or -operated social media channels exist, this should be done on a "non-interference" cost-neutral basis.
8. Initiate awards for successful reuse. Established professional societies and journals within the communities enabled by M&S should be encouraged to initiate awards for particularly successful asset reuse mechanisms.

3.3.3 Process-Based Approach

Standard systems engineering process models are growing in importance in M&S system development. Two examples focused on distributed simulation are the HLA-specific Federation Development and Execution Process (FEDEP) [SISC, 2003] and the general Distributed Simulation Engineering and Execution Process (DSEEP) [DSEEP PDG, 2008]. Such development process models are intended to increase the consistency of the development process and to improve the quality of the developed systems. The third alternative approach to increasing the frequency of reuse during M&S development is based on enhancing existing standard development process models, or defining and implementing new standard development process models for M&S development so as to emphasize opportunities, methods, and advantages for reuse.

The Process-Based Approach is desirable because it provides a sound engineering framework for enterprise-wide M&S reuse mechanisms. It is compatible with and can be used in conjunction with the other two approaches. Development processes provide a procedural context for the technical transactions of the first approach, and the cultural inducements of the second approach can motivate developers to apply the reuse aspects of the development process models. Moreover, it enables M&S reuse mechanisms to exploit service-oriented architecture solutions as they arise by providing guidance to developers on how to find and use those solutions.

The Process-Based Approach is achievable because it works within structures already extant within the M&S community. Development process models such as the FEDEP and DSEEP are widely used and accepted. While they already give some attention to reuse, they can be enhanced to more prominently identify opportunities for reuse within the context of an M&S paradigm (distributed simulation) partially motivated by its enabling potential for reuse. Of course, non-distributed simulation development process models should also be enhanced or developed.

The Process-Based Approach is affordable because it leverages existing investments in development processes, including time and effort spent defining and standardizing the processes and tools developed to support the processes. It also enables the collection of process activity; that is, specific information about technical and programmatic barriers to M&S reuse, thereby providing a strong basis for collecting both qualitative and quantitative metrics to measure M&S reuse progress.

There are certain barriers to this approach. No "system of systems" or "enterprise" architecture is recognized as applicable to existing M&S reuse mechanisms, so process model references to reuse may need to be less specific than desired. A lack of universally accepted standards and broadly accepted business models for M&S development could inhibit the success of a process-based approach.

Overarching enterprise wide process improvements aimed at increasing reuse are needed, not simply program-by-program incremental practices (although the latter offer valuable lessons learned). Given the organizational and financial authority available in the DoD M&S community, a straightforward enterprise-wide mandate to coerce reuse may be attractive to some decision makers. However, history has shown that even DoD mandates are not as effective as might be hoped (e.g., the Ada programming language experience). Instead, it may be more effective to encourage and enable reuse by including it within the M&S community's best practices for development, as proposed in this approach.

Therefore, to implement this approach, these actions are recommended:

1. Increase the emphasis on reuse in M&S systems engineering processes (e.g., the FEDEP and DSEEP). Reuse-oriented enhancements to the processes can begin as

"overlays", i.e., separate documents that serve as appendices to the main document with an emphasis on a special topic, in this case reuse. As community consensus grows, the reuse overlay material can be incorporated into the main standards, in accordance with the applicable standardization procedures.

2. Identify improvements to DoD system development and acquisition processes (existing or new) that facilitate M&S reuse. These improvements should both encourage reuse directly, and also encourage the use of M&S standards, which as a side effect of standards compliance encourage reuse indirectly. Improved processes can both encourage reuse of existing M&S assets and secure new assets for future reuse, the latter accomplished by promoting development practices that produce reusable assets and including process steps that encourage the upload of reusable assets to suitable M&S asset repositories.
3. Leverage emerging M&S discovery processes and repository capabilities to help developers identify and acquire available M&S assets and minimize redundant development. This relates closely to the repository assessment discussed elsewhere in this document; easier discovery of applicable M&S artifacts and inclusion of needed repository capabilities will promote increased reuse. (Repository use cases essential to reuse include Use Case (UC) 01 Access Portal, UC 13 Acquire Asset, UC 14 Download Asset, UC 19 Secure Assets, and UC 20 Access Federate Portal; repositories must be able to support these operations.)
4. Examine communities where software repositories, product line frameworks, and community development processes lead to reuse (e.g. HLA, MATREX, CTIA, TENA) and incorporate their best practices into development process models.

3.3.4 Comparison of Approaches

Table 3-2 summarizes the short-term and long-term potential of the three approaches to achieve the strategic goals for LVC Asset Reuse as described in Section 3.1. Although, all three approaches advance the building of communities of trust in the short-term, the Social Marketing Approach requires a longer term effort to overcome barriers to trust that currently existing within the communities enabled by M&S. Both the Transactional Approach and the Process-Based Approach offer benefits to model success for LVC Asset Reuse mechanisms. All three approaches enable the achievement of critical mass based on local sharing and offer venues for the collection of metrics necessary to gauge progress. The Transactional Approach offers both short-term and long-term benefits for the incentivization of M&S stakeholders to support LVC Asset Reuse mechanisms. The Process-Based Approach and the Social Marketing Approach require a longer-term effort to achieve beneficial results in this area.

Figure 3-5 illustrates the comparative benefits versus barriers of the three approaches examined in support of the immediate objectives of the LVCAR Implementation Project. The color coding in this diagram reflects a subjective assessment by the study team of the maturity of

each approach. The brighter the color, the greater the benefit or barrier. The lighter the color, the greater the effort to achieve positive results, and the greater the impact on the communities enabled by M&S. The Transactional Approach is rated as the most affordable due to existing investments and is roughly equivalent to the Process-Based Approach in terms of desirability. The need to implement stronger measures of effectiveness and incentives across communities enabled by M&S is considered the least significant barrier to prevent the success of the three approaches. The Process-Based Approach is rated as the most easily achievable based on ongoing standards initiatives in M&S systems engineering processes and also ongoing impetus towards Service Oriented Architectures (SOA). Social Marketing is rated as the least mature in the short term for all three indices of desirability, achievability and affordability. Barriers to the success of the Social Marketing and Process-Based Approaches are rated as equal in difficulty.

Table 3-2: Comparison of Approaches to Achieve Reuse: Short and Long Term Goals

Challenges	LVC Asset Reuse Goals	Applicability		
		Transactional Approach	Social Marketing Approach	Process-Based Approach
Build communities of trust by advertising real successes	Leverage existing initiatives and investments	S		S
	Enable self-forming communities to interact	S	S	
	Overcome barriers to trust across the broader M&S community		L	
Model success to the M&S community	Build a short-term capability to support LVC Architecture Roadmap needs	S		S
	Expand short-term capability to address wider LVC Architecture Roadmap challenges	L		L
	Build an enterprise-wide capability	L		L
Build critical mass based on local sharing	Identify key Phase II stakeholders	S	S	S
	Expand utilization vertically and horizontally	L	L	L
	Provide long-term institutional support	L		L
Establish and capture metrics on reuse	Capture feedback from users	S/L	S/L	S/L
	Establish community in which users and developers may interact	S/L	S/L	
	Provide useful data for strategic investment decisions	L		L
Set up incentives based on measurable progress	Reinforce successful M&S community reuse mechanisms in the form of standard practices and policies.	S		L
	Advocate the expanded utilization of standard reuse mechanisms	L		L
	Institutionalize collaborative reuse as a community value		L	

S = Short-term goals **L = Long-term goals**

	Transactional	Social Marketing	Process-Based
Desirable	Leverages existing investments in discovery of M&S assets	Addresses negative behaviors that have caused M&S reuse mechanisms to fail in the past	Provides sound engineering foundation for enterprise-wide M&S reuse mechanisms including SOA solutions
Achievable	Promotes an incremental change to current practices	Studies show there is broad desire for improvement of M&S reuse mechanisms	Addresses technical standards for operational and systems architectures
Affordable	Solutions to support improved visibility of M&S assets can be designed to cost	Incremental investment may progress over time to cultural "Tipping Point"	Leverages existing investments in M&S reuse mechanisms
Barriers	Measures of effectiveness are difficult to implement and incentives are not addressed	Changes in behavior must be consistently reinforced to change the culture	No existing "enterprise architecture" facilitating M&S asset reuse

Figure 3-5: Comparison of Approaches to LVC Asset Reuse

On balance, therefore, the Transaction-Based Approach offers the most attractive positive attributes, with the least difficult barriers to success. However, the consensus of the team was that the other two approaches had desirable benefits that merit limited and low-risk investment.

3.4 SUPPORTING ANALYSIS

A series of supporting analyses were conducted to support the formulation of alternatives and specific recommendations that support these alternatives. These included the assessment of existing M&S-related catalogs, repositories, and registries; a series of questionnaires to collect information about M&S stakeholder attitudes, beliefs, and opinions about LVC asset reuse mechanisms; and conduct of workshop exercises using qualitative methods to elicit feedback from key M&S stakeholders about LVC asset reuse and facilities that support reuse.

3.4.1 Assessment of Existing M&S-related Catalogs, Repositories and Registries

Thirteen (13) M&S-related catalogs, repositories, and registries were assessed according to the twenty-two (22) use cases described in Section 3.2.5 and further detailed in Appendix C. Each of these sites was scored by use case as having full functionality, partial functionality, or no functionality needed to fulfill the use case in accordance with the aggregate criteria found in Appendix B. Raw scores obtained through this methodology were converted into weighted scores as applicable to each category. While the results in no way reflect on the success or the overall usefulness of any of these facilities, they do indicate how well each of them represents the desired functionality associated with M&S catalogs, repositories, and registries and collectively describe where centers of excellence reside within the facilities surveyed. The weighting of use cases by category was determined by the expert consensus of the study team, and reflects their collective opinion as to the relative importance of use cases and associated criteria. Although any particular weight may be the subject of discussion or disagreement among knowledgeable experts, the cumulative effect of the weighted ratings nevertheless accurately characterizes relative overall capabilities among the assessed repositories.

Figures 3-6 and 3-7 depict the relative capability of all sites to support each use case. These results indicate that most of the sites surveyed are reasonably well-supported and have taken appropriate measures to secure the data maintained in them. It also shows a strong preference for asynchronous over synchronous collaboration consistent with the store and forward model. Many of these asset reuse mechanisms provide means for user feedback on LVC assets, even if these assets are maintained elsewhere. A small number of sites possess loosely coupled linkage in accordance with the "Access Federated Portal" Use Case. Capabilities to upload and download assets and/or edit or modify metadata vary by category and site. Discovery mechanisms are generally present. This is an area where improvement is possible, particularly in terms of support for DoD-wide metadata standards, including MSC-DMS.

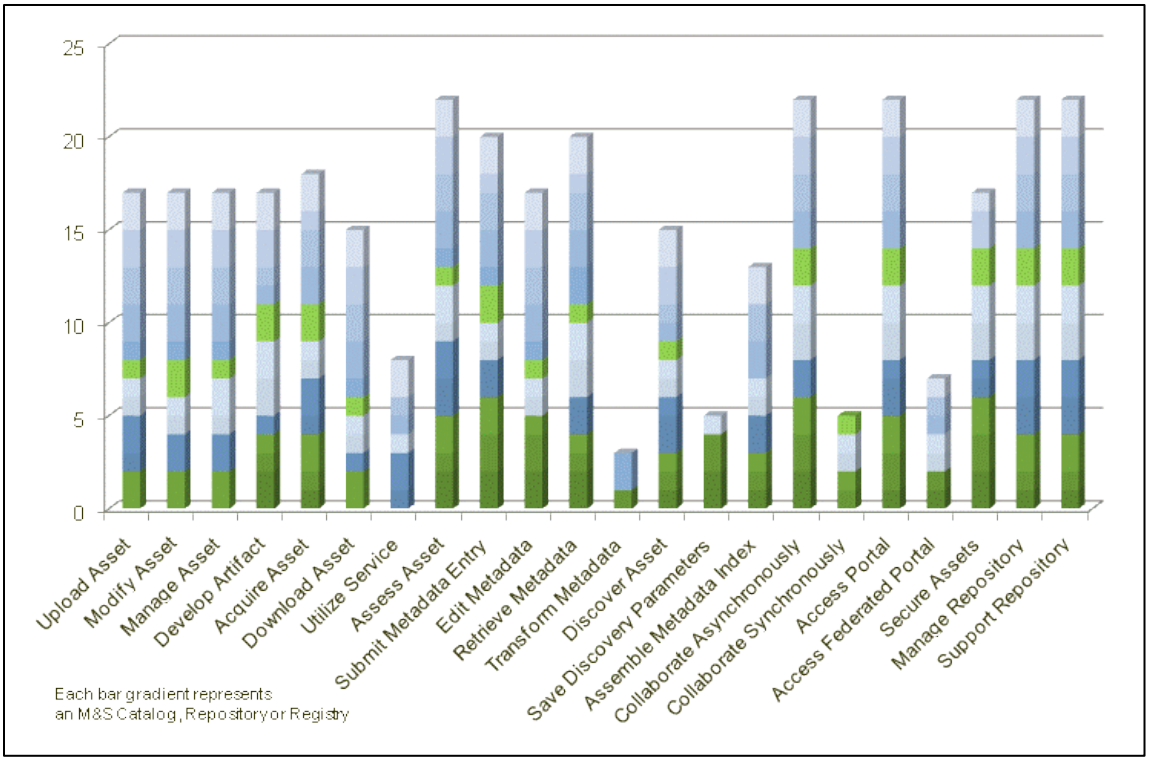


Figure 3-6: Assessment Results (Sum of Raw Scores by Use Case)

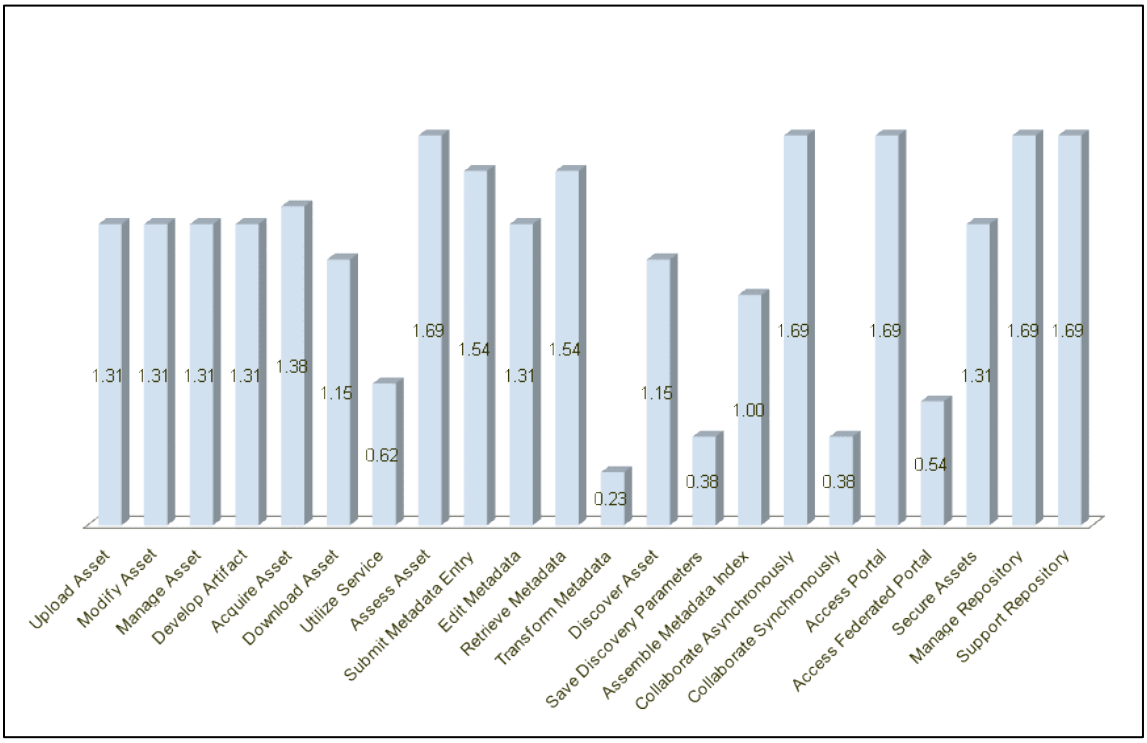


Figure 3-7: Assessment Results (Average of Raw Scores by Use Case)

3.4.2 M&S Catalogs and Metadata Repositories

3.4.2.1 Definition

A metadata catalog is (1) A system that accepts, stores, and provides access to discovery metadata for assets and/or (2) A system that accepts, stores, and provides access to metadata, discovery and structural, for assets.

3.4.2.2 Modeling and Simulation Information System

The DoD Modeling and Simulation Information System (MSIS) is operated by the MSIAC. MSIS is an electronic archive used to store metadata descriptions covering a variety of M&S tools, documents, databases, object models and contacts.

The MSIS maintains both unclassified (on the Internet) and classified (on the SIPRNet) systems. In addition to search, storage, and retrieval, both systems provide a secure method for protecting resources, and enforcing "need to know".

The MSIS provides a drill-down browse capability and a search function. In both cases, resulting lists of available resources are sorted alphabetically. There is no option to sort the results by relevance or date. There is a capability to save search specifications for later use.

The MSIS provides links to the indicated repositories but does not include their content in search results:

- Army Modeling and Simulation Resource Repository;
- Air Force Modeling and Simulation Resource Repository;
- Navy Modeling and Simulation Resource Repository; and
- Defense Intelligence Modeling & Simulation Resource Repository.

Registered users can add or modify resources for which they are responsible.

The MSIS provides features to:

- Create special interest groups to facilitate collaboration;
- List strengths, limitations and intended uses of the assets; and
- Include usage histories on assets.

Observed shortcomings in the implementation included:

- Many links on the site return an "Under Construction" error message, particularly the functions involving user IDs and passwords; and
- Drill-down browsing and keyword searching are commingled. If users do not know how to categorize the asset that they are looking for, they will not be able to locate it by either drilling down or by searching.

The Object Model Resource Center (OMRC) was a specialized repository containing HLA object models. It is not currently operational. The collection of assets that formed the content of the OMRC began from an effort of the Electronic Proving Ground to create a data dictionary known as the Joint Data Elements for Modeling and Simulation. After support was transitioned to the University of Texas Applied Research Laboratory, the repository was developed with two components, both focused on HLA object models: the Object Model Library, which stored object model structures, and the Object Model Data Dictionary System, which stored class and attribute definitions. Both Federation Object Models and Simulation Object Models were included in the repository, since they were usually automatically acquired during the HLA compliance certification process. The contents were typically full object models, as the reuse of component object models (such as Base Object Models) had not yet developed, and the best granularity for reuse of object models was not clear. Responsibility for the OMRC was eventually transitioned to the MSIAC, where it was supported for some period of time, but as noted it is not currently operational, and its former contents are not available.

3.4.2.3 M&S Catalog

The M&S Catalog is one of the first DoD repository projects to apply a search engine against resources that are commonly tagged with the same type of metadata. Users of the M&S Catalog and MSC-DMS include the Army, Navy, Air Force, and DoD MSRRs, and the joint analysis community. A user interested in a resource can learn of availability from multiple repositories with a single query. For the M&S Catalog, content feed files use metatags derived from the M&S COI Discovery Metadata Specification (MSC-DMS). These can be very useful, but, because of the restrictions of the Google Search Appliance (GSA) metatags, is not as powerful as the MSC-DMS itself. For example, it cannot perform a search that lists the Subject Matter Experts (SMEs) associated with a specific resource along with a listing of the resources each SME has supported in a technical capacity. The M&S Catalog provides a common portal with connection to various M&S-related repository sources, and is expected to be declared operational in early 2010. In addition, the M&S Catalog will be federated with the DoD Enterprise Catalog, and publish-and-subscribe mechanisms using DoD Net-Centric Enterprise Services (NCES) will be developed. The M&S Catalog currently requires Common Access Card (CAC) access, which may limit its utility to non-DoD stakeholders. It stores no assets directly but rather provides metadata about assets which are stored in and disseminated from other mechanisms (e.g., M&S repositories maintained by programs of record).

3.4.2.4 US Army Modeling and Simulation Resource Repository (MSRR)

The Army Modeling & Simulation Resource Repository promotes interoperability, reuse, and commonality through information sharing and communication throughout the M&S community. The Army MSRR holds the metadata (descriptions) about Army M&S resources.

Army MSRR registered resources are categorized below, with the number of available resources in parentheses:

- All (1146) - Alphabetical listing of every Resource registered in the Army MSRR.
- Data Sources (129) - Sources of data utilized in Army M&S activities, specifically including: databank, dataset, library, repository, software program, subject matter expert, warehouse, and other.
- Documents (25) - Publications used in the management of Army M&S.
- Models and Simulations (927) - Models, simulations, and simulators found in the current Army inventory.
- Related Sites (23) - Websites containing information on Army M&S activities.
- Support Tools/Utilities (42) - Tools and utilities utilized in the support, development, and management of Army M&S activities.

In some cases, the resource will be available for immediate download. Otherwise, requests for acquiring the actual resources are submitted to the point of contact designated in the MSRR metadata.

The Army MSRR provides a drill-down browse capability and a search function. In both cases, resulting lists of available resources can be sorted alphabetically or chronologically. There is no option to sort the results by relevance. There is a capability to customize report content (i.e., specify a subset of the available data elements to include, and provide selection criteria for choosing which resources) and to save the report definition for later use.

The Army MSRR allows search results to include information obtained from:

- Air Force Modeling and Simulation Repository;
- Navy Modeling and Simulation Catalog; and
- DoD Modeling & Simulation Resource Repository (now named MSIS).

Registered users can add or modify resources for which they are responsible.

Synchronous collaboration capabilities are provided by the Army Knowledge Online (AKO) system.

3.4.2.5 Joint Data Architecture 2 (JDA2)

JDA Phase I focused on improving M&S interoperability through increased data interoperability. The Phase I study included a recommendation for further efforts in data collection. JDA Phase II included implementation of a prototype repository, DataCat. DataCat differs from some of the other repositories that were studied in its focus on asynchronous collaboration. During the JDA project, the DoD and Service MSRRs were data-mined by human means for some descriptive and point-of-contact information used to populate DataCat for demonstration purposes.

While DataCat can output MSC-DMS 1.1 records for the purposes of publishing it out to the M&S Catalog, its strengths consist of collaboration and linkages between entries. DataCat allows for detailed linkages between logically related elements (e.g., a Point of Contact (POC) for an element leads to the POC's entry that includes references to all the elements to which the POC is related and the associated role). It also represents both atomic and aggregate elements (e.g., federations, with linkages to the constituent elements as illustrated in Figure 3-5).

3.4.2.6 Cross Command Collaboration Environment (3CE) Knowledge Repository (Metadata Only Repository/Catalog)

The 3CE Knowledge repository is a catalog of M&S assets maintained and utilized by the US Army Training and Doctrine Command (TRADOC), US Army Research, Development and Engineering Command (RDECOM), and US Army Test and Evaluation Command (ATEC). This tool is hosted on the 3CE AKO cabinet and can be downloaded in spreadsheet format. This site practices access control in two stages: (1) All users must have an AKO account and must be granted access to the respective AKO cabinet through 3CE. The M&S metadata maintained in the 3CE Knowledge Repository is primarily used to assess known assets rather than to support discovery of assets, and 3CE has developed its own metadata schema to support these evaluation processes. In general, the store-and-forward and collaboration functions accessible in the 3CE Knowledge Repository are fully sufficient for government and DoD contractor usage. Both synchronous (e.g., chat) and asynchronous (e.g., e-mail, bulletin board) functions are available on AKO. AKO provides the 3CE site owner the ability to assign read-write permissions to each cabinet by individual and user group. M&S assets listed in the 3CE Knowledge Repository are also cross-linked to the US Army MSRR, which also uses the AKO portal to regulate access. 3CE maintains a management plan and training materials that describe processes and procedures for site operation. [Army, 2009]

3.4.2.7 Summary Assessment: M&S Catalogs

Figure 3-8 depicts the weighted scores of the five M&S catalogs surveyed by use case. As with the overall set of M&S asset reuse mechanisms, these facilities tend to have strong functionality regulating portal access. In some cases individual sites have establish loosely coupled linkages to other sites as well, either within a common portal or through a separate portal. Although some collaboration capabilities are supported by these sites, considerable room for improvement remains in this area. The maturity of discovery, feedback, and metadata submission mechanisms vary by site, as does the currency of metadata maintained by these facilities. It should be noted that only sixteen (16) of the twenty-two (22) use cases were used to assess these sites, the remainder being not relevant to the role and function of catalog mechanisms.

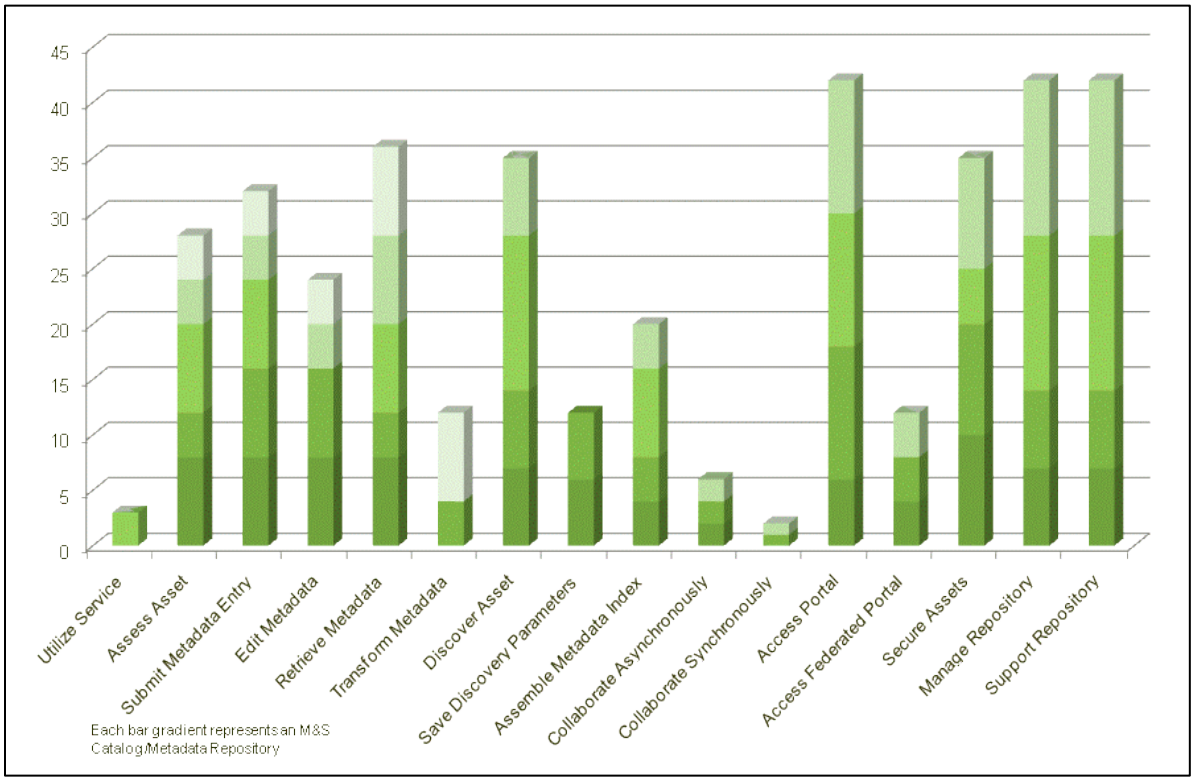


Figure 3-8: M&S Catalogs ("Metadata Repositories"): Weighted Scores

3.4.3 M&S Asset Storage Repositories

3.4.3.1 Definitions

An asset repository accepts, stores, and provides access to assets that may be reused. This typically includes both hardware (e.g., disk storage) and software (e.g., configuration management) aspects. Such a repository may store software (components or modules), artifacts, metadata, data, or other assets.

Many M&S repositories which provide either asset metadata or direct access to M&S assets make use of asynchronous or synchronous collaboration services. Synchronous collaboration involves the exchange of information and assets in real-time through face-to-face, teleconference, or web-enabled interactions (e.g., through a chat or instant message server). Asynchronous collaboration takes place when one party posts information pertaining to artifacts or assets to a repository which is then accessed and/or downloaded by another party. The latter asynchronous method is sometimes called "store and forward" collaboration.

3.4.3.2 Forge.mil

Forge.mil is a family of services provided to support the DoD's technology development community. The system currently enables the collaborative development and use of open source

and DoD community source software. These initial software development capabilities are growing to support the full system life-cycle and enable continuous collaboration among all stakeholders including developers, testers, certifiers, operators, and users.

Forge.mil is a Defense Information Systems Agency (DISA)-led activity designed to improve the ability of the US Department of Defense to deliver dependable software, services, and systems in support of net-centric operations and warfare. The Forge.mil effort started development in October 2008, and the first capability, SoftwareForge, is now available for limited, unclassified use. SoftwareForge is the first component of Forge.mil to be deployed. SoftwareForge enables the collaborative development and distribution of open source software and DoD community source software

M&S utilization of Forge.mil is quite limited at present, although a few software developers such as the Army Research Laboratory have utilized it to store and disseminate government rights software.

3.4.3.3 US Navy Modeling and Simulation Resource Repository

The Navy Modeling & Simulation (M&S) Resource Repository (MSRR) provides a web portal for the Navy M&S community identifying the following types of resources:

- Models and Simulations including simulators used for Navy activities;
- Data Sources utilized in Navy M&S activities;
- Tools and Utilities utilized in the support, development and management of Navy M&S activities; and
- Organizations involved in Navy M&S management.

VV&A Documents

- Related Sites pertaining to Navy M&S activities.
- References such as publications used in the management of Navy M&S.

At present the Navy MSRR identifies 1298 resources dating back to January 2006 [NMSO, 2010]. The most common resource type identified consists of "models and simulations." The metadata that is captured and reflected for each of these resources varies dependent upon the resource type. However, the Navy MSRR is a source participant with the M&S Catalog and offers its metacards in a format consistent with the MSC-DMS.

3.4.3.4 US Air Force Modeling and Simulation Resource Repository

The Air Force MSRR provides a web portal for the Air Force M&S community identifying the following types of M&S resources for Air Force activities:

- Models representing physical, mathematical or logical specification of a system, entity, phenomenon, or process;
- Simulations representing methods for implementing a simulation over time;
- Simulators identifying a physical device used to implement a model or simulation;
- Architectures related to Air Force M&S efforts;
- Data Sources utilized in Air Force M&S activities;
- Facilities containing specialized equipment used in analysis, training, experimentation test and evaluation, etc.;
- Tools and Utilities utilized in the support, development and management of Air Force M&S activities;
- Technology Research being done by government or contract personnel supporting Air Force M&S activities;
- Studies identifying investigations of a problem for which M&S was used;
- References such as publications used in the management of Air Force M&S; and
- Related Sites pertaining to Air Force M&S activities.

At present the Air Force MSRR identifies 327 resources dating back to January 2002 [AFAMS, 2010]. The most common resource type that is identified is "models and simulations." The metadata that is captured and reflected for each of these resources varies dependent upon the resource type. However, the Air Force MSRR is a source participant with the M&S Catalog and offers its metacards in a format consistent with the MSC-DMS.

3.4.3.5 TENA Repository

TENA combines a distributed simulation interoperability protocol, a set of standard object models, a software architecture, and communications middleware. It is intended to support the development of entity-level real-time distributed simulation systems for test and training range applications. The TENA repository is found within a general purpose web portal for the TENA development community. The repository provides access to the software components of the TENA architecture, including object models, object implementations, communications middleware, and tools, and also a wide range of supporting artifacts, including briefings, documentation, training materials, data sets, test results, and more. The portal offers additional community support functions, including user email reflectors and help desk services.

The TENA repository was assessed very positively. It supports nearly all of the essential functionality defined in the assessment use cases and does so in an apparently easy to use manner. Consequently, it can be seen as an example of an effective M&S asset repository. However, two concerns should be mentioned. First, certain specialized capabilities, such as

connections to federated repositories and export of asset metadata to external catalogs, are absent. Second and more importantly, the capabilities of the repository seemed very focused on the asset types specific to the TENA development environment; it is not immediately obvious that those capabilities would generalize directly to support a broader range of M&S asset types (especially non-TENA object models and software components).

3.4.3.6 CTIA Live Training Transformation (LT2) Portal

The LT2 Portal is used by the CTIA and other US Army and US Marine Corps training range instrumentation programs to enable collaborative engineering and software product support. This facility reflects the PEO Simulation Training and Instrumentation (STRI) product line approach to reuse of M&S software assets and operates at a high level of software maturity. Two levels of access are supported, depending on whether the user needs to download M&S and other supporting software assets. The more restrictive access level only allows documentation to be downloaded. The execution of distribution agreements is done as part of the registration process. Once given download access, qualified portal users can download software freely from this repository. Internal repository discovery mechanisms are robust, and the metadata and supporting documentation for M&S assets stored in the repository is maintained at a high level of accuracy with version control. Users can provide feedback through a number of mechanisms, including trouble reports. This repository also collects qualitative and quantitative data on repository use and solicits customer feedback on the repository itself through a survey mechanism.

3.4.3.7 MATREX Integrated Development Environment

The MATREX Integrated Development Environment (IDE) is a collaborative systems and software engineering environment utilized by the US Army RDECOM laboratories to develop and enhance the MATREX federation. Core MATREX software assets and engineering artifacts are accessible through the MATREX IDE. This site offers a number of utilities for asynchronous interaction. Standard US Army collaboration tools not directly linked to the site are utilized to support synchronous collaboration. MATREX uses a loosely coupled file transfer protocol (FTP) server to store and forward non-core assets maintained by RDECOM laboratories and to disseminate software updates within the MATREX development teams. The MATREX IDE offers planning and scheduling tools, a mechanism to trace architecture and requirements specific to the MATREX core, and event-specific configurations of MATREX software.

3.4.3.7 TurboSquid

TurboSquid is an M&S asset vendor/broker, offering M&S assets for sale via an on-line portal, with an implicit repository supporting its business. TurboSquid's content is highly focused, consisting primarily of digital 3D visual models. These models come in many categories, including vehicles, people, architecture, and others. These models were created, and are compatible with, industry standard tools, including 3D Max and May, and are available in a

variety of file formats. In addition to the models, TurboSquid offers tools and tool plug-ins to support the creation and animation of 3D visual models. Primary access to TurboSquid is via an on-line web site, which offers many repository access, search, and download features, as well as processing payments for downloaded content. TurboSquid content is created by independent developers and then offered for sale. TurboSquid acts as a broker between the developers and the purchasers, who are themselves likely to be developers of game and film products.

3.4.3.8 Summary Assessment: M&S Asset Storage Repositories

Figure 3-9 describes the collective assessment of the seven (7) repositories surveyed. Although all sites provide a robust means to regulate portal access, and to perform store and forward functions, practices vary in terms of the mechanism to modify assets readily or to support collaborative engineering. Most collaboration remains asynchronous, with limited online services provided in the repository environment itself. Discovery of assets outside the repository is generally less well-supported. Adherence to DoD metadata discovery standards is minimal, or in the case of the one commercial site surveyed, not applicable.

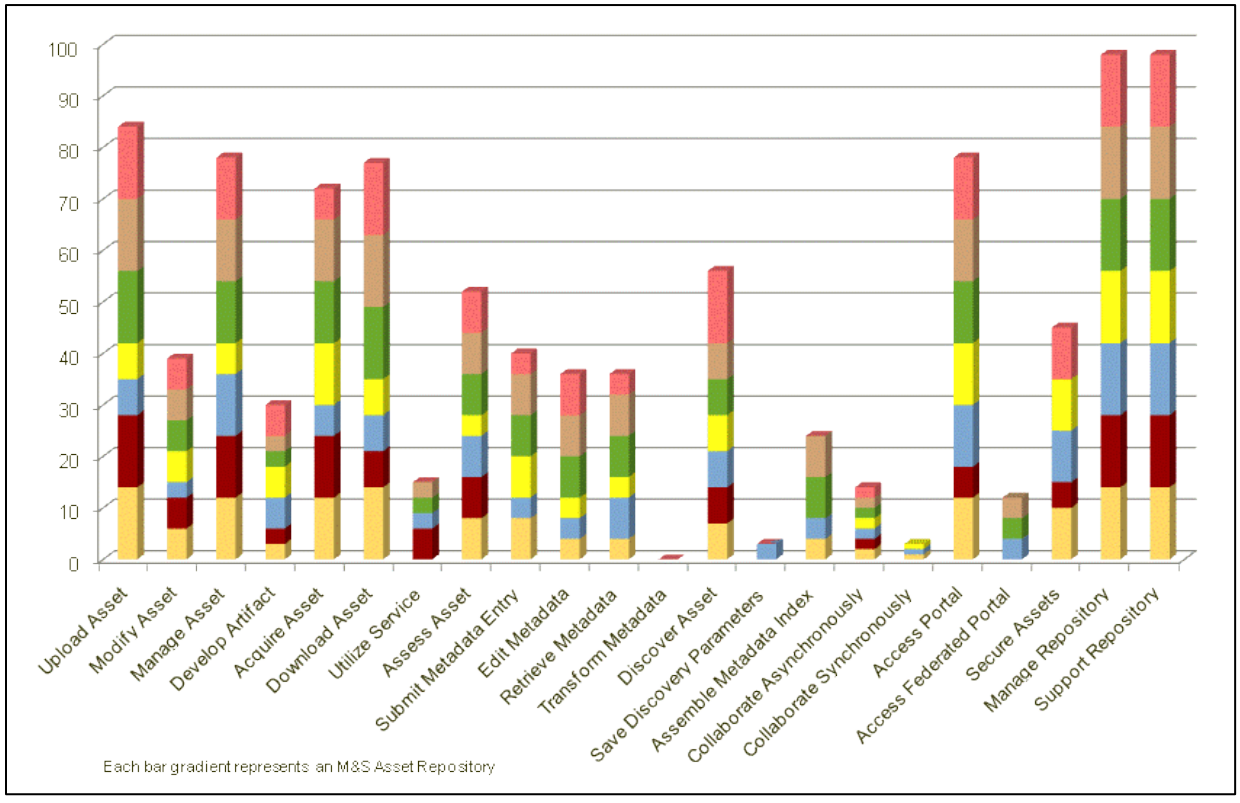


Figure 3-9: M&S Asset Storage Repositories: Weighted Scores

3.4.4 Metadata Registry

3.4.4.1 Definition

A metadata registry is a system that accepts, stores, and provides access to schemas or templates for metadata (discovery metadata and/or structural metadata), but not the metadata itself. The DoD Metadata Registry provides this service for all structural data within DoD, including schemas, data elements, attributes, document type definitions, style-sheets, data structures etc. Although the M&S Community of Interest has a section in the DoD Metadata Registry, it is very sparsely populated.

3.4.4.2 DoD Metadata Registry

The DoD Metadata Registry (MDR) was established in support of the Net-Centric Data Strategy to provide a common location across all DoD communities for registering metadata information resources. These resources include schemas, data elements, attributes, document type definitions (DTDs), style-sheets, data structures, and more [DoD MDR, 2010]. The MDR is also identified as a clearinghouse; a one-stop web portal for government and industry to share and acquire the necessary metadata information resource that might be needed to build discovery metadata (i.e., metacards), or structural metadata related to DoD programs and efforts. One of the more prominent metadata information resources registered at the MDR is the DoD Discovery Metadata Specification. Another is the DoD Modeling and Simulation COI Discovery Metadata Specification (MSC-DMS). Extensible Markup Language (XML)-based resources, such as the Defense Discovery Metadata Specification (DDMS) and MSC-DMS, are the primary type of metadata that the MDR has focused upon.

The DoD MDR is maintained and operated by the DISA under the direction and oversight of Office of the Assistant Secretary of Defense, Networks and Information Integration (OASD (NII)), and supports two types of users: Publishers and Consumers. Publishers are "those who post and configuration manage metadata artifacts on the MDR so those artifacts can be reused across the Department to support information sharing" [DoD MDR, 2010]. Consumers of the MDR, on the other hand, are "those who retrieve and subscribe to metadata artifacts or information about artifacts in order to use the artifacts to create information sharing capabilities" [DISA, 2007].

Figure 3-10 describes the scoring of the DoD Metadata registry in terms of the use cases and criteria used in this study. It should be noted that while not all XML schemas relevant to M&S are stored in the M&S Community of Interest portion of the DoD Metadata Registry, a number of key schemas referring to structural and discovery metadata are maintained in this section, including MSC-DMS 1.2.1 (September 11, 2009), the SEDRIS Environmental Data Coding Specification Version 1.0 (January 3, 2006), and a set of XML schemas governed by MIL STD 3022 pertaining to M&S VV&A (Version 0.40, December 12, 2008). One

consideration for the LVC Architecture Roadmap will be to improve the coverage of the DoD Metadata Registry by incorporating not only discovery metadata schemas (e.g. MSC-DMS), but also structural metadata emerging from the effort. The Federation Agreements template would be one such example.

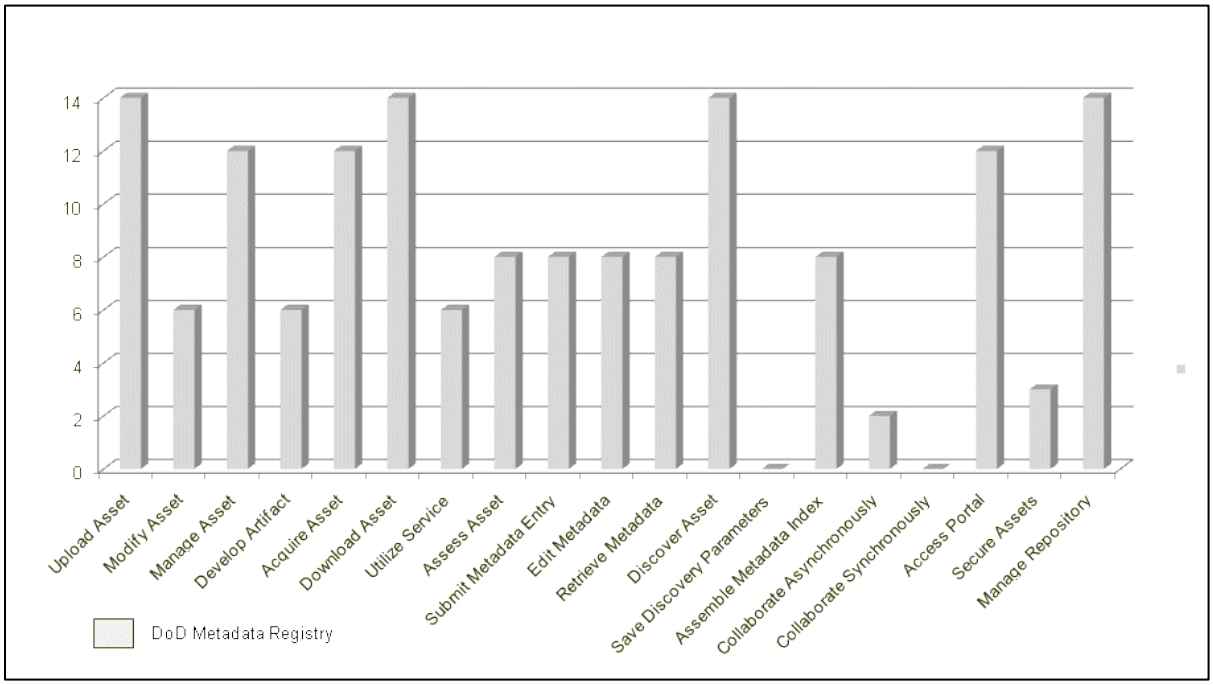


Figure 3-10: DoD Metadata Registry: Weighted Scores

3.4.5 Questionnaire

There were two questionnaires administered as part of this study. The first of these was administered prior to the LVC Common Capabilities workshop and made extensive use of free form responses. Seventeen (17) responses were received to this questionnaire from workshop participants. Although this survey did not reveal any dominant reason for repository failure, it did provide useful insights on the types of M&S assets (software components, data, concepts, tools) to be reused, and the motivations for reuse, which were in rank order:

- Lower cost
- Faster development
- Increased model credibility
- Increased quality

This questionnaire provided useful context for the focus group exercises and discussions of LVC asset reuse held during the workshop and provided the team with necessary information to develop and deliver a discretized questionnaire, which was disseminated more broadly.

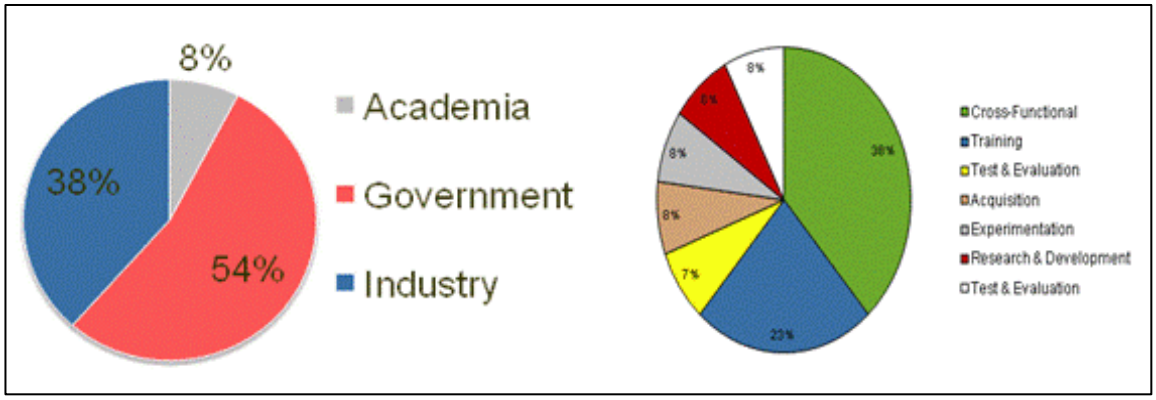


Figure 3-11: First (Left) and Second (Right) Questionnaire Respondents

This follow-up questionnaire consisted of fifty (50) discrete answer questions covering the areas:

- Types of reuse assets
- Attributes of successful reuse
- Reasons for repository failures

Although only thirteen (13) responses were received, the resulting data was useful to assist the team in verifying previous data collected and in comparison of approaches to LVC asset reuse. The detailed responses from both questionnaires are found in Appendix D.

3.4.6 LVC Common Capabilities Workshop

The LVC Common Capabilities Workshop held on November 4-5, 2009 afforded the study team the ability to interact directly with key M&S stakeholders in a collaborative environment. During this session, the study team presented its understanding of LVC asset reuse mechanisms and work undertaken, including the emerging concept of operations. Focus group sessions were conducted to elicit stakeholder feedback in a problem-solving mode. Following this, results of the first questionnaire were reviewed, and the breakout session conducted a facilitated discussion, which yielded the following key insights:

- Operational requirements should drive technical capabilities for repositories;
- Equal emphasis on developer and user roles is desired;
- Human relationships and trust are an important element of reuse;
- Entry and search should be based on some common ontology; and
- Assets do not have to be perfect to be reusable.

3.4.7 Stakeholder Coordination

Throughout the conduct of this study, coordination with key M&S stakeholders has been ongoing. In addition to the workshop activities described in Section 3.4.6 above, the team also interacted with industry and government stakeholders at the Interservice/Industry Training, Simulation and Education Conference (I/ITSEC) 2009, and conducted a presentation of the findings and recommendations of this effort at the Spring 2010 Simulation Interoperability Workshop.

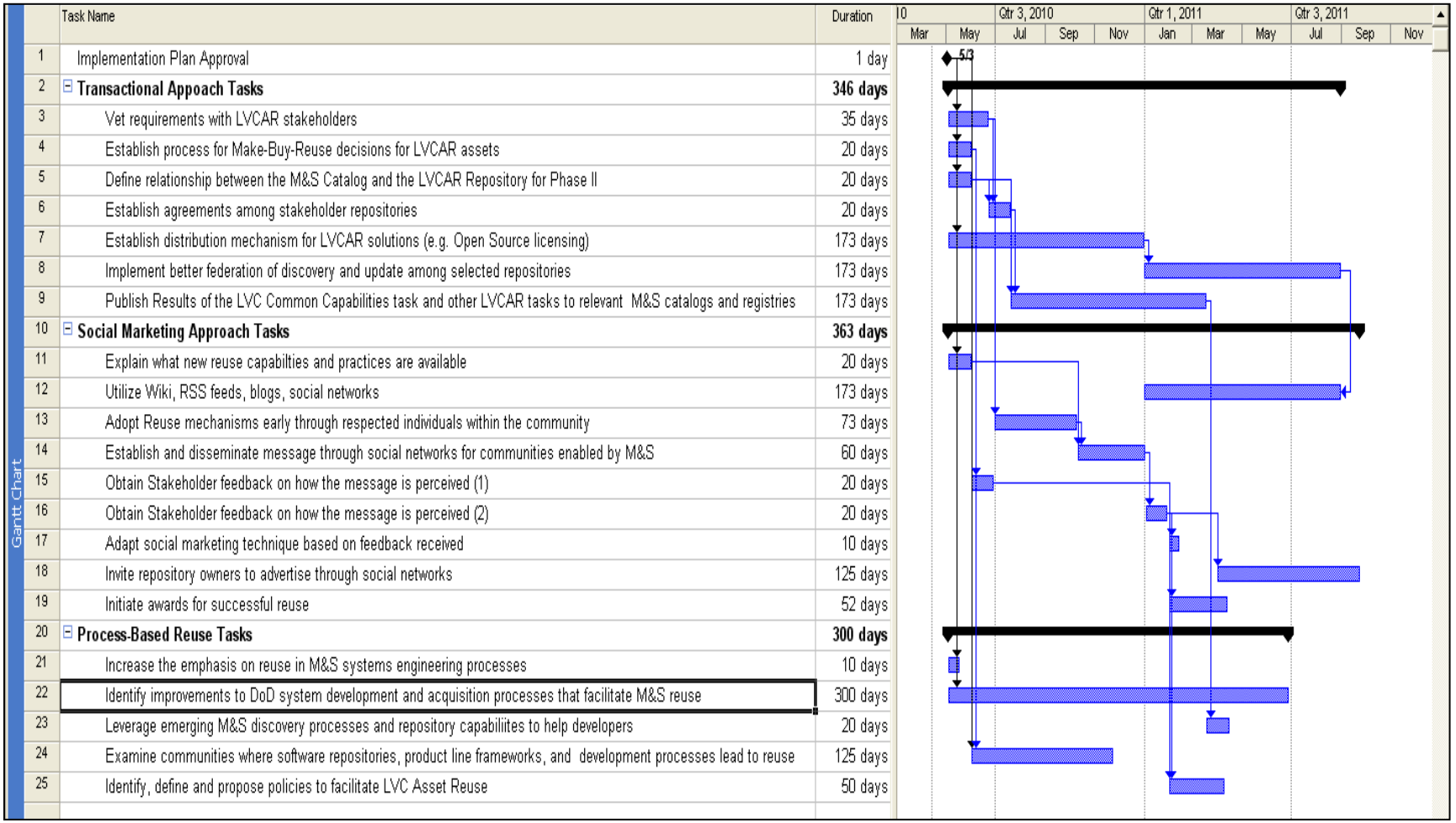
4. RESOURCES AND SCHEDULE

Notional schedules and engineering resources to support the findings and recommendations of this study are found in the Figure 4-1 and Table 4-1. Although Government Furnished Equipment resources are not specifically identified, it is assumed that access to government repositories will be afforded without service fees to LVC Asset Reuse Implementation Project participants.

The periods of performance are likewise preliminary, and assume an eighteen- (18) month project duration from when authorization to proceed has been given.

Table 4-1: Tasks and Resources

	Task	Predecessor	Successor	Staff Months
	Transactional Approach			**9**
T1	Vet requirements with LVCAR stakeholders.	Implementation Plan Approval	T4	0.75
T2	Establish process for make-buy-reuse decisions for LVCAR assets.	Implementation Plan Approval	P4	1
T3	Define Relationship between the M&S Catalog and LVCAR asset repository for Phase II.	Implementation Plan Approval	T4, T7	0.5
T4	Establish agreements among candidate stakeholder repositories.	T1, T3		1
T5	Establish distribution mechanism for LVCAR solutions (e.g. Open Source licensing).	Implementation Plan Approval, Convergence Report completed		3
T6	Implement federation of discovery and update among selected repositories.	T5		2.25
T7	Publish results of the LVC Common Capabilities and other LVCAR tasks to relevant M&S catalogs and registries	T3,T4		0.5
	Social Marketing Approach			**4.5**
S1	Explain what new reuse capabilities and practices are available (e.g. MSIAC Journal)	Implementation Plan Approval,		0.5
S2	Utilize Wiki, RSS feeds, blogs, social networks.	S5		0.5
S3	Adopt reuse mechanisms early through respected individuals within the community.	T1		0.5
S4	Establish and disseminate message through social networks for communities enabled by M&S	Implementation Plan Approval S1, S3	S5	0.5
S5	Obtain feedback from stakeholders on how the message is perceived.	S1, S4	S3	1
S6	Adapt social marketing technique based on feedback received	S5		0.5
S7	Invite repository owners to advertise through social networks.	S5		0.5
S8	Initiate awards for successful reuse.	S5		0.5
	Process-based Approach			**6.5**
P1	Increase the emphasis on reuse in M&S systems engineering processes (e.g., the FEDEP and DSEEP).	Implementation Plan Approval		0.5
P2	Identify improvements to DoD system development and acquisition processes (existing or new) that facilitate M&S reuse.	Parallel with SE Process Overlay to DSEEP		1.5
P3	Leverage emerging M&S discovery processes and repository capabilities to help developers identify and acquire available M&S assets and minimize redundant development.	T7		1
P4	Examine communities where software repositories, product line frameworks, and community development processes lead to reuse (e.g., HLA, MATREX, CTIA, TENA) and incorporate their best practices into development process models.	T2		1.5
P5	Identify, define and propose policies to facilitate LVC Asset Reuse	S5		2



	Task Name	Duration
1	Implementation Plan Approval	1 day
2	**Transactional Appoach Tasks**	**346 days**
3	Vet requirements with LVCAR stakeholders	35 days
4	Establish process for Make-Buy-Reuse decisions for LVCAR assets	20 days
5	Define relationship between the M&S Catalog and the LVCAR Repository for Phase II	20 days
6	Establish agreements among stakeholder repositories	20 days
7	Establish distribution mechanism for LVCAR solutions (e.g. Open Source licensing)	173 days
8	Implement better federation of discovery and update among selected repositories	173 days
9	Publish Results of the LVC Common Capabilities task and other LVCAR tasks to relevant M&S catalogs and registries	173 days
10	**Social Marketing Approach Tasks**	**363 days**
11	Explain what new reuse capabilties and practices are available	20 days
12	Utilize Wiki, RSS feeds, blogs, social networks	173 days
13	Adopt Reuse mechanisms early through respected individuals within the community	73 days
14	Establish and disseminate message through social networks for communities enabled by M&S	60 days
15	Obtain Stakeholder feedback on how the message is perceived (1)	20 days
16	Obtain Stakeholder feedback on how the message is perceived (2)	20 days
17	Adapt social marketing technique based on feedback received	10 days
18	Invite repository owners to advertise through social networks	125 days
19	Initiate awards for successful reuse	52 days
20	**Process-Based Reuse Tasks**	**300 days**
21	Increase the emphasis on reuse in M&S systems engineering processes	10 days
22	Identify improvements to DoD system development and acquisition processes that facilitate M&S reuse	300 days
23	Leverage emerging M&S discovery processes and repository capabiliites to help developers	20 days
24	Examine communities where software repositories, product line frameworks, and development processes lead to reuse	125 days
25	Identify, define and propose policies to facilitate LVC Asset Reuse	50 days

Figure 4-1: Schedule

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APPENDIX A: REFERENCES

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APPENDIX B: CAPABILTIES ASSESSMENT DETAILS

B.1 REPOSITORY ASSESSMENT CRITERIA DETAILS

The following tables provide details of the repository assessment criteria and repository use cases used to assess the repositories. In preparing to assess M&S asset repositories, 22 repository uses cases were identified, described, and diagrammed. Each use case defines an operation or transaction, or a class of operations or transactions that a repository user might perform while engaged in repository-supported M&S asset reuse activities. Then, drawing on several different sources, over 240 detailed repository assessment criteria were developed and assigned numerical identifiers in the form C999. Each detailed assessment criterion is a capability or characteristic desirable or essential in a repository supporting M&S asset reuse. Finally, the detailed assessment criteria were grouped into 13 aggregate assessment criteria containing as few as one and as many as 37 detailed assessment criteria identified using the number of a selected representative detail assessment criteria from within each one. Each aggregate assessment criterion represents a coherent category of assessment criteria.

The first table (single page) relates the use cases to the aggregate criteria. If denoted in the table, an aggregate assessment criterion contains detailed assessment criteria that should be considered when assessing a repository's capabilities with respect to the marked use case. The second table (multiple pages) relates the detailed assessment criteria to the aggregate criteria. For each of the aggregate criterion, listed in ascending identifier sequence, all of the associated detailed assessment criteria are shown.

Table B-1: Use Case to Aggregate Criteria Crosswalk

Use Cases	Aggregate Criteria												
	C001	C002	C003	C011	C014	C019	C038	C051	C057	C066	C084	C123	C182
UC 01 Access Portal										X			
UC 02 Collaborate										X			
UC 03 Collaborate										X			
UC 04 Assemble Metadata Index			X										
UC 05 Discover Asset													X
UC 06 Save Discovery													X
UC 07 Submit Metadata Entry		X				X							
UC 08 Retrieve Metadata		X				X							
UC 09 Edit Metadata		X				X							
UC 10 Transform Metadata		X				X							
UC 11 Assess Asset					X								
UC 12 Utilize Service	X							X					
UC 13 Acquire Asset	X							X					
UC 14 Download Asset	X							X					
UC 15 Modify Asset	X							X					
UC 16 Upload Asset	X							X					
UC 17 Manage Asset	X							X					
UC 18 Develop Artifact	X							X					
UC 19 Secure Assets								X	X	X			
UC 20 Access Federated Portal										X			
UC 21 Manage Repository				X			X				X		
UC 22 Support Repository									X			X	

Aggregate Criteria Summary Descriptions

C001 Authenticated repository users can post, manage, and retrieve genuine M&S assets and related artifacts.
C002 Discovery, structural, security, and format metadata are associated with M&S assets and related artifacts.
C003 Repository supports automated and manual creation and maintenance of catalog entries.
C011 Repository provides online support tools to train and educate users in its operation.
C014 Feedback on M&S assets and related artifacts and utilization metrics are collected to support assessment of repository effectiveness.
C019 Repository supports associations of multiple M&S assets and related artifacts using content-related metadata.
C038 Repository governance plans, management policies, and operational procedures are documented and periodically reviewed.
C051 Repository has mechanisms to manage and protect asset copyrights and intellectual property restrictions.
C057 The repository has a mechanism to ensure that the information stored therein has been acquired from an authenticated source.
C066 The repository provides collaboration services and provenance mechanisms for human review and approval of submitted assets and metadata.
C084 The repository's infrastructure is documented and managed as a configuration-controlled product.
C123 Repository support staff have the necessary skills to maintain the repository infrastructure, asset management system, and provide user assistance.
C182 The repository discovery mechanism allows the user to search and browse for assets available for reuse.

Table B-2: Aggregate and Detailed Criteria

	Aggregate Criteria		Detailed Criteria
001	Authenticated repository users can post, manage, and retrieve genuine M&S assets and related artifacts.	C001	Users can post data to shared spaces.
		C073	The repository has the capability to add new asset definitions.
		C104	The repository supports asset dissemination in an approved format.
		C108	The repository provides notification of the result of an access request.
		C145	The repository contents include software design artifacts.
		C146	The repository contents include software configuration artifacts.
		C147	The repository contents include software tools.
		C148	The repository contents include source code assets.
		C149	The repository stores V&V history.
		C150	The repository stores V&V data.
		C151	The repository stores documentation.
		C152	The repository stores conceptual models.
		C153	The repository stores architecture/protocols.
		C154	The repository stores data models.
		C166	The repository associates V&V history with software assets.
		C167	The repository associates V&V data with software assets.
		C175	The repository associates points of contact for original developers with software assets.
		C176	The repository associates points of contact for current maintainers with software assets.
		C178	The repository associates information pertaining to model fidelity with software assets.
		C180	The repository associates usage scenarios with software assets.
		C181	The repository associates asset integration methods with software assets.
		C218	The repository allows posting of newly developed assets.
		C219	The repository allows posting of modified assets.

	Aggregate Criteria		Detailed Criteria
002	Discovery, structural, security, and format metadata are associated with M&S assets and related artifacts.	C002	Discovery and structural metadata are associated with M&S assets appropriate to the site's role.
		C004	Repository metadata has been registered in structure and definition in accordance with NCDS.
		C008	Access services control access to M&S assets stored in shared spaces.
		C018	Repository uses MSC-DMS to define and share COI-Specific ontologies.
		C020	Assets are associated with format-related metadata for discovery and assessment.
		C021	Repository uses MSC-DMS to define COI-specific content-related metadata.
		C022	Repository associates assets with data pedigree metadata.
		C023	Repository associates assets with security metadata.
		C024	Repository identifies authoritative sources for key data assets within its domain.
		C025	Register metadata.
		C026	Repository identifies key interfaces among M&S assets.
		C053	The repository has defined the properties of assets to be preserved.
		C054	The repository allows the depositor to customize asset properties.
		C086	Supplemental technical metadata.
		C087	Asset package information.
		C088	Supplemental technical metadata.
		C096	The repository defines minimum descriptive metadata for each asset.
		C115	Minimum descriptive metadata.
		C163	The repository stores usage scenarios.
		C165	The repository stores asset integration methods.
		C194	Asset metadata includes asset name.
		C195	Asset metadata includes asset developer.
		C196	Asset metadata includes purpose and intended use.
		C197	Asset metadata includes user instructions (e.g. how to make it work).
		C198	Asset metadata includes technical operating environment.
		C199	Asset metadata includes maximum and minimum load ratings.
		C200	Asset metadata includes timing requirements.
		C201	Asset metadata includes current point of contact.
		C202	Asset metadata includes usage history.
		C203	Asset metadata includes creation/modification date.
		C204	Asset metadata includes strengths and limitations.
		C205	Asset metadata includes what is being represented.
		C206	Asset metadata includes modeling method or paradigm.
		C216	The repository has sufficient metadata to determine if an asset is suitable for an application.
		C221	The repository supports user-defined procedures for asset posting.
		C246	Asset metadata are XML metatags.
		C247	Asset metadata are based on something like MSC-DMS.

	Aggregate Criteria		Detailed Criteria
003	Repository supports automated and manual creation and maintenance of catalog entries.	C003	Repository supports the creation and maintenance of catalog entries for the M&S Community of Interest.
		C006	Users can create shared spaces.
		C012	Repository provides online advocacy for Network Centric data practices.
		C027	Repository complies with Net-Centric interface standards.
		C028	The repository provides sufficient collaborative services to involve users in the M&S Community of Interest.
		C217	The repository has links to federated repositories.
		C236	The repository asset descriptions (metadata) are open to web crawlers.
		C244	The M&S asset catalog should connect to every DoD-related repository.
		C245	Assets stored someplace other than the repository are discoverable via a registry mechanism.
011	Repository provides online support tools to train and educate users in its operation.	C011	Repository provides online support tools to train and educate users in Network Centric Data Strategy data practices.

	Aggregate Criteria		Detailed Criteria
014	Feedback on M&S assets and related artifacts and utilization metrics are collected to support assessment of repository effectiveness.	C013	Metrics are collected to track implementation of Network Centric Data Strategy approach, as applicable.
		C014	Metrics are collected to support assessment of repository utilization.
		C015	Metrics are collected to support analysis of return on investment (ROI).
		C061	Does the repository software maintain audit logs that identify by whom and when all changes were made?
		C069	Does the repository maintain an auditable record of all events in the asset lifecycle?
		C070	Audit log of submission process.
		C082	Audit log of all events in asset lifecycle.
		C091	The repository has a defined process governing the generation of audit logs..
		C092	Audit logs are understandable by humans and machines.
		C095	The repository can provide evidence of the success of its asset preservation planning.
		C100	The Repository records access events in an auditable log.
		C101	Repository access audit logs capture access events.
		C102	Repository access audit logs are available to and understandable by humans and machines.
		C109	Repository access audit logs capture the results of access events.
		C117	Repository audits access events.
		C158	The repository stores points of contact for original developers.
		C159	The repository stores points of contact for current maintainers.
		C215	The repository has a mechanism to provide feedback from asset users to asset developers.
		C220	The repository tracks and reveals who posted an asset.
		C223	The repository collects and maintains search and discovery metrics.
		C224	The repository collects and maintains search and discovery metrics on what was searched for.
		C225	The repository collects and maintains search and discovery metrics on what assets were downloaded.
		C226	The repository collects and maintains search and discovery metrics on what assets were downloaded.
		C227	The repository collects and maintains search and discovery metrics with respect to download counts.
		C228	The repository collects and maintains search and discovery metrics on who conducted searches.
		C230	The repository collects and maintains reuse metrics.
		C231	The repository collects and maintains reuse metrics on who used an asset.
		C232	The repository collects and maintains reuse metrics on what the asset was used for.
		C233	The repository collects and maintains reuse metrics on what changes were made.
		C234	The repository collects and maintains reuse metrics on modification of assets returned to the repository.
		C235	The repository collects and maintains reuse metrics on current users.

	Aggregate Criteria		Detailed Criteria
019	Repository supports associations of multiple M&S assets and related artifacts using content-related metadata.	C019	Assets are associated with content-related metadata for discovery and assessment.
		C097	The repository allows associated assets to be linked.
		C098	Linking of associated metadata.
		C105	Links to associated assets are maintained after dissemination.
		C106	Links to associated asset metadata are maintained after dissemination.
		C160	The repository stores software practices used.
		C161	The repository stores information pertaining to model fidelity.
		C162	The repository stores an asset hierarchy (e.g. in a tree structure).
		C164	The repository stores lists of assets used together.
		C168	The repository associates documentation with software assets.
		C169	The repository associates conceptual models with software assets.
		C170	The repository associates architecture/protocols with software assets.
		C171	The repository associates data models with software assets.
		C172	The repository associates usage history with software assets.
		C173	The repository associates user comments with software assets.
		C174	The repository associates utility assessments with software assets.
		C177	The repository associates software practices used with software assets.
		C179	The repository associates an asset hierarchy (e.g. in a tree structure) with software assets.

	Aggregate Criteria		Detailed Criteria
038	Repository governance plans, management policies, and operational procedures are documented and periodically reviewed.	C009	Sponsor organization exerts sustained leadership to establish and enforce data processes governing the repository.
		C010	Repository incorporates data approaches to sponsor organization processes and practices.
		C016	Repository minimizes disincentives to utilization.
		C017	Repository provides positive incentives to reuse of M&S assets.
		C031	Repository has artifacts (e.g. mission statement, formal succession plan, contingency plans, and/or escrow arrangements) that reflect a commitment to long term management of reusable M&S assets.
		C036	The repository has a mechanism to review and update the policies and procedures applicable to it.
		C038	Repository is committed to formal, periodic review and assessment to ensure continued development.
		C039	Documentation of policies and procedures.
		C040	Responsibility for operation and management of the repository is cleared defined.
		C043	The repository sponsor has a short term and long term plan to sustain it financially.
		C044	The repository sponsor conducts regular financial sustainability reviews, at least once a year.
		C045	Transparent business practices.
		C047	The repository has secure and adequate funding.
		C048	M&S producers, proponents and sponsors have made asset deposit agreements with the repository sponsor.
		C049	The repository software provides adequate mechanisms that tie specific agreements to repository-stored assets.
		C055	Written agreements with asset depositors.
		C056	The repository has documented procedures that govern the submission of assets.
		C072	The repository has documented procedures that govern the storage of assets.
		C074	Defined submission process.
		C075	Supplemental technical metadata.
		C083	The repository has a documented strategy to preserve stored assets.
		C094	The repository sponsor periodically reviews the strategy to preserve stored assets.
		C103	The repository has a defined process for the dissemination of assets.
		C107	The repository has a process to validate the dissemination of assets.
		C112	The repository has a charter stating its purpose and intended audience.
		C113	Repository charter is publically available.
		C114	Understandability commitment.
		C116	The Repository makes public to the Community of Interest a description of the services it provides.
		C119	Repository access policies are documented.
		C120	Asset deposit agreements are consistent with repository policies.
		C121	Community understandability is defined and monitored.
		C134	Hardware requirements for repository management software are documented.
		C136	Requirements for repository management software are documented.
		C144	Repository has defined processes for service continuity and disaster recovery.

	Aggregate Criteria		Detailed Criteria
051	Repository has mechanisms to manage and protect asset copyrights and intellectual property restrictions.	C051	Does the repository have a mechanism to manage asset copyrights and intellectual property restrictions?
		C099	The repository controls read and download access to assets to authorized agents with legitimate rights.
		C118	Repository agreements are enforced.
		C222	The repository supports restrictions on asset posting (e.g., control board approval).
		C237	Assets have access levels with only authorized users should be allowed access to each asset.
		C238	Asset metadata has access levels with only authorized users allowed access.
		C239	The repository allow an asset and metadata for that asset to have a different access level.
		C240	The repository authenticates users for specific classes of controlled assets.
		C241	Assets and access to them are organized by access groups and permission sets.
		C242	Restrictions on access or use of assets are be discoverable during search and discovery.
		C243	Restrictions on access or use of assets are allowable as search criteria (e.g., "return unclassified assets only").
057	The repository has a mechanism to ensure that the information stored therein has been acquired from an authenticated source.	C007	Access services control access to M&S assets stored in shared spaces.
		C042	The repository conducts certification of the currency, integrity and authenticity of information stored in the repository and notifies producers, users and integrators of the results of these assessments.
		C057	The repository has a mechanism to ensure that the information stored therein has been acquired from an authenticated source.
		C058	The repository provides a mechanism to limit who is allowed to submit entries/assets.
		C059	The repository provides a mechanism to limit who is allowed to update assets.
		C060	The repository provides a mechanism to limit who is allowed to update asset metadata.
		C062	Anti-tamper mechanisms.
		C063	The repository maintains control of physical access to assets stored on the repository host.
		C064	Asset metadata is validated against a defined schema.
		C065	The repository offers a mechanism to verify asset metadata against the asset itself.
		C076	The repository assigns and maintains unique asset identifiers.
		C077	The repository establishes and maintains a persistent asset location address.
		C078	The repository preserves and maintains pre-existing asset identifiers assigned prior to submission, review and approval.
		C079	Validation of asset metadata against a defined schema.
		C080	Verification of asset metadata against the asset.
		C089	The repository conducts periodic verification of asset integrity.
		C110	Repository provides proof of authenticity of disseminated assets.
		C111	Repository provides provenance (chain of custody and change control) data for assets.

	Aggregate Criteria		Detailed Criteria
066	The repository provides collaboration services and provenance mechanisms for human review and approval of submitted assets and metadata.	C029	The repository provides sufficient collaborative services to involve users in an active M&S domain-specific community of users, producers, and integrators.
		C030	The repository has an established process to enable user feedback, ensure continued efficient operation, support problem resolution, and address evolving requirements of providers, integrators and users.
		C037	User feedback collection.
		C041	The repository has defined measurements by which the integrity of information stored in the repository can be assessed.
		C066	The repository provides a workflow mechanism for human review and approval of submitted assets and metadata.
		C067	The repository provides automated feedback to the depositor when predefined actions have been completed (e.g. acceptance or rejection of submission).
		C071	Formal acceptance of submission by human.
		C081	Human review of automated V&V errors.
		C093	Repository warns of technological obsolescence.
		C122	Community feedback verifies understandability.
		C137	Users are notified of new repository management software versions.
		C138	Mechanism for receiving feedback on the repository management software exists and feedback is evaluated.
		C155	The repository stores usage history.
		C156	The repository stores user comments.
		C157	The repository stores utility assessments.
084	The repository's infrastructure is documented and managed as a configuration-controlled product.	C084	The preservation strategy adopted by the repository is implemented for all assets stored there.
		C207	The repository supports software configuration management.
		C208	The repository supports software version control.
		C209	The repository supports software check-in/check-out.
		C210	The repository supports change tracking.
		C211	The repository supports version labeling.
		C212	The repository supports revision history.
		C213	The repository content is kept up to date.

	Aggregate Criteria		Detailed Criteria
123	Repository support staff have the necessary skills to maintain the repository infrastructure, asset management system, and provide user assistance.	C032	Repository COOP plan.
		C033	The repository support staff is sufficient for the repository's scope and tasks.
		C034	Adequate staffing.
		C035	Professional development of staff.
		C085	International representation information.
		C123	Repository computing resources are well-supported.
		C124	Repository computing resources includes backups (e.g., backup, recovery plan, data replication at safe sites).
		C125	Repository computing load balancing to meet high demand.
		C126	Repository checks for duplicate assets.
		C127	Repository has a mechanism to detect data corruption or data loss.
		C128	Repository has a process to report data corruption/loss incidents and mitigate their effects.
		C129	Repository accommodates bulk imports and exports of data.
		C130	Repository management software is under change control processes.
		C131	Repository management software changes are tested before implementation.
		C132	Repository management software and host systems are maintained by qualified personnel.
		C133	Repository management software and host systems are current with latest operating system updates.
		C135	The Repository sponsor conducts a regular review and assessment of repository hardware technology.
		C139	Regular reviews of repository system including management software, hardware, personnel, physical plant, and physical security.
		C140	Repository complies with security regulations related to information classification.
		C141	Repository staff have delineated roles, responsibilities, and authorizations.
		C142	Disaster recovery, COOP.
		C143	Regular testing of COOP plans.
		C214	The repository has sufficient capacity for expansion.

	Aggregate Criteria		Detailed Criteria
182	The repository discovery mechanism allows the user to search and browse for assets available for reuse.	C005	All data assets pertaining to the M&S enterprise of the sponsor organization have been inventoried.
		C182	The repository discovery mechanism allows the user to search for assets available for reuse.
		C183	The repository discovery mechanism allows the user to browse for assets available for reuse.
		C184	The repository search and discovery mechanism supports search on M&S related criteria (e.g., simuland, resolution, V&V status).
		C185	The repository search and discovery mechanism is simple to use.
		C186	The repository search and discovery mechanism supports search on key words, related assets, and user ratings.
		C187	The repository search and discovery mechanism supports search on all aspects of the asset.
		C188	The repository search and discovery mechanism supports connecting asset conceptual capabilities with operational requirements.
		C189	The repository search and discovery mechanism supports spelling correction in search keywords.
		C190	The repository search and discovery mechanism supports word family searches (e.g., “federations” matches “federation”).
		C191	The repository search and discovery mechanism allows Boolean operators linking search terms.
		C192	The repository search and discovery mechanism supports “unstructured” queries.
		C193	The repository search and discovery mechanism provides taxonomically-organized keyword definitions to allow unambiguous and categorical queries.

APPENDIX C: USE CASE SUMMARY AND DESCRIPTIONS

C.1 ACCESS PORTAL

All roles access Asset Reuse Mechanism services through one or more portals. The Asset Reuse Mechanism provides a single entry point to core services and federated M&S COI portals through the GIG,, with information assurance, secure access and transport services..

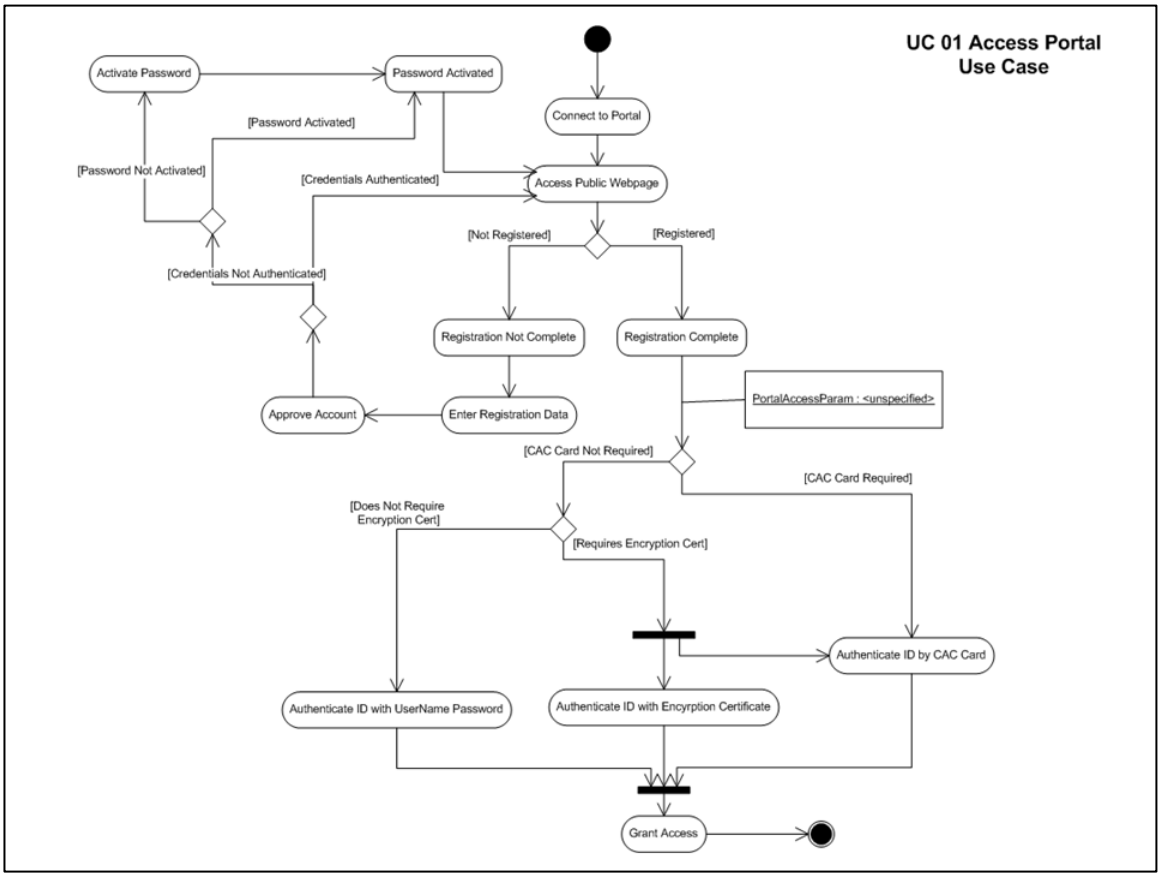


Figure C-1: Access Portal Use Case

C.2 COLLABORATE SYNCHRONOUSLY

The Asset Reuse Mechanism supports synchronous collaboration services include chat, desktop collaboration, and limited video conferencing. This use case is an extension of Access Portal capabilities.

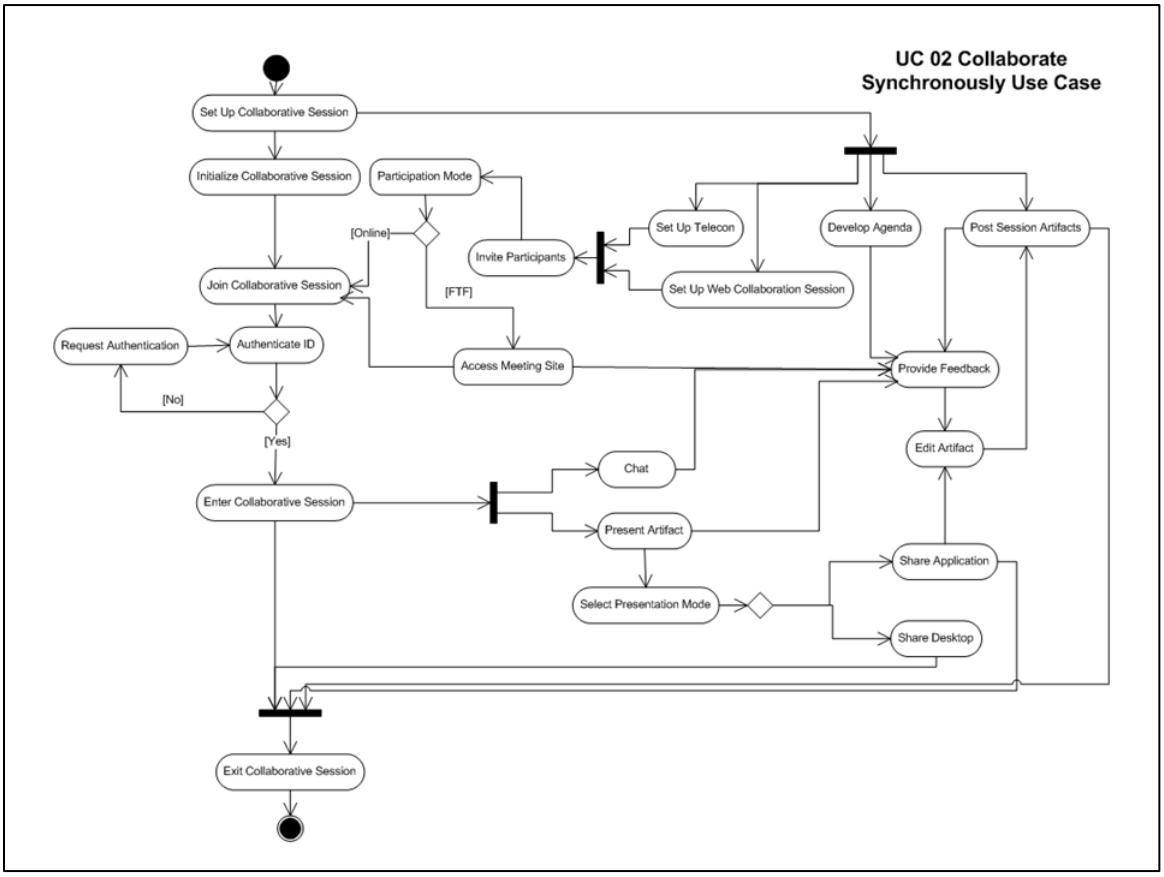


Figure C-2: Collaborate Synchronously Use Case

C.3 COLLABORATE ASYNCHRONOUSLY

The Asset Reuse Mechanism supports asynchronous collaboration services to include bulletin board, email, document storage, access subscription, and display. This use case is an extension of Access Portal capabilities.

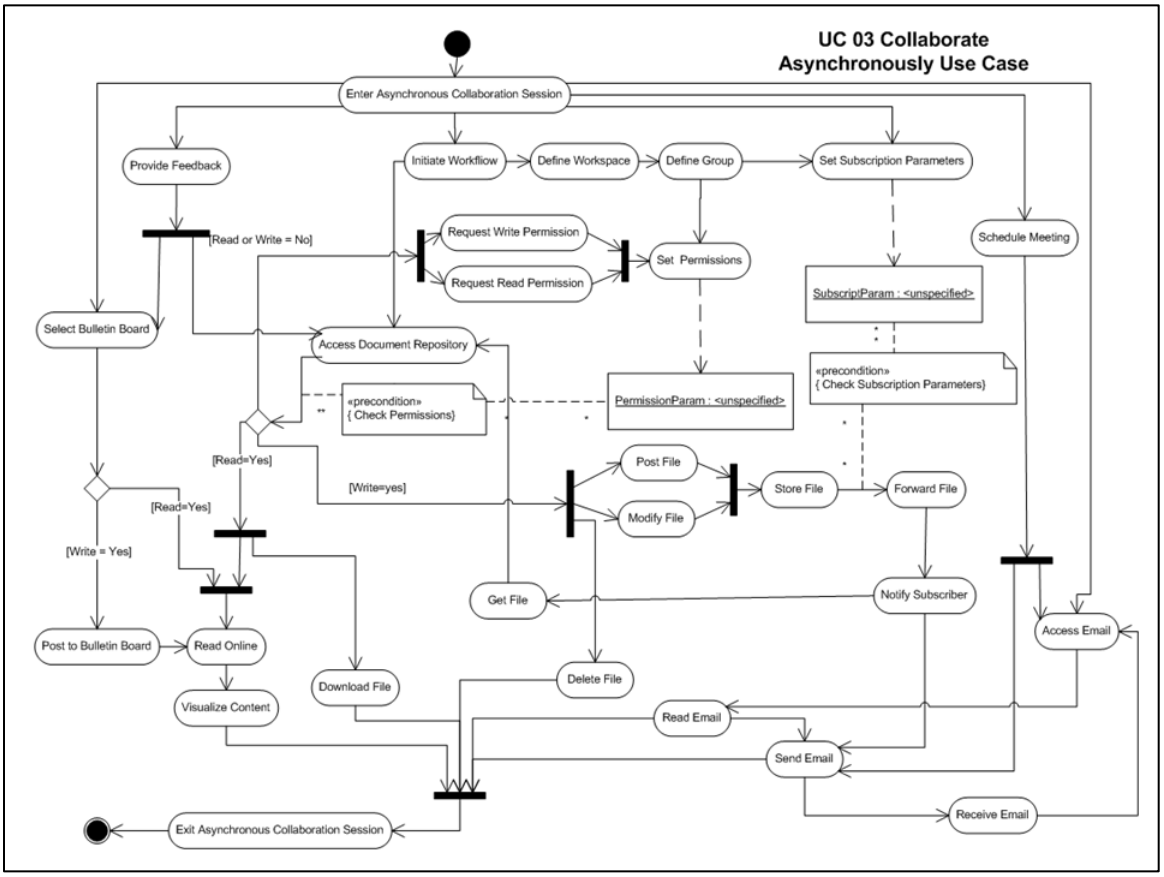


Figure C-3: Collaborate Asynchronously Use Case

C.4 ASSEMBLE METADATA INDEX

The Asset Reuse Mechanism enables the assembly of a searchable M&S catalog and associated taxonomy from registered metadata tags.

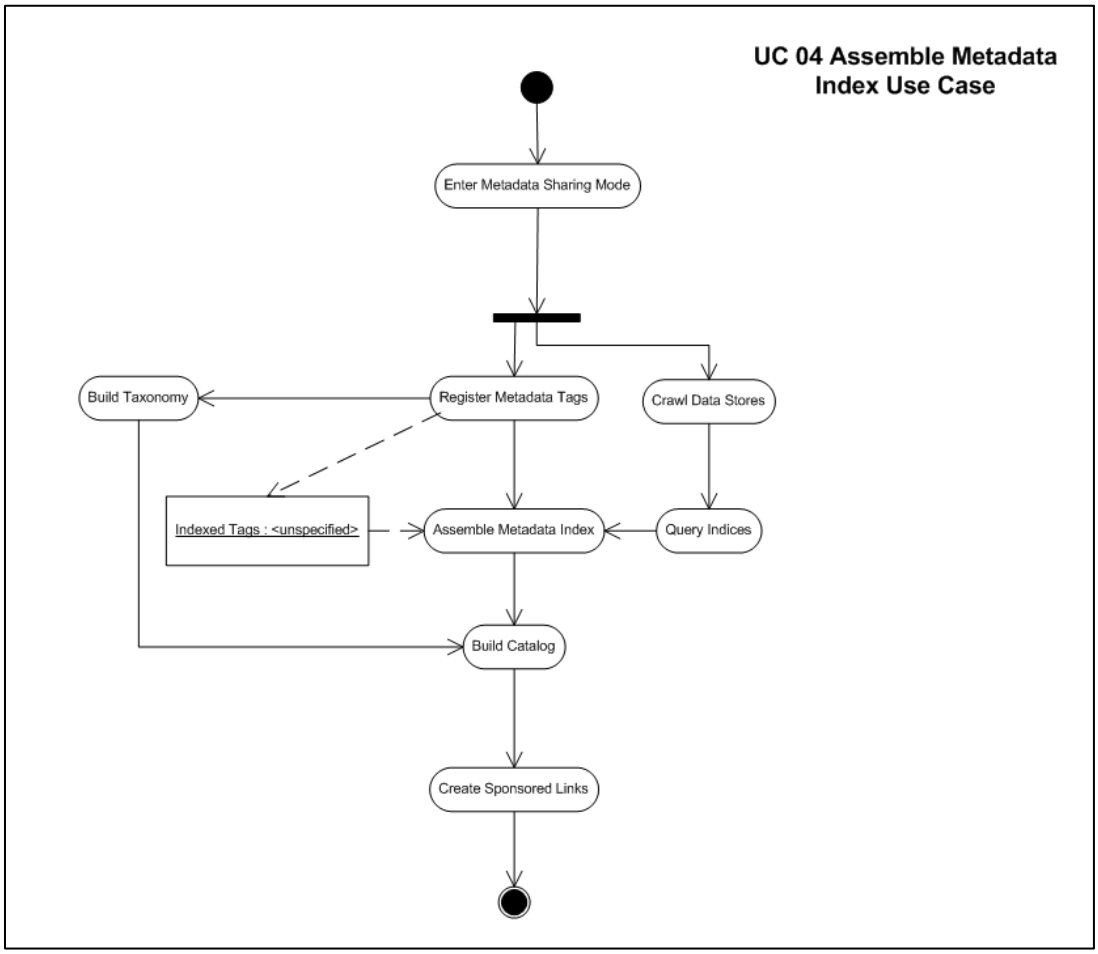


Figure C-4: Assemble Metadata Index Use Case

C.5 DISCOVER ASSET

Asset Reuse Mechanism discovery services provide extended search capability for M&S assets stored in core and federated repositories using extensions to the DoD Metadata Specification for the M&S COI. These extensions will be documented in the Modeling and Simulation Community of Interest Discovery Metadata Specification.

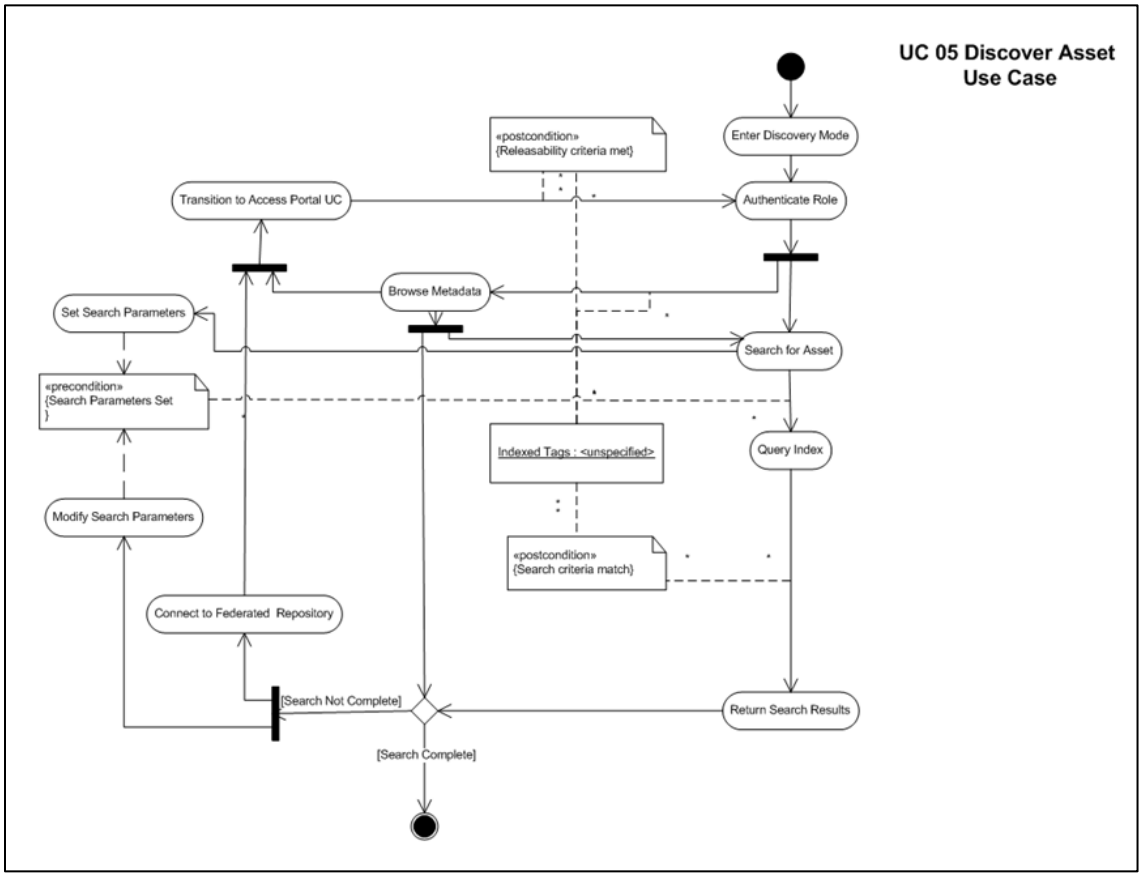


Figure C-5: Discover Asset Use Case

C.6 SAVE DISCOVERY PARAMETERS

The Asset Reuse Mechanism enables the user to save search parameters used during M&S Asset discovery.

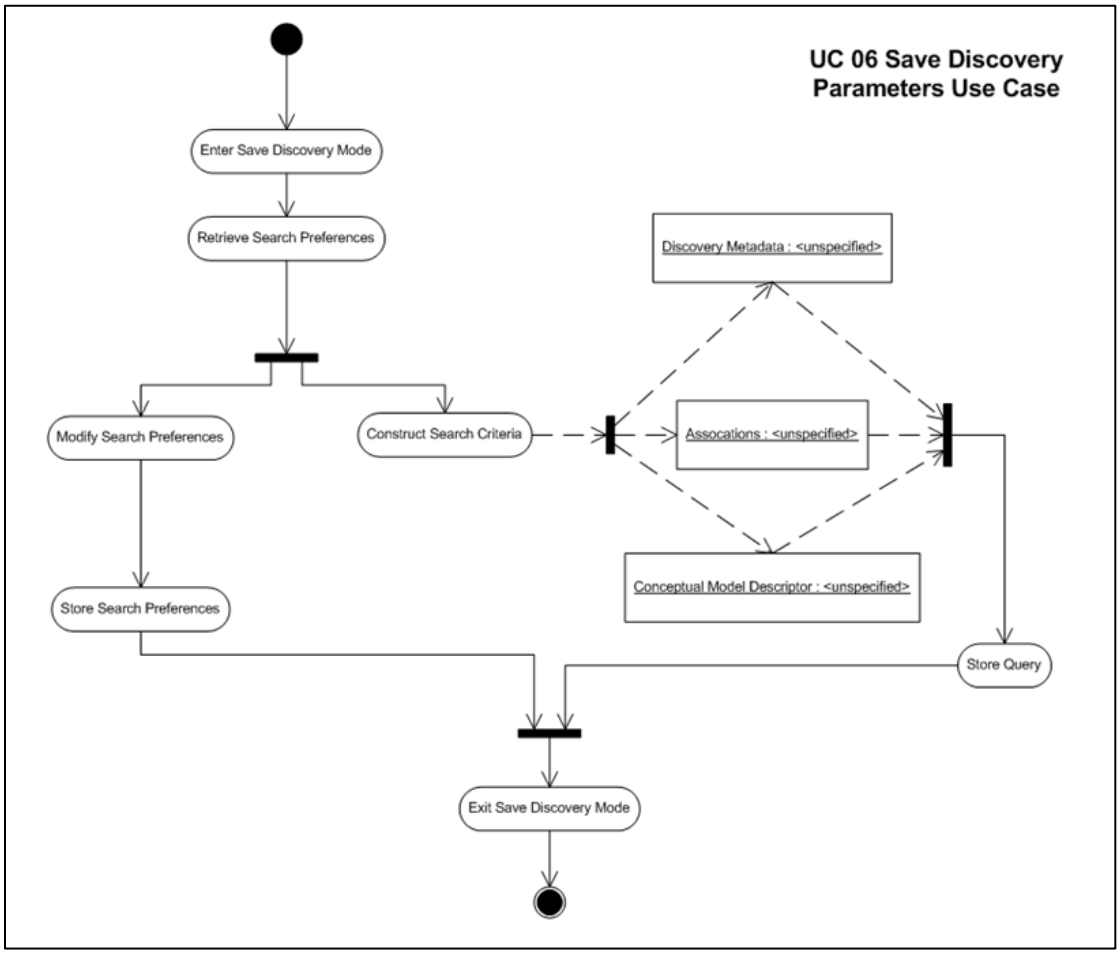


Figure C-6: Discovery Parameters Use Case

C.7 SUBMIT METADATA ENTRY

The Asset Reuse Mechanism enables M&S Sponsors and other authorized roles to register metadata entered into the core and federated repositories.

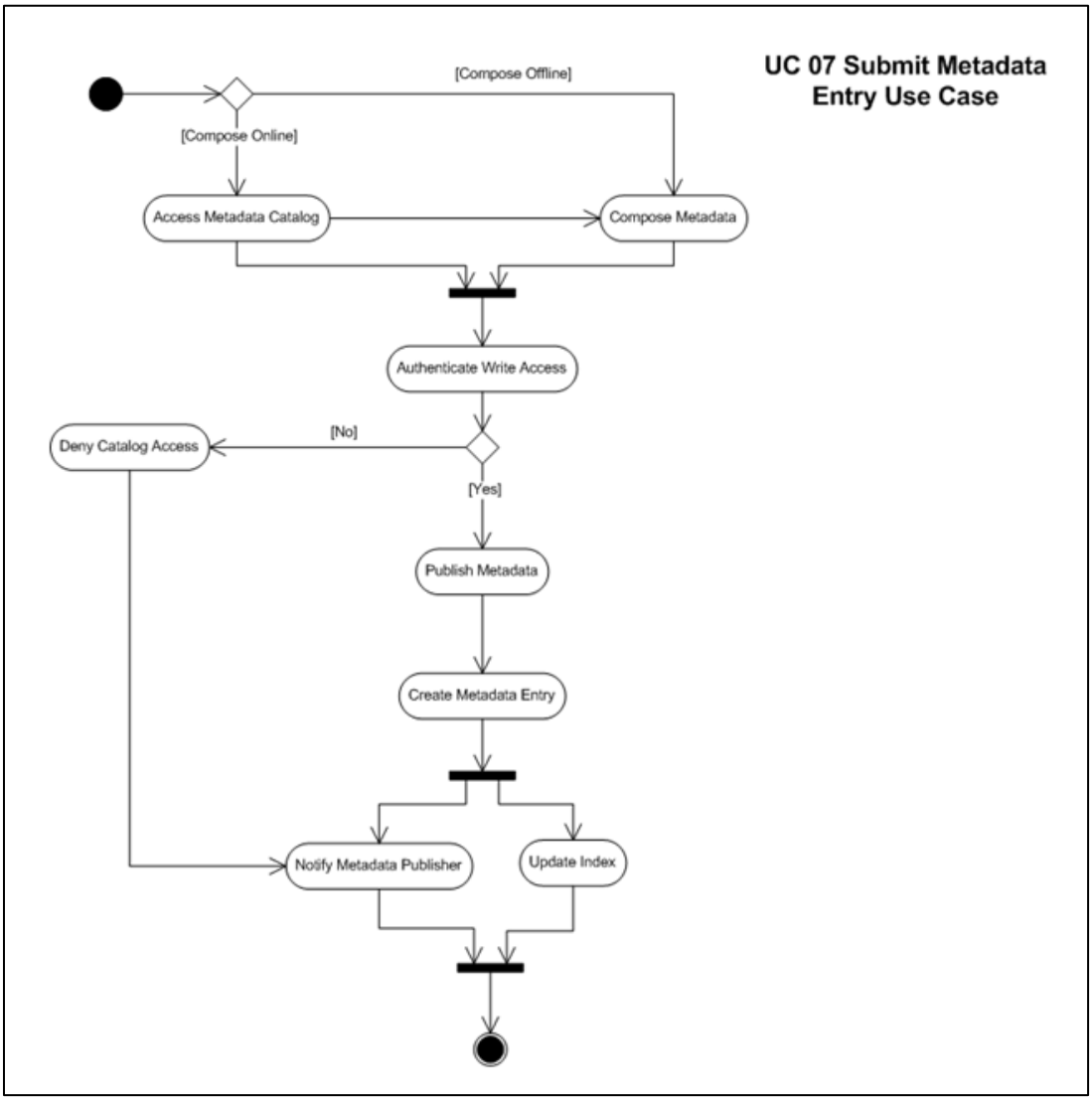


Figure C-7: Submit Metadata Entry Use Case

C.8 RETRIEVE METADATA

The Asset Reuse Mechanism enables the retrieval of metadata on M&S assets from repository data stores using discovery/search and browse functions. Retrieval may be filtered using MSC-DMS categories.

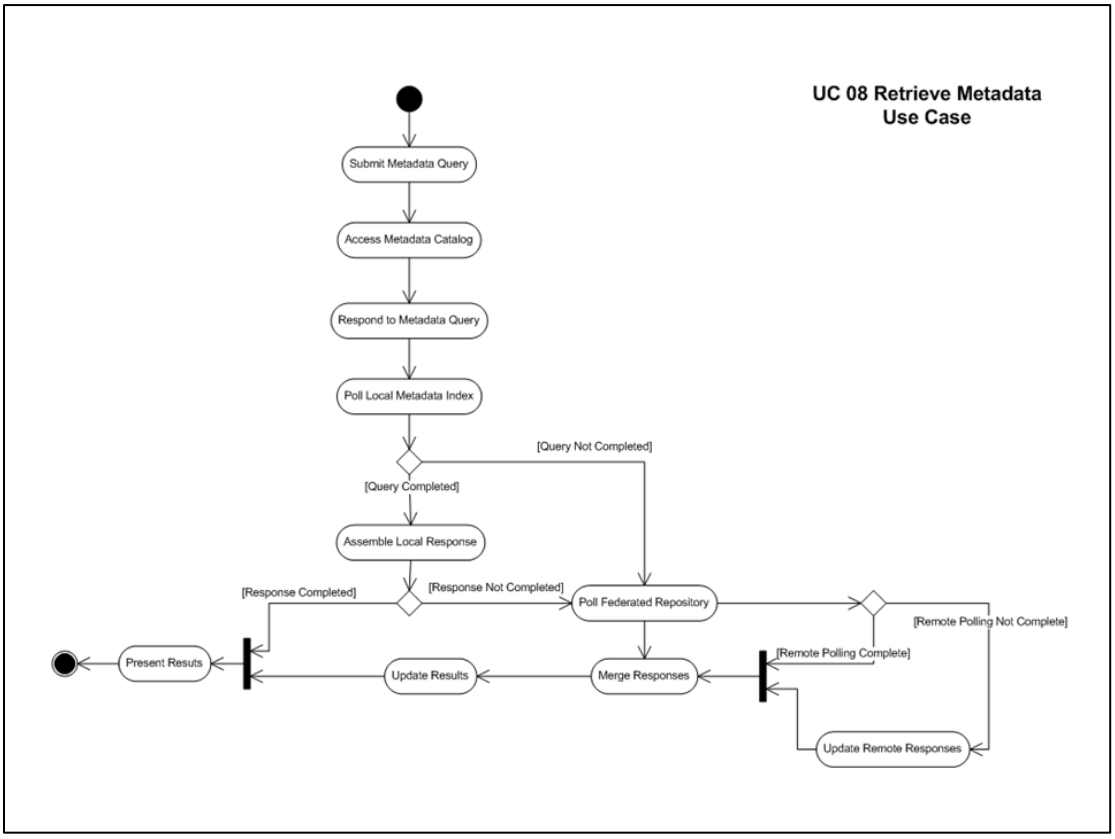


Figure C-8: Retrieve Metadata Use Case

C.9 EDIT METADATA

The Asset Mechanism provides utilities enabling role-based editing of M&S asset metadata stored in the core and federated repositories.

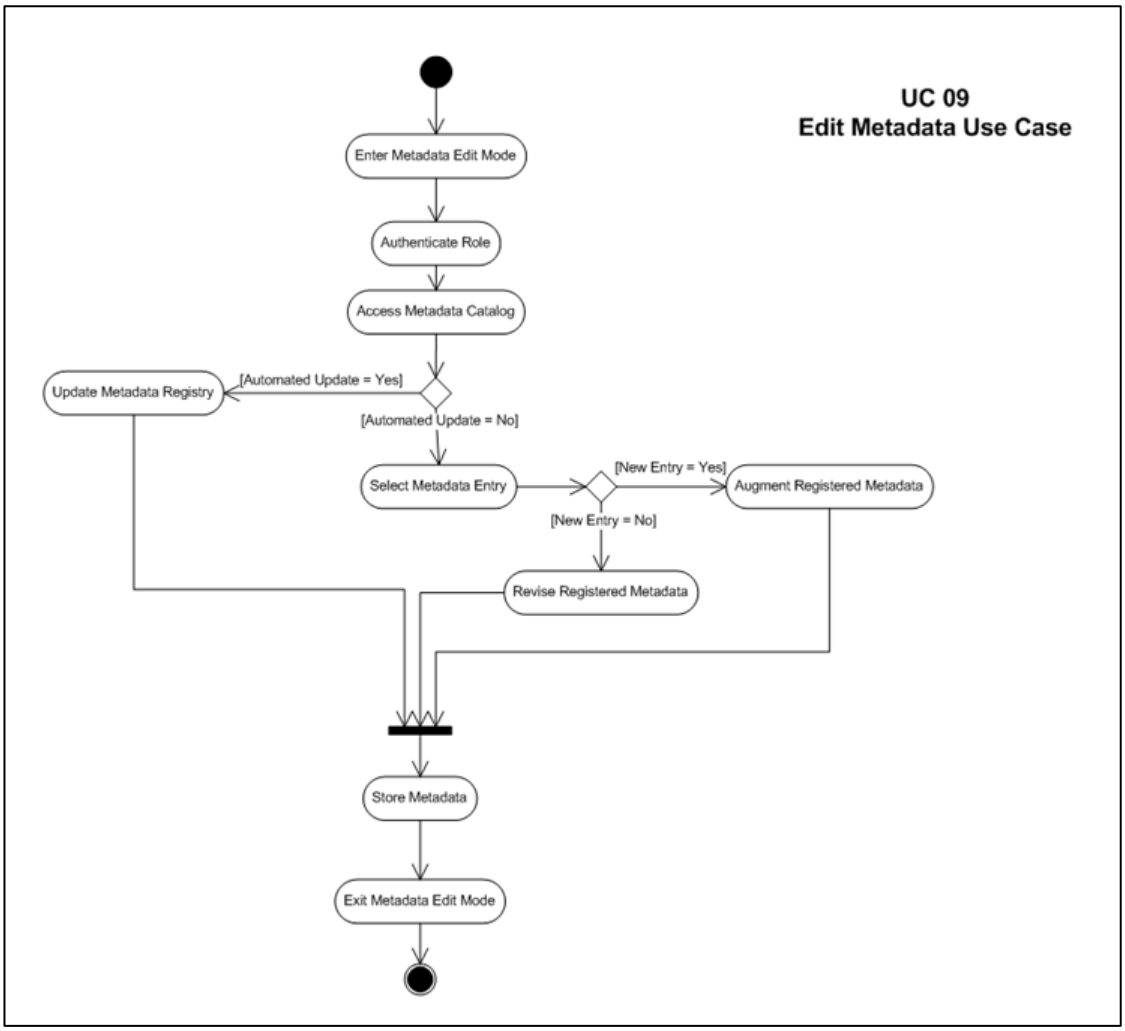


Figure C-9: Edit Metadata Use Case

C.10 TRANSFORM METADATA

The Asset Reuse Mechanism provides the ability to convert M&S asset metadata from one schema to another.

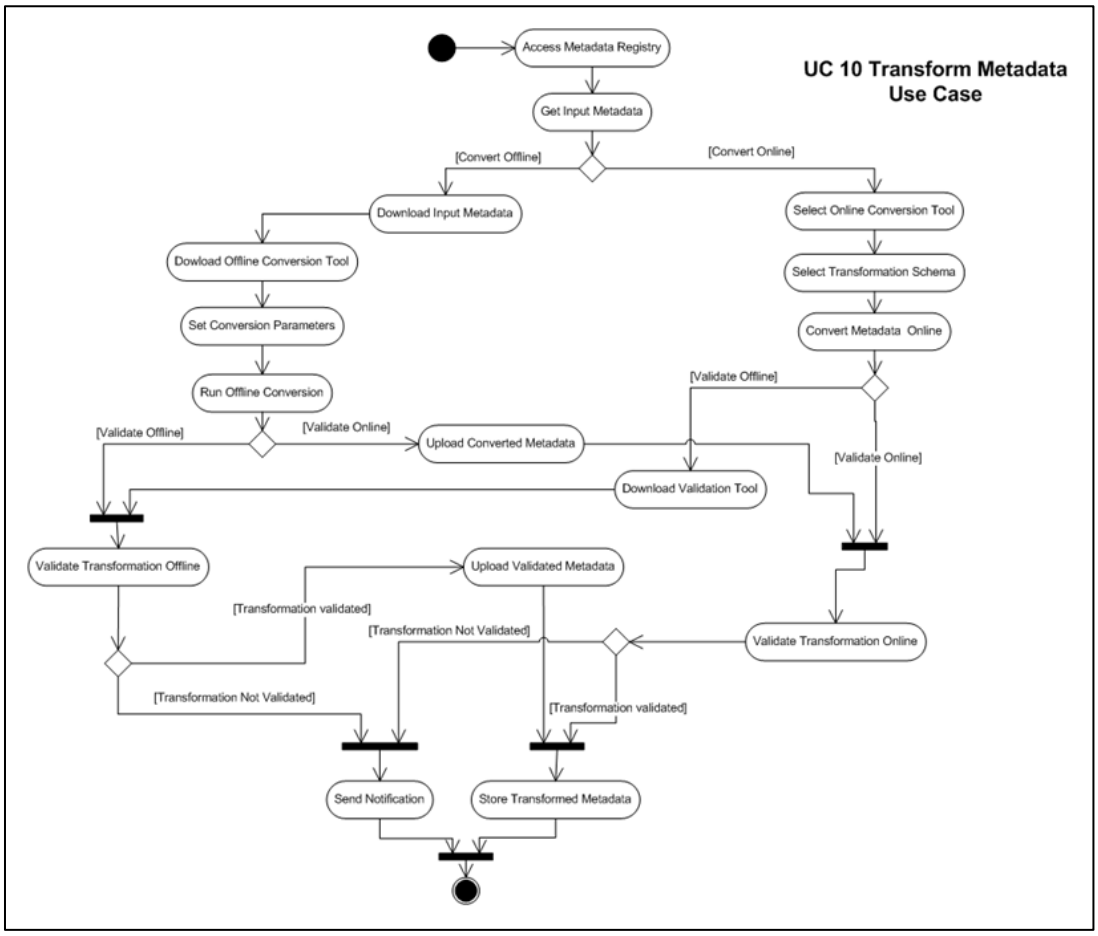


Figure C-10: Transform Metadata Use Case

C.11 ASSESS ASSET

The Asset Reuse Mechanism provides services to facilitate role-based assessment of M&S assets described by the core and federated repositories.

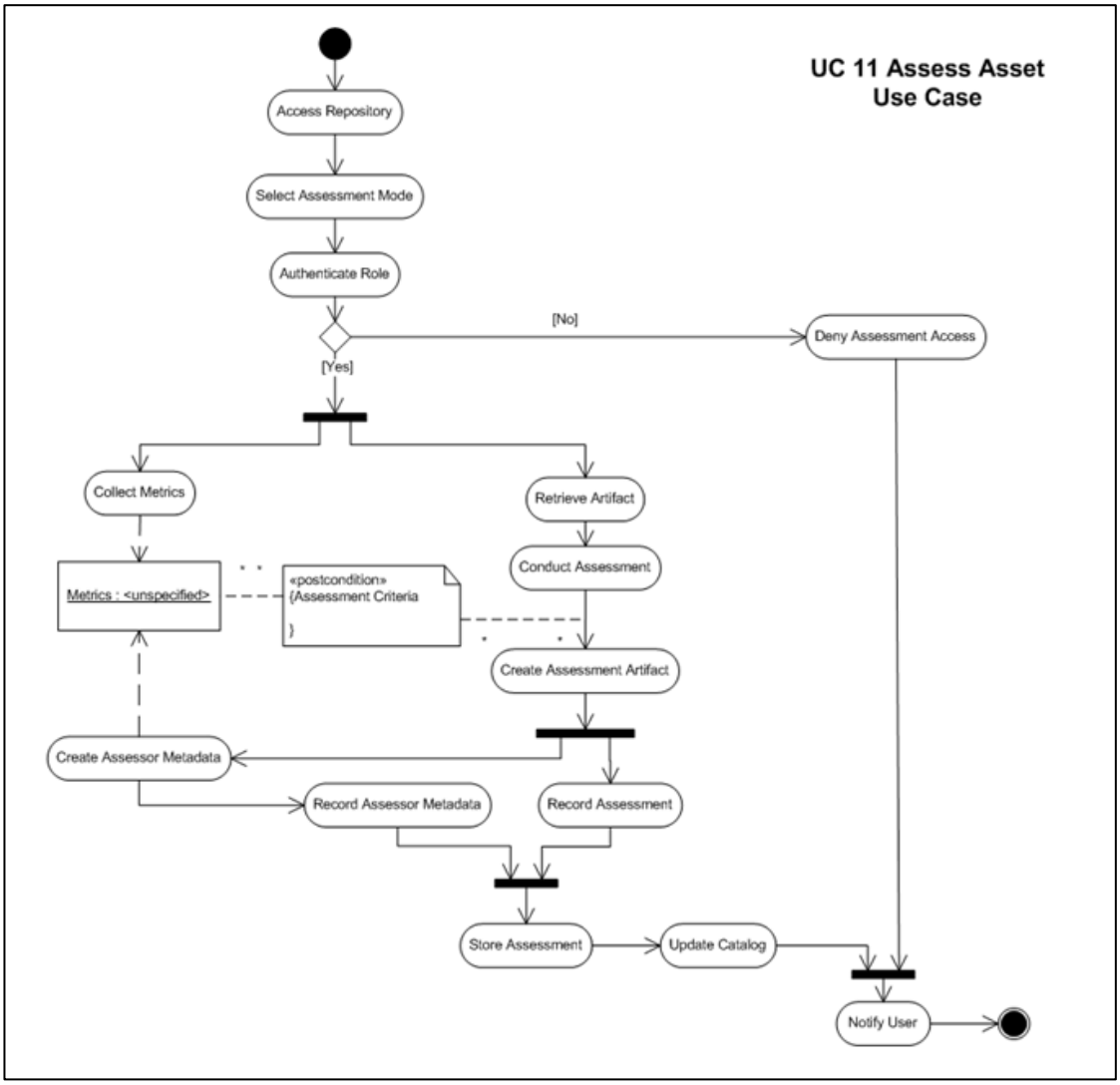


Figure C-11: Assess Asset Use Case

C.12 UTILIZE SERVICE

The Asset Reuse Mechanism provides the capability to execute selected M&S services in a Web 2.0 environment over the GIG.

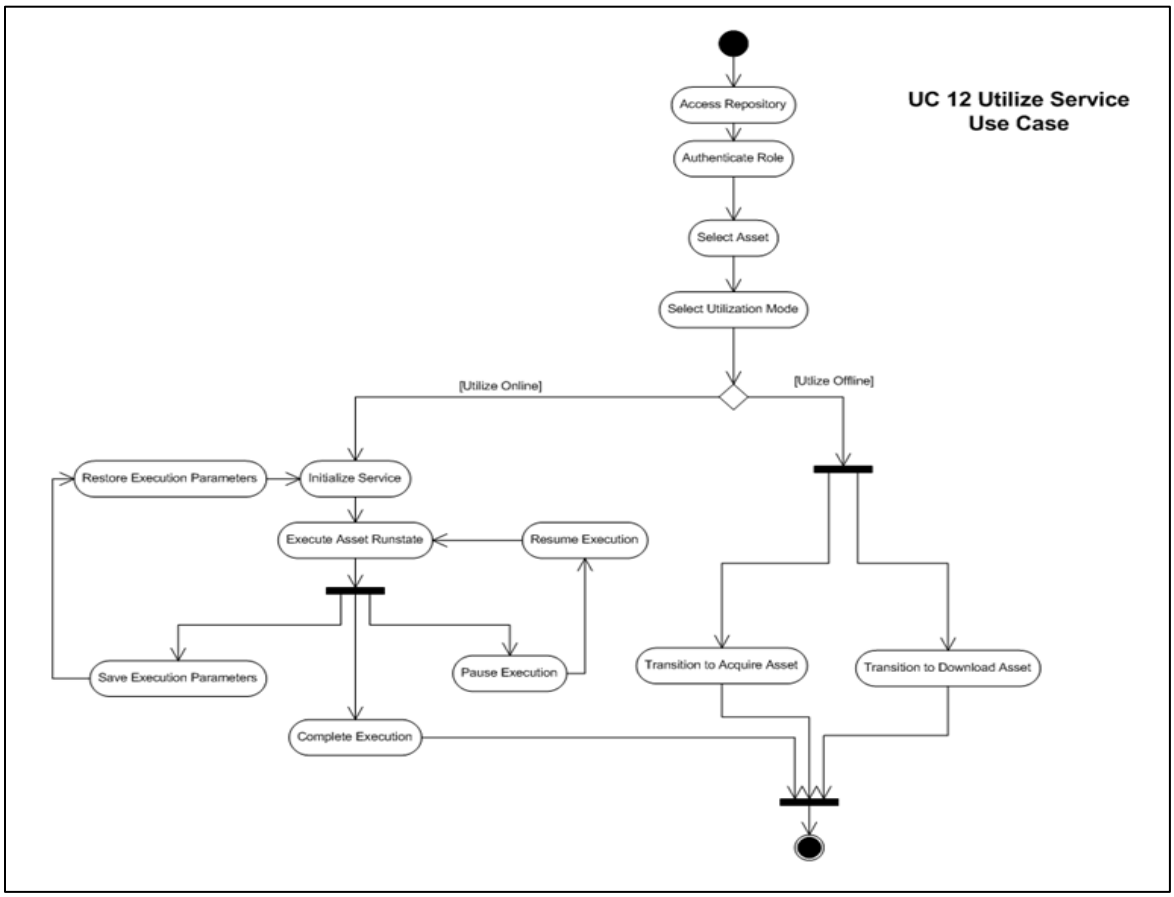


Figure C-12: Utilize Service Use Case

C.13 ACQUIRE ASSET

The Asset Reuse Mechanism provides utilities and services that enable online requests for access to M&S assets stored in the core and federated repositories. These services include online initiation and processing of GFX request and distribution agreements, distribution of access and download instructions, and M&S sponsor information.

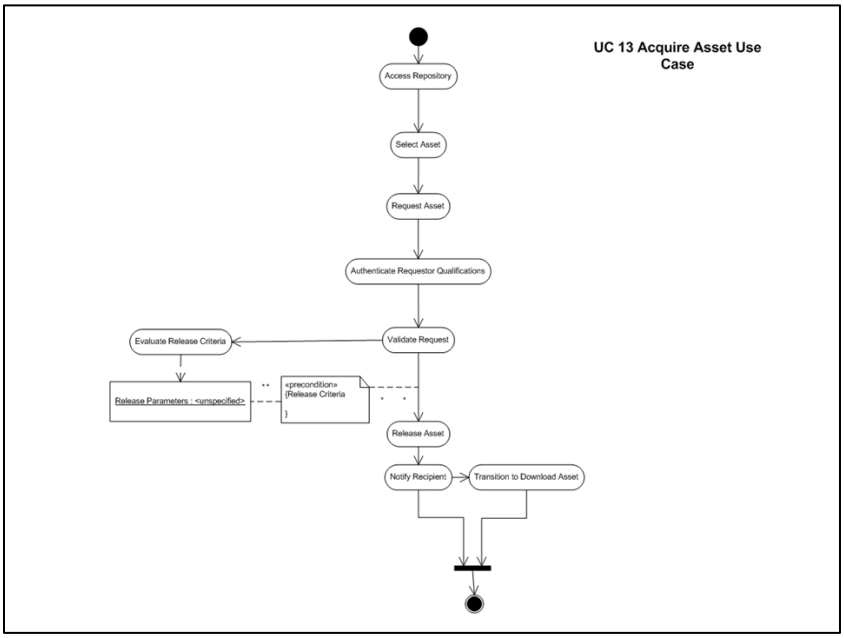


Figure C-13: Acquire Asset Use Case

C.14 DOWNLOAD ASSET

The Asset Reuse Mechanism provides secure download of M&S assets stored in core and federated repositories, once the M&S Sponsor has authorized the M&S asset to be acquired.

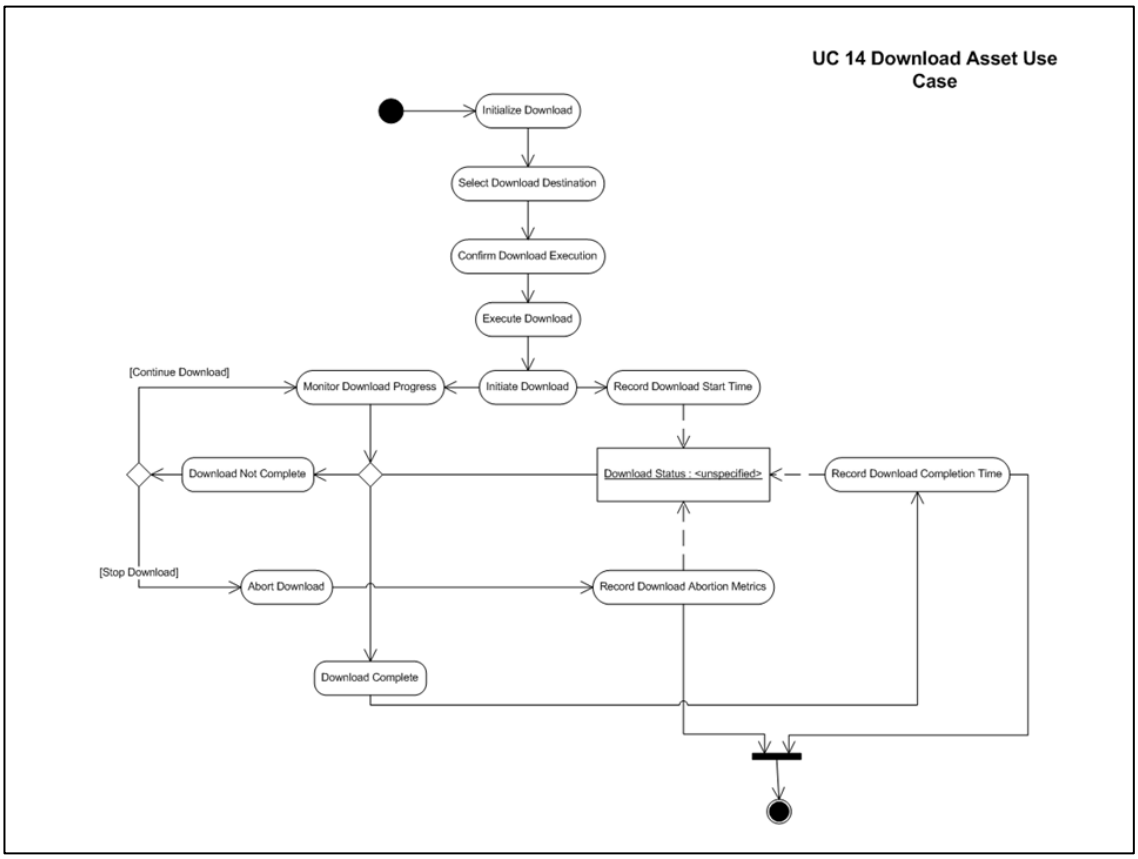


Figure C-14: Download Asset Use Case

C.15 MODIFY ASSET

The Asset Reuse Mechanism provides the capability to modify an M&S Asset for an intended use.

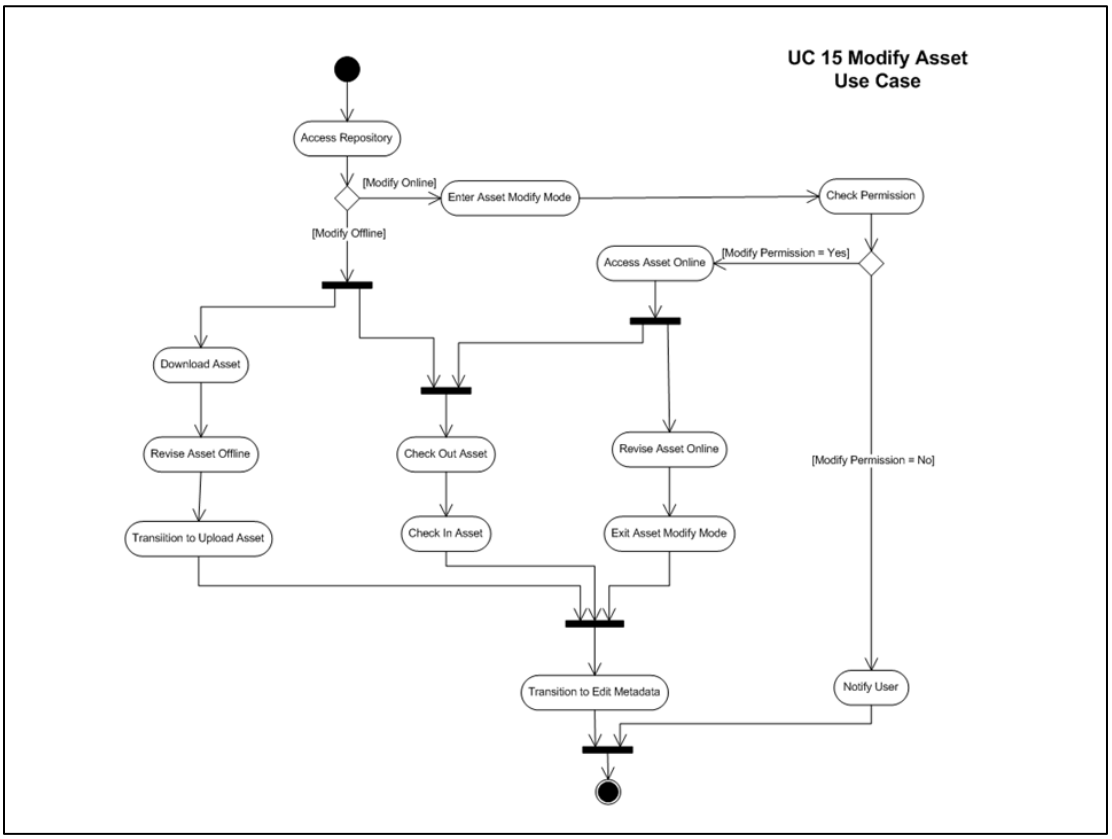


Figure C-15: Modify Asset Use Case

C.16 UPLOAD ASSET

The Asset Reuse Mechanism provides secure upload of M&S assets into the core or a federated repository using GIG services.

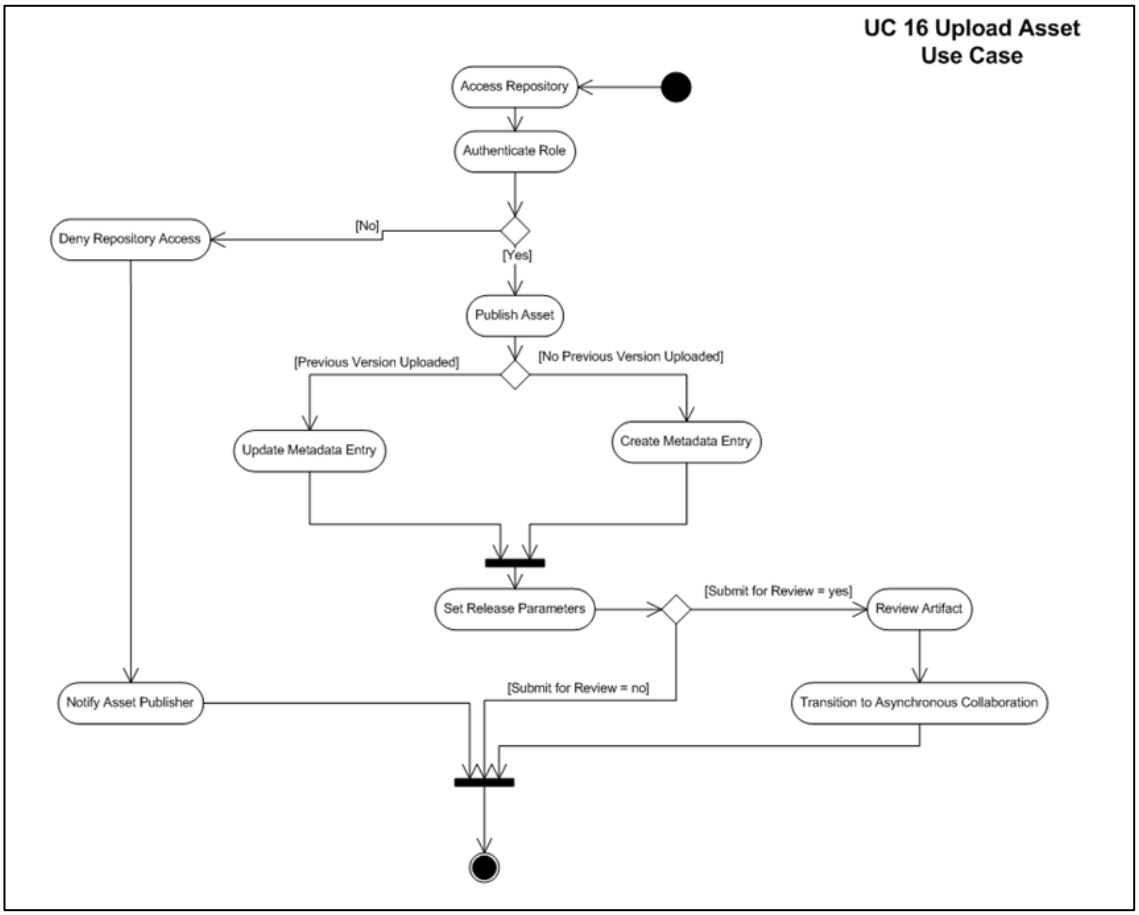


Figure C-16: Upload Asset Use Case

C.17 MANAGE ASSET

The Asset Reuse Mechanism provides supporting tools, software configuration management and versioning capabilities to enable role-based modification of M&S assets.

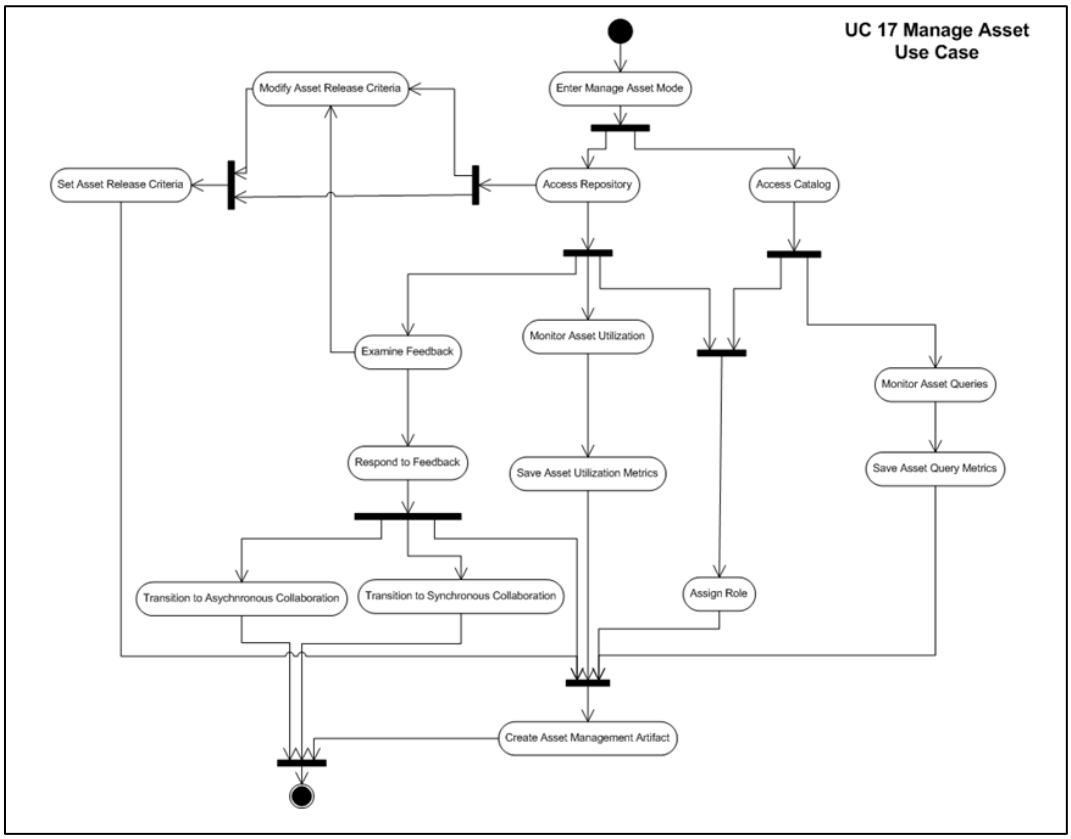


Figure C-17: Manage Asset Use Case

C.18 DEVELOP ARTIFACT

The Asset Reuse Mechanism provides online templates and supporting tools to develop role-based artifacts associated with M&S assets.

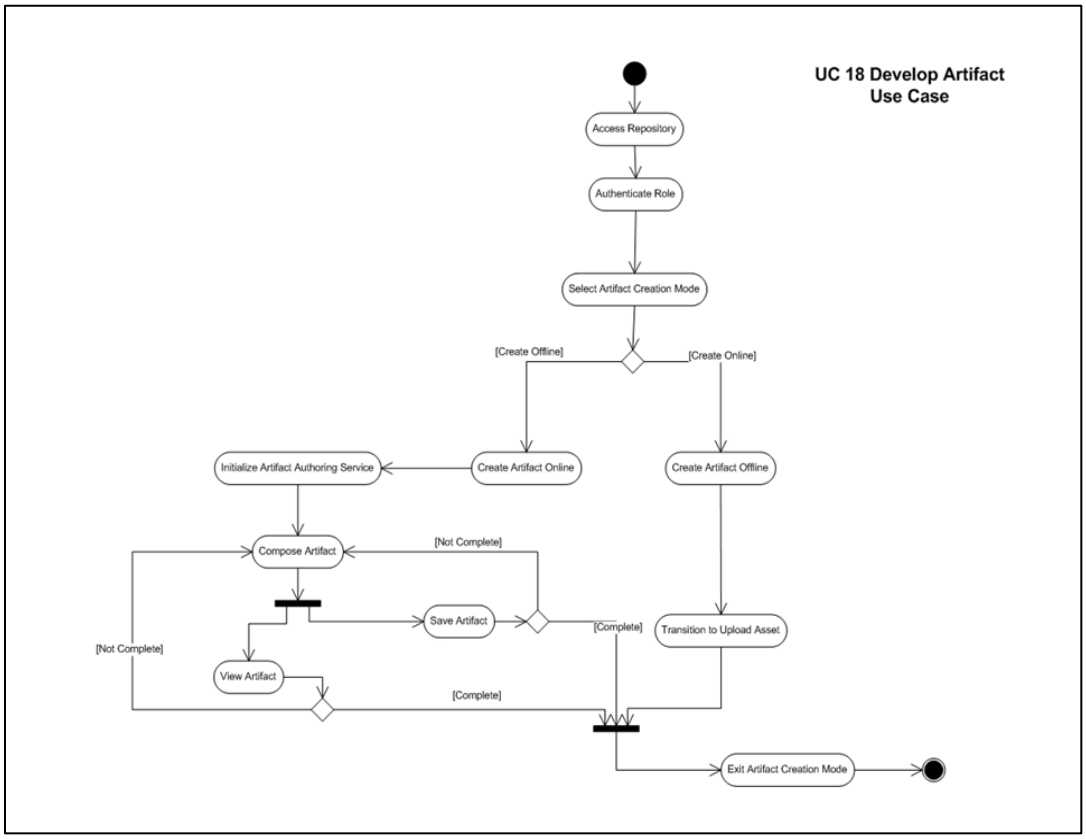


Figure C-18: Develop Artifact Use Case

C.19 SECURE ASSETS

The Asset Reuse Mechanism provides information assurance, data rights and distribution controls to ensure that only authorized personnel may access data according to DoD policy processed.

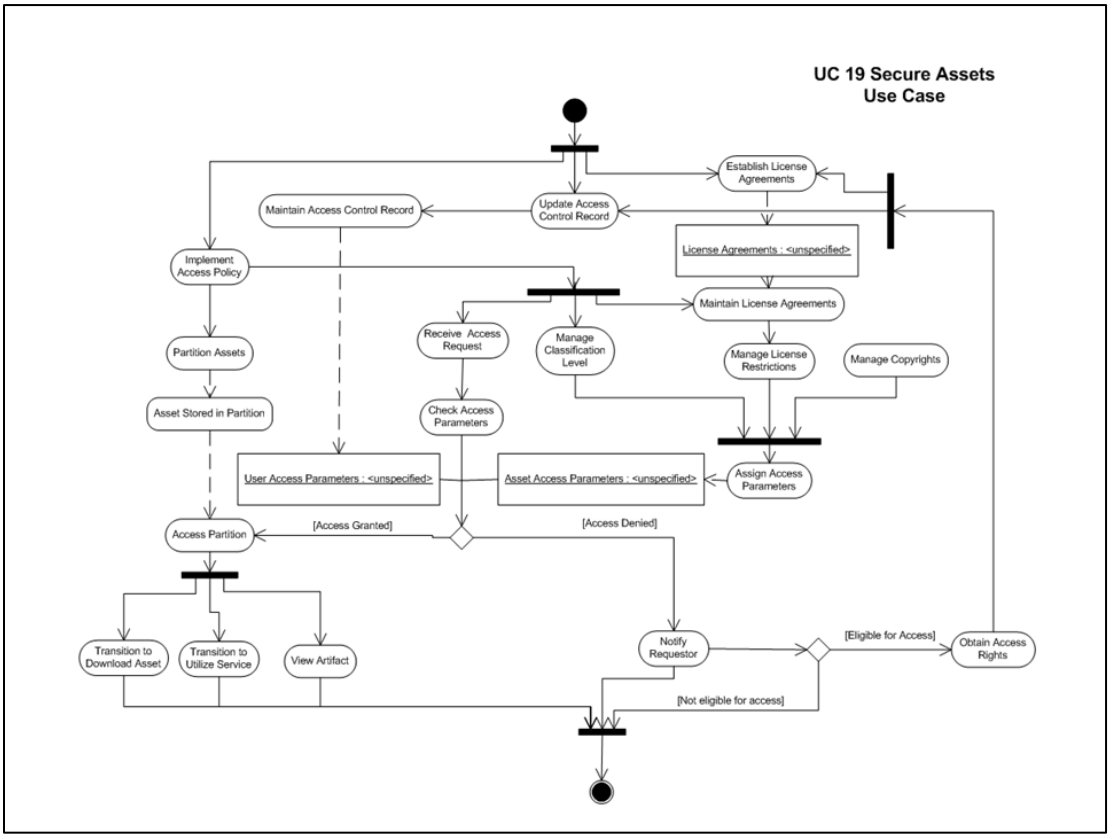


Figure C-19: Secure Assets Use Case

C.20 ACCESS FEDERATED PORTAL

The Asset Reuse Mechanism enables the user to access a federated repository either directly based on a set of credentials, or through the target repository's native portal.

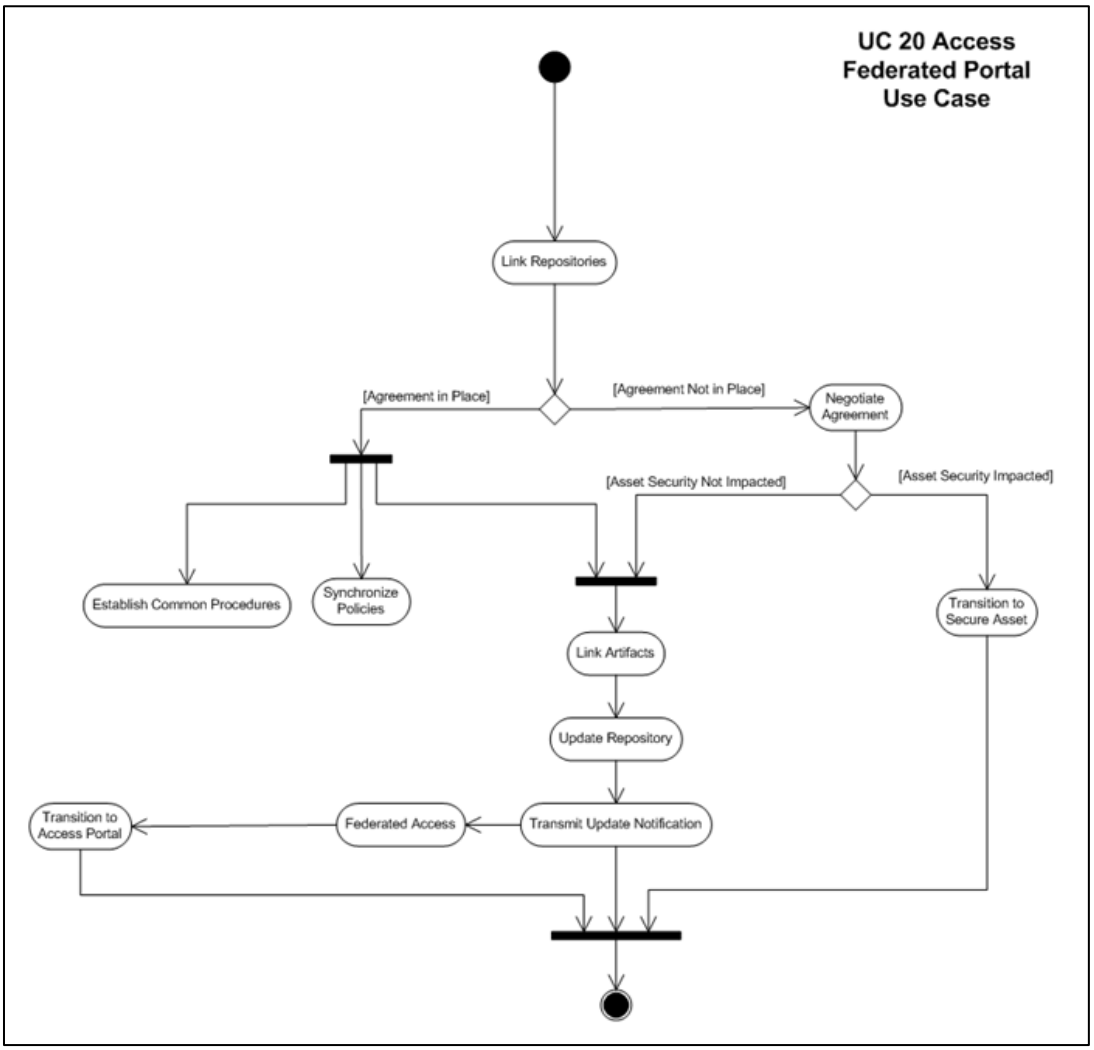


Figure C-20: Access Federated Portal Use Case

C.21 MANAGE REPOSITORY

The Asset Reuse Mechanism enables M&S Managers to establish and enforce practices/processes to fulfill the repository's goals.

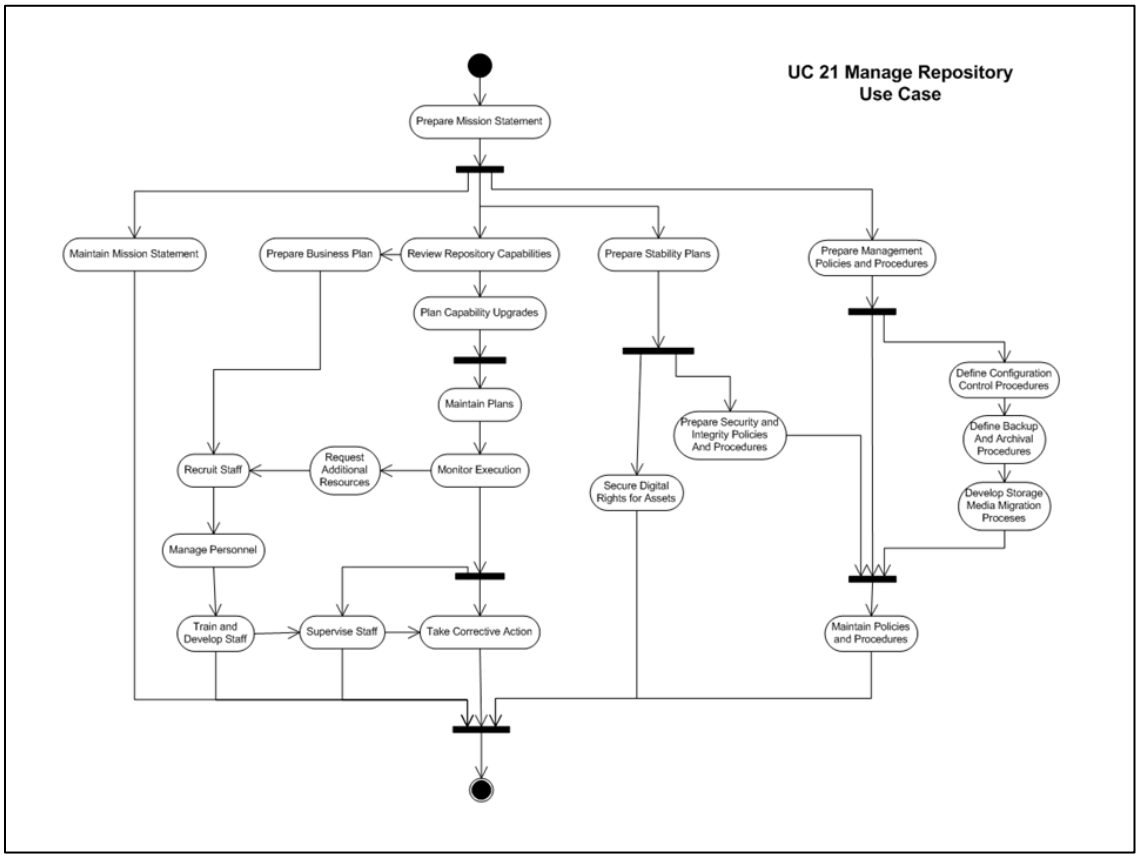


Figure C-21: Manage Repository Use Case

C.22 SUPPORT REPOSITORY

The Asset Reuse Mechanism provides accessible and reliable resources to assist users in utilizing repository services and maintain repository infrastructure.

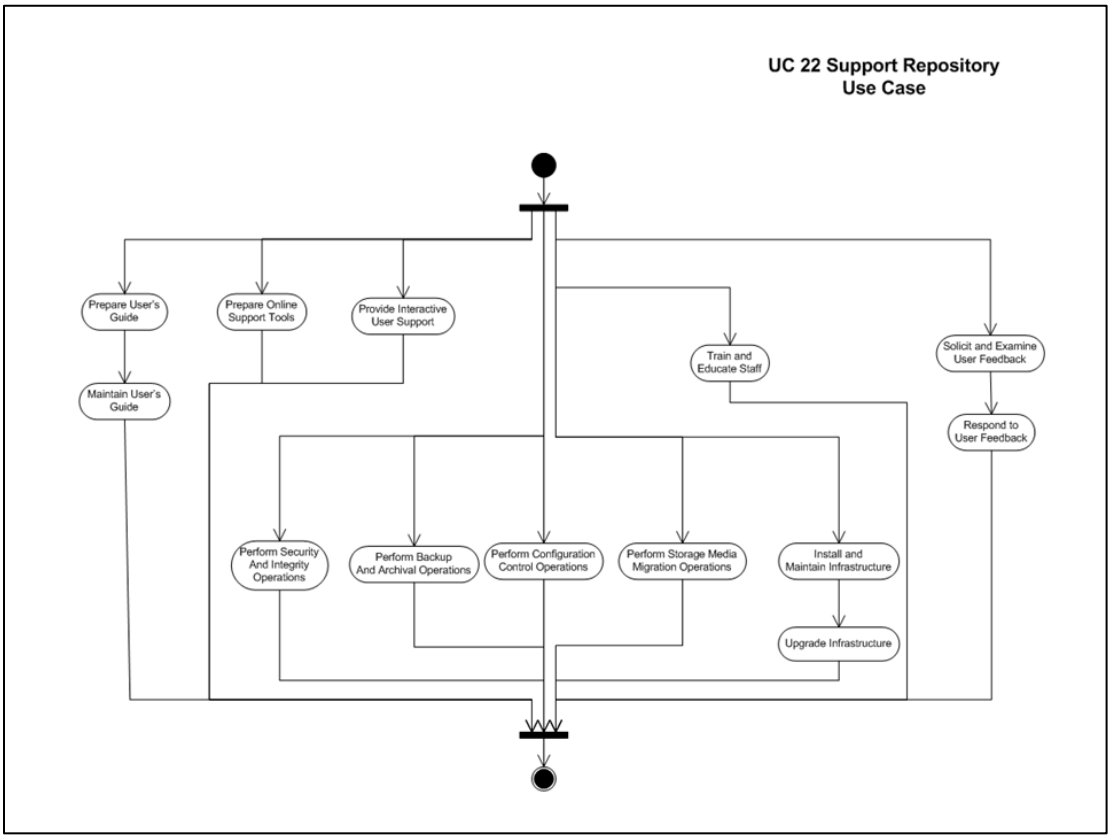


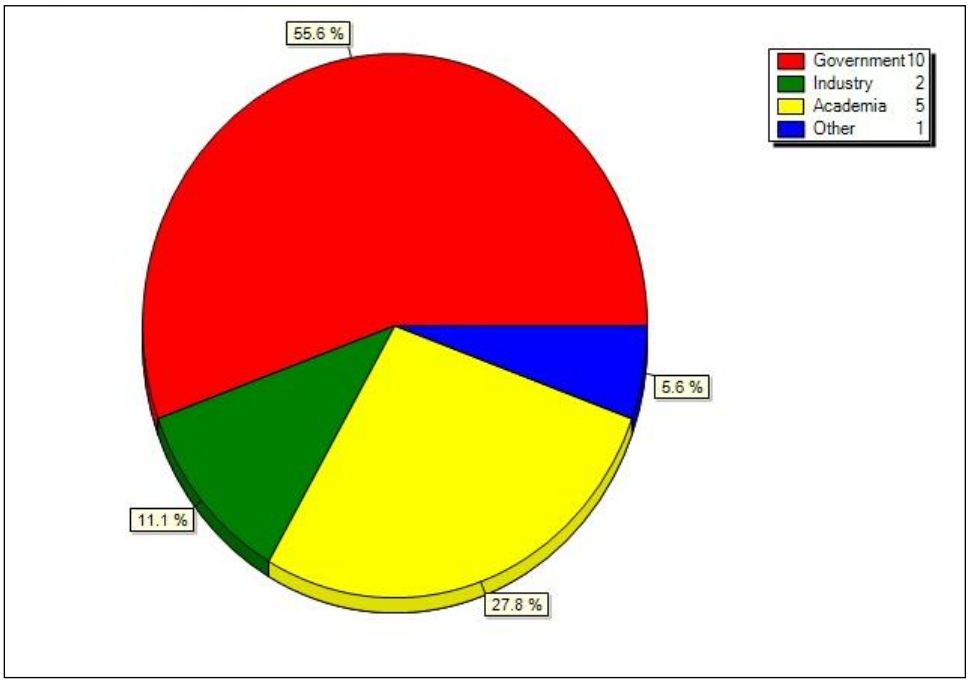
Figure C-22: Support Repository Use Case

APPENDIX D: QUESTIONNAIRE RESULTS

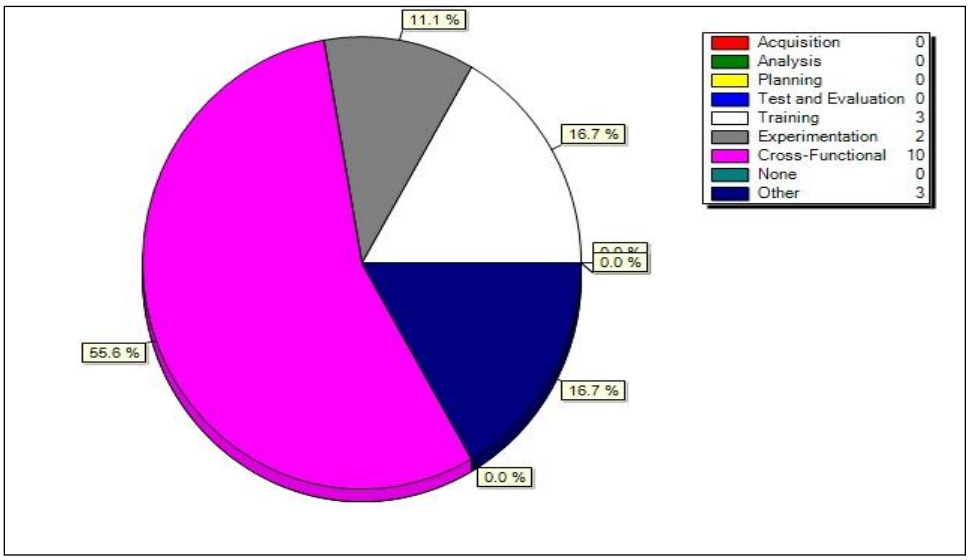
The LVC Asset Reuse Team delivered a battery of surveys in two stages. The first set of surveys consisted of forty-six (46) short-answer questions. Eighteen (18) persons responded to this questionnaire. The responses to these questions were used to shape the LVC Common Capabilities Workshop discussion and analysis, and to develop a refined discrete response questionnaire that consisted of fifty (50) multiple choice questions. Thirteen (13) persons responded to this questionnaire. This appendix provides key insights provided by these two questionnaires.

D.1 FIRST QUESTIONNAIRE RESULTS

1. In which area do you primarily work?



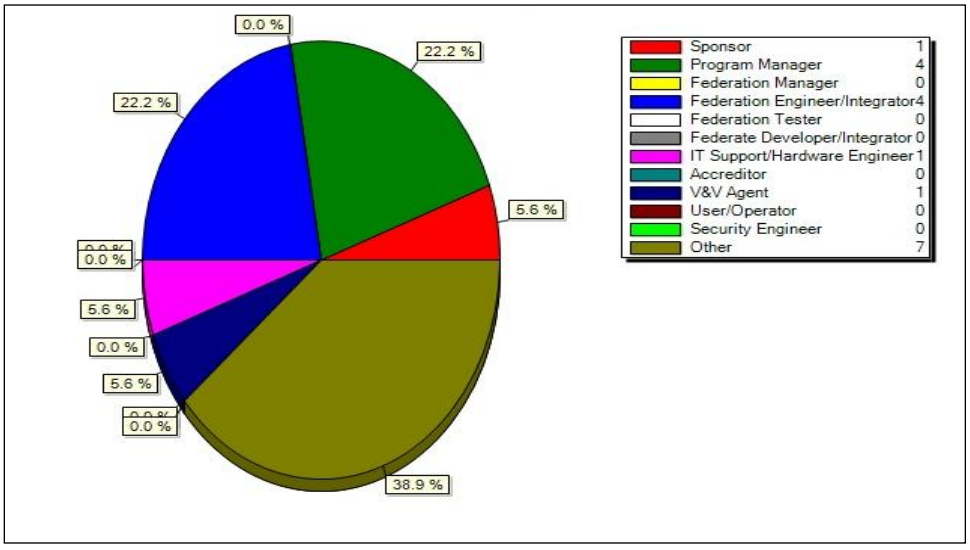
2. Which of the M&S communities of interest are you primarily associated with?



Other Responses:

- All
- Verification & Validation
- Planning, Test and Evaluation, and Training

3. In which of these roles do you most often act or provide support?



Other Responses:

- Analyst
- Research and Development
- Government Systems Engineer
- Assessment
- Project Lead and Developer/Integrator
- Technical lead for development projects.
- M&S SME / M&S instructor

C.1.1 Sample Responses: Context and Assumptions

4. Are reuse mechanisms relevant to you and your organization's requirements? If so, how?

Negative Responses	3
Positive Responses	15
Total Responses	18
Percent Negative Responses	16.67%
Percent Positive Responses	83.33%

- Yes, as a federal government employee in a training acquisition organization, it would make no sense to develop a product or methodology over and over again. Various web portals are available with controlled access that allows users to obtain and evaluate products for reuse.
- No, since most time the simulation framework in itself is a reusable asset (e.g., CGF), framework and tools provide the mechanisms and are therefore already there and integrated with methodology. Therefore, additional repositories are of no or little interest.
- Yes. However, those mechanisms and/or repositories are not managed or controlled by my organization.
- Yes. On the one hand, we strive to maximize reuse to control cost to our government customers. On the other, much of our research is in the area of standards and mechanism to maintain standards, to facilitate reuse.

5. Some technologies could potentially be categorized as either a reuse mechanism or a method to produce a reusable asset; examples include…HLA …TENA…DSEEP…on-line reuse (e.g., web services). Would you categorize these examples as reuse mechanisms or not, and can you identify other such borderline examples?

Disagrees with the premise of the question, no additional examples provided	0
Disagrees with the premise of the question, examples provided	0
Agrees with the premise of the question, no additional examples provided	3
Agrees with the premise of the question, additional examples provided	4
Partially agrees with the premise of the question, no additional examples provided	6
Partially agrees with the premise of the question, additional examples provided	2
Neither agrees nor disagrees with the premise of the question, additional examples provided	1
Neither agrees nor disagrees with the premise of the question, no additional examples provided	2
Total disagreeing with the premise of the question	0
Total agreeing with the premise of the question	7
Total partially agreeing with the premise of the question	8
Total neither agreeing nor disagreeing with the premise of the question	3
Total Responses	18
Percent disagreeing with the premise of the question	0.00%
Percent agreeing with the premise of the question	38.89%
Percent partially agreeing with the premise of the question	44.44%
Percent neither agreeing nor disagreeing with the premise of the question	16.67%

- Standardized practices, middleware, and services do not by themselves constitute a reuse mechanism. They may facilitate reuse across an enterprise, but there are business processes that must be instituted that enable reuse for that enterprise.
- Web services, yes. The others, no.
- I would think that most anything is capable of reuse in the right situation.

6. Reuse is often closely identified with repositories of reusable assets and the technologies associated with such repositories. Can you identify reuse technologies or mechanisms not associated with repositories?

Negative Responses	3
Positive Responses	13
Repsonses Neither Positive nor Negative	2
Total Responses	18
Percent Negative Responses	16.67%
Percent Positive Responses	72.22%
Percent Repsonses Neither Positive nor Negative	11.11%

- To me, reuse mechanisms are not confined to repositories. Software libraries (e.g., Java class libraries), system architectures (e.g., OneSAF Product Line Architecture), and web services are reuse mechanisms that do not obviously involve repositories.
- I typically don't associate 'reuse' with repositories or asset storage...rather, reuse is more closely associated with software interoperability and portability across multiple or varying platforms and designed to achieve or enable an identical or similar feature/function on that platform.
- I think that it could be said that languages which allow for the capture of architectures and designs for export and import could be considered reusable assets.
- Yes, mathematically rigorous definitions enabling reuse even on cross-repository level, mediating between logically equivalent methods and tools.
- When we speak of repositories, we are usually talking about actual product repositories. However, the availability of reusable knowledge products can often come from metadata repositories, which probably comprise the majority of operational repositories.
- Web services. Registries make it possible for assets to be stored some place other than a repository, e.g. on a server maintained by the asset developer.
- Standards, best practices, and policy.

7. If an asset is used repeatedly but with little or no change from previous uses (e.g., a training federation is used for another training exercise), should this repeated use be considered a form of reuse or not?

Negative Responses	0
Negative Responses (Conditions added)	1
Positive Responses (No conditions added)	10
Positive Responses (Conditions added)	7
Total Responses	18
Percent Negative Responses	0.00%
Percent Negative Responses (Conditions added)	5.56%
Percent Positive Responses	55.56%
Percent Positive Responses (Conditions added)	38.89%

- Yes - seems to be best form of reuse when it's not changed.
- Repeatability may be construed as 'reuse'. However, not for cross utilization and therefore, would more likely to be deemed 'usable' within its current environment rather than 'reusable' across the enterprise.
- Yes, but it is re-use on another level (like captured in B. Zeigler's framework first published in 1987).
- Repeated use of an asset with little or no change is considered reuse by me. It just means that it was well modularized for reuse. This includes components that are

configurable via parameters without recompilation. The components that are the easiest to use (and the least expensive) will be the ones that drive reuse within the M&S community.

- Yes – emphatically
- Yes, if it's used by another organization. The key to this distinction is that the new organization must discover the asset and use it without having the same people doing the work.

8. Are there differences between the previously-listed M&S communities of interest in objectives, methods, models, culture, or otherwise that would affect the mechanisms for reuse appropriate for each?

Negative Responses	1
No Response or Ambiguous Response	5
Positive Responses (No qualifications added)	4
Mixed Responses (Qualifications added)	8
Total Responses	18
Percent Negative Responses	5.56%
Percent No Response or Ambiguous Response	27.78%
Percent Positive Responses (No qualifications added)	22.22%
Percent Positive Responses (Qualifications added)	44.44%

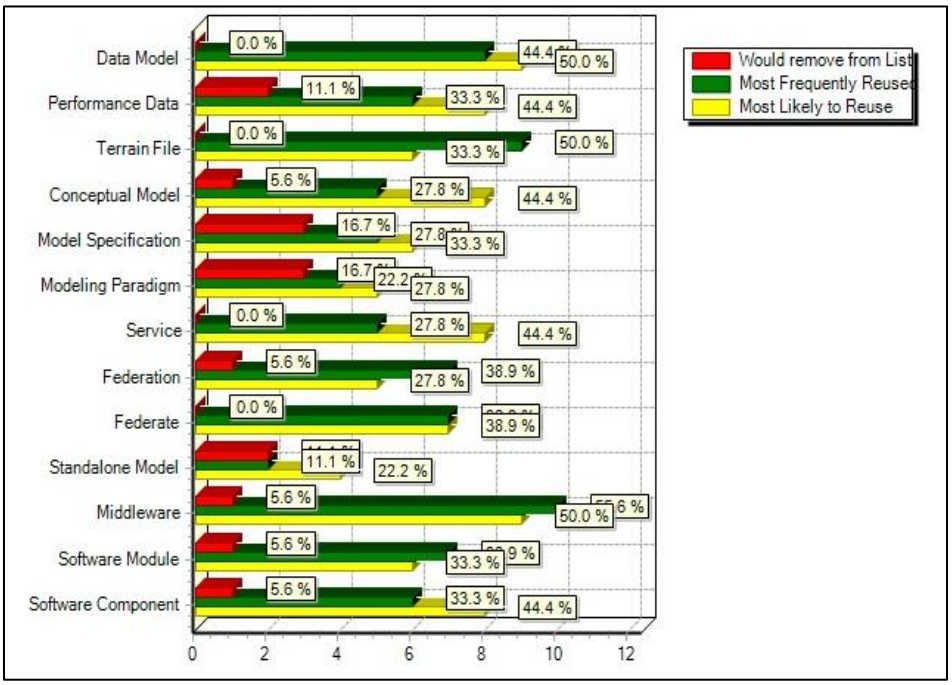
- Mainly, we use different terms on different levels of reuse. Unifying ideas are still in their infancy
- Main differences are cultural and accuracy (V&V) required.
- Definitely. Reuse has typically been more effective in smaller communities (such as planning), where informal interchange of reusable items is more likely to occur, and there's a trust among those in the community. In a community as large as Acquisition, encouraging reuse without enforcing policy will be much harder.
- Yes - but sometimes those differences are more perceived than real

9. Are there differences between the military services' use of the M&S that could affect the mechanisms for reuse appropriate for each?

Negative Responses	2
No Response or Ambiguous Response	5
Positive Responses (No qualifications added)	5
Mixed Responses (Qualifications added)	6
Total Responses	18
Percent Negative Responses	11.11%
Percent No Response or Ambiguous Response	27.78%
Percent Positive Responses (No qualifications added)	27.78%
Percent Positive Responses (Qualifications added)	33.33%

- Yes, without the appropriate standards that allow for clear and concise exchange most M&S activities are constructed in cylinders of excellence based on tools of choice, vendors of choice, or needs and requirements without consideration for reusable application.
- M&S is still organized and paid for by services, not by capabilities (e.g., done successfully in the Dutch Armed Forces, see recent NATO M&S Conference, Oct 2009, Brussels).
- I'm sure there are. The one I've encountered is that different services (and agencies) maintain repositories at different levels of access. For example, Army's MSRR is public. Air Force's MSRR requires a DoD CAC. Some other places won't list anything in an UNCLASS environment.
- Not technically. Main differences are culture and scale.
- As in the Navy vs. the Army? No, the differences in their use of M&S and its reuse are small. Ironically, I could say that reuse between the services makes their reuse needs exactly the same. The use of M&S for different needs, such as simulation-based acquisition vs. battlespace simulation, are where the differences lie. Reuse challenges across those lines are the most significant.
- The USMC is a master at reuse, primarily because of constrained budgets.

10. Which unit of reuse would you remove from the list, which have you and your organization most frequently used? Which are you most likely to use?



- Some of the items (e.g. data model, conceptual model) would be desirable to reuse, but less frequently reused unless there is an improvement in structural metadata standardization.
- My organization assesses, does not use M&S. If a model specification and a conceptual model are written for a specific model, why would they be reused -- for another model? -- doesn't make sense. Reuse tools to build conceptual models, model specs
- "Software Component" and "Software Module" are too broad.
- I am not aware of any specific instances of M&S reuse by my organization.
- Reuse at the federate and federation (to use HLA-speak) is the most convenient so far.

No Response (includes N/A and unresponsive input)	12
Provided Specific Examples	1
Other comments provided	5
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	66.67%
Percent provided Specific Examples	5.56%
Percent other comments provided	27.78%

11. Which "units of reuse" would you add to the list?

No Response (includes N/A and unresponsive input)	10
Proposed added items to taxonomy	7
Other comments provided	1
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	55.56%
Percent proposed added items to taxonomy	38.89%
Percent other comments provided	5.56%

- 3D models
- Scenarios
- AAR Tools
- Reuse of Integration environment
- Network Component or Platform Interface Component (Communications - not middleware) Virtual Model
- Operational concept or frame for the experiment or exercise to be supported (as reusability can only be decided in the context of what needs to be supported). Scope, structure, and resolution of modeled capabilities can only be evaluated in the light of what is needed.
- I suggest looking at the offerings of OPNET Technologies, which does comms & network M&S. They offer (1) simulation environments; (2) models that run in those environments; (3) scenarios that use models and data in simulations; and (4) tools that generate scenarios based on actual networks and network traffic. How would these things fit into the categories above?
- Frameworks (actual software frameworks, not conceptual) - Formal Design Patterns (think "Gang of Four") specific to M&S - Organized (non-chaotic) communities of M&S reuse (think Forums that span academia, industry, government, and military) where concepts and code fragments can be shared
- Other data file types such as scenarios
- Performance data is much too narrow to capture the need for reusable data. Data is the fundamental input to simulation and it needs to be better classified and archived as a reusable asset. For example behavioral data, preference data, social network data, organizational network data. The paradigm should be to reuse source data by organizing it through conceptual models and simulating it via a modeling paradigms.

12. Which modes of reuse would you remove from the list, which have you and your organization most frequently used? Which are you most likely to use?

Comment Responses:

- Company role is largely assessment, not modeling and reuse.
- Non M&S developer. Frequency of reuse modes unknown.
- As before, definitions are needed to make these different ideas comparable.
- In our own case, we've modified source code.
- Given the complexity and uniqueness of code, I would think that most anything reused would require some sort of minimum adjustment.
- This list sort of assumes a second generation coding method, all source code compilation. Reuse of 3rd or 4th generation tools source or integration (mash-ups) of existing services may be the long-term solution.

No Response (includes N/A and unresponsive input)	14
Provided Specific Examples	0
Other comments provided	4
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	77.78%
Percent provided Specific Examples	0.00%
Percent other comments provided	22.22%

13. Which modes of reuse would you add to the list?

No Response (includes N/A and unresponsive input)	15
Proposed added items to taxonomy	3
Other comments provided	0
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	83.33%
Percent proposed added items to taxonomy	16.67%
Percent other comments provided	0.00%

- Deriving conceptual capability models. Map those to operational requirement models. Mediate between different technical implementations.
- Software as a Service (SAAS)
- Integrated Services - Reuse of architecture-independent conceptual layers and objects

14. What repositories (DoD or COTS, M&S-specific or general) have you or your organization used?

No Response (includes N/A and unresponsive input)	5
Provided Specific Examples	12
Other comments provided	1
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	27.78%
Percent provided Specific Examples	66.67%
Percent other comments provided	5.56%

- MSRR (now DoD MSIS) (6)
- Army MSRR (5)
- Navy MSRR (3)
- Air Force MSRR (3)
- ACE / AKO
- CADM, DARS, CADIE, ABCAS, ARMS
- Those supported at J7 JFCOM JATTL.
- The DoD M&S Catalog is trying to connect to every DoD-related source/repository it can. But we've used the Service MSRRs to look for things.

- MoD DoD NATO TTCP
- PIVOMS (ATEC repository)
- TENA Repository
- OneSAF.Net
- FCS ACE Portal (2)

15. With respect to the units and modes of reuse defined earlier, which units and modes are currently found in the repositories that you have used?

No Response (includes N/A and unresponsive input)	9
Provided Specific Examples	6
Other comments provided	3
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	50.00%
Percent provided Specific Examples	33.33%
Percent other comments provided	16.67%

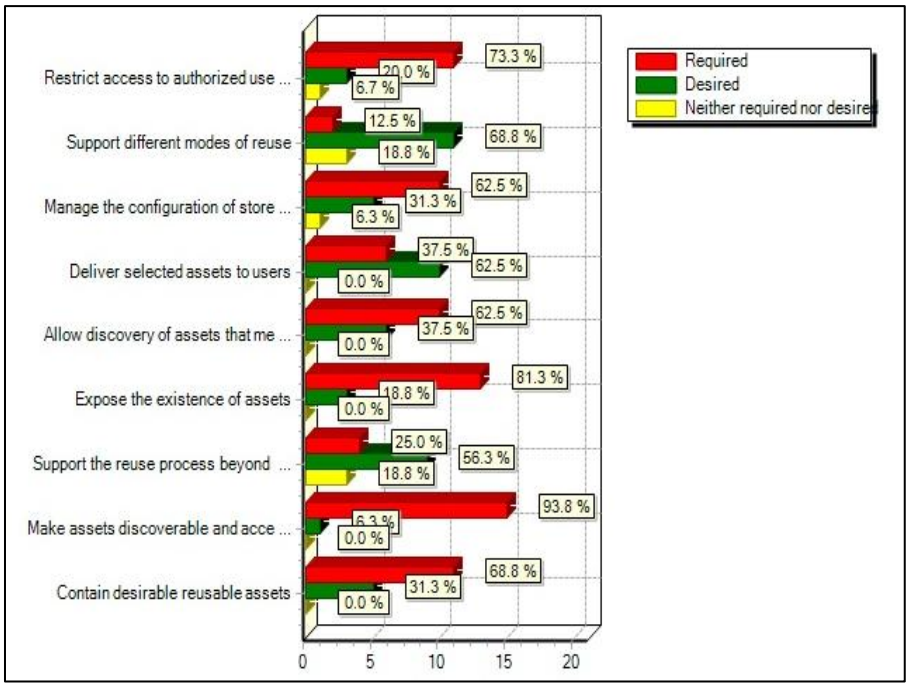
- Software module/modify code
- Models, Data, Files, Code
- Software Component; Federates; Federation
- FEDEP - Complete Federations (wrote gateway) - Models reused - Data reused (geographical, and terrain)
- Most are data driven (not even data model). Too close to implementation, not enough support of conceptual ideas.
- Models/federates
- Entire simulations and datasets.
- The DoD and Army provide only a "reference catalog" describing models and simulations maintained elsewhere by M&S sponsor and proponent agencies. PIVOMS was similar to the Army MSRR, with added information about the utility of M&S applications to support specific system evaluation criteria for Army future force programs. The OneSAF.net repository provides user level documentation, standardized test scenarios, software design and software configuration artifacts, with limited online support services. Only the TENA repository provides direct access to engineering artifacts as well as software tools for developers, integrators, and end users.

16. With respect to the units and modes of reuse defined earlier, which units and modes should be added to the repositories and you have used?

No Response (includes N/A and unresponsive input)	12
Proposed additional reuse units and modes for repositories	4
Other comments provided	2
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	66.67%
Percent proposed additional reuse units and modes for repositories	22.22%
Percent other comments provided	11.11%

- A deeper articulation of engineering artifacts associated with development, integration, test, and usage functions may be helpful, since these documents are frequently stored and forwarded through a repository mechanism.
- A layered model of re-use needs to be used to define the required meta-data to be stored in data models (see Andreas Tolk, Saikou Y. Diallo, Robert D. King, Charles D. Turnitsa, Jose Padilla: "Conceptual Modeling for Composition of Model-based Complex Systems" in Stewart Robinson, Roger Brooks, Kathy Kotiadis, and Durk-Jouke van der Zee (Eds.) *Conceptual Modelling for Discrete-Event Simulation*, CRC Press, draft accepted in September 2009).
- Federation, Service.
- Data models and standards.

17. Please check if each one of the following characteristics is required, desired, or neither.



18. What repository characteristics and capabilities would you add to this list, and why?

No Response (includes N/A and unresponsive input)	7
Proposed characteristics to be added	9
Other comments provided	2
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	38.89%
Percent proposed characteristics to be added	50.00%
Percent other comments provided	11.11%

- Accuracy, currency, user friendly
- Provide V&V history

Protocol and information model

- Provide associated documentation including conceptual model.
- Provide adequate capacity for asset growth and expansion.
- Unambiguously define user criteria in support of the discovery and selection process.
- Comment on "Restrict access to authorized users" above: It's required for FOUO and above; it's neither required nor desired for "Distribution Statement A" stuff.

- Exploration of use and V&V data.
  - Community forum (for authorized users, with access controls in place).
  - Commenting capability per asset, so that usability issues can be raised and addressed (monitored).
  - Links (points of contact) to asset support system, if it exists, for help, notices of progress, and update dates.
  - A feedback capability to the maintainer of an asset (to drive updates, bug reports, workarounds, and the like).
  - The repository should be organized more like SourceForge than like a searchable static repository of assets. The feeling should be that each asset has a maintainer, and that the asset is being kept relevant. If an asset is unmaintained, then it should be date marked and treated as static, looking for a maintainer.
- Provides a history of previous use. Provides VV&A history of the asset.
- Restrictions on access are required in some cases but in general restricting access is counter-productive.

19. How well did the characteristics and capabilities of the repositories you have used support your reuse requirements?

Negative Responses (no qualifications added)	2
Negative Responses (Qualifications added)	5
No Response or Ambiguous Response	4
Positive Responses (No qualifications added)	0
Positive Responses (Qualifications added)	5
Minimally Positive Repsonses	2
Total Responses	18
Percent Negative Responses (no qualifications added)	11.11%
Percent Negative Responses (Qualifications added)	27.78%
Percent No Response or Ambiguous Response	22.22%
Percent Positive Responses (No qualifications added)	0.00%
Percent Positive Responses (Qualifications added)	27.78%
Percent Minimally Positive Repsonses	11.11%

- Adequate, management of the assets could be improved.
- None so far - since there are no public repositories.
- The owners' (proprietary) repositories fills the function well.
- Somewhat sufficient. Unable to link/map assets to...or determine their reuse capability as a feature of the repository.

- Most of them poorly, most were developed out of need or requirements and never for the bigger picture.
- OK with one big exception: Current POC information is hard to get, and sometimes just doesn't exist.
- Adequately.
- Well at Constructive (CGF) level.
- Discovery was nearly useless, either delivering no results or so many that the search result was not much better than just scanning. Metadata was so old as to be useless in most cases.
- Rarely if at all.

20. What aspects and operations of conventional software configuration management are important in a repository specifically intended to support reuse?

No Response (includes N/A and unresponsive input)	5
Comments related to S/W and version control	9
Other comments provided	4
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	27.78%
Percent Comments related to S/W and version control	50.00%
Percent other comments provided	22.22%

- Configuration identification and traceability (5).
- Version control (5) check-in/check-out, and change tracking.
- Baseline management (2) …proper labeling of baselines needs to be implemented to ensure correct versions are reused…all changes to the base line tracked.
- Who made the changes for what purpose (3).
- Ability to go back to older versions (3).

Problem report tracking.

- Provenance of changes as well as date changed.
- Identification of current and legacy (no longer supported) versions.
- Traceability across multiple reuse systems/platforms/component.
- All aspects of software configuration management are important…source and well as build details available…Note: there is an IEEE standard for software configuration management plans: IEEE Std. 828-1998.

- What is "...Conventional software configuration management", is it source code, the Binary or what? From my point of view it is important.
- Can be applied one-on-one, but need to be extended by modeling specific processes (traditional IT is only supporting simulation).
- Crawl-ability (by Google, etc.).
- Generation/support of XML metadata (e.g., MSC-DMS).

21. A repository can collect and maintain reuse metrics (e.g., what was searched for, what was found, what assets were downloaded, who conducted searches, who downloaded assets). What specific reuse metrics would be useful to you?

No Response (includes N/A and unresponsive input)	4
Proposed metrics for reuse (1-2)	8
Proposed metrics for reuse (3 or more)	5
Other comments provided	1
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	22.22%
Percent proposed metrics for reuse	44.44%
Percent proposed metrics for reuse (3 or more)	27.78%
Percent other comments provided	5.56%

- Purposes for which assets were reused.
- Previous use, related items, experiences.
- What products were successfully reused, and were they found with the help of the repository.
- Quality, best practice etc. most downloads, categories etc, fidelity.
  - All attributes that can be used.
- Modification History.
- Search criteria (key).
- Current Users.
- Asset Hierarchy / Tree / Structure.....not particularly interested in download (check-in/check-out) metrics.
- In addition to those listed: what was the M&S scenario, LVC scenario, or architecture rendering were the selected items used for and how were linked, incorporated, or used? What modifications had to be made to allow for re-use?
- BOM is a first step into the right direction, but more is needed (see Tolk, A., and C.D. Turnitsa. (2009). An Extended Interoperability Framework for Joint Composability. Fall Simulation Interoperability Workshop, Orlando, FL, September 2009).

- Who looked for what and found what? Failing that, what was searched for (the query) and what was found (the results).
- How many "stars" have been awarded to a particular asset by previous users?
- Number of downloads (4) by asset (3).
- Which assets had high download counts, what assets were used together?
- Who downloaded and for what purpose?
- The "who" downloaded my get into privacy issues…better stick to generic numbers and not mention specific…users.
- User ratings and comments.
- None of the above are reuse metrics -- they are search and retrieval metrics. No documentation of reuse was mentioned. Need who used, for what purpose, and were changes needed/made (even if you don't get the modified module)?

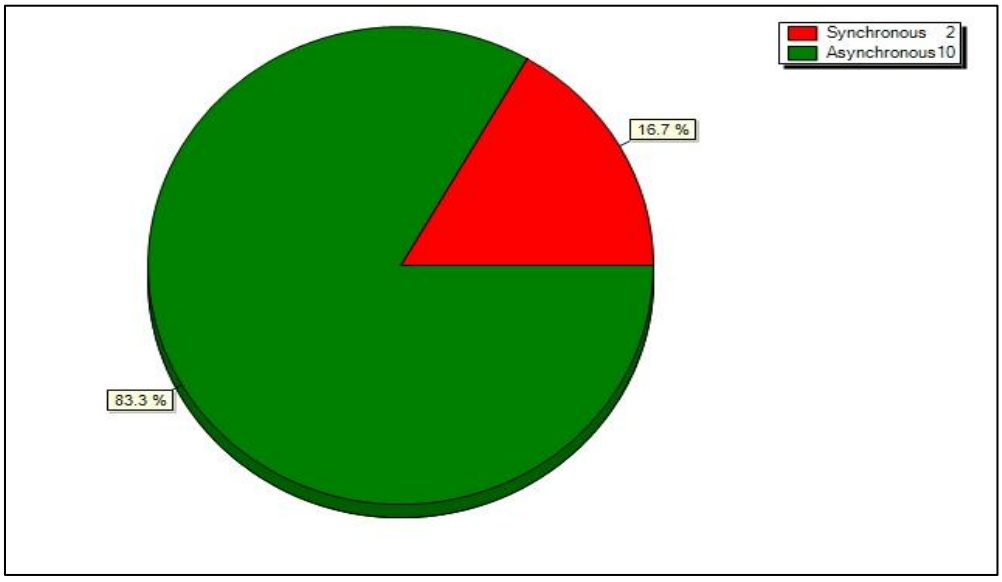
22. In your experience, are collaboration and reuse independent of each other (i.e., reuse without collaboration and collaboration without reuse are both possible) or are they tightly bound (i.e., all reuse involves some form of collaboration between developer and use)?

No Response (includes N/A and unresponsive input)	2
No or minimal relationship	2
Loosely related	2
Mixed Response	4
Strongly related	6
Other Response	2
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	11.11%
Percent Responded No or minimal relationship	11.11%
Percent Responded Loosely related	11.11%
Percent Mixed Response	22.22%
Percent Responded Strongly related	33.33%
Percent Other Responses	11.11%

- Collaboration and reuse are loosely coupled functions.
- In my experience, reuse and synchronous collaboration and reuse are largely independent of each other; most reuse involves asynchronous store-and-forward collaboration.
- Nothing is ever perfect, there needs to be some form of collaboration when issues arise, though not necessarily real time.
- Reuse and collaboration can be done separately, but there should be some minimal level of collaboration.

- Nature of coupling is strongly dependent upon the quality of documentation provided.
- Independent collaboration and reuse exist when the mechanisms that are in-place are inadequate or designed as such. However, ideally, collaboration and reuse should be tightly bound between developer and user to help maintain configuration management and use of multiple versions across multiple systems/platforms/users.
- No, these are not independent. Developers should understand or know the user requirements as the reusable components are developed. This is why we currently use SME's during development.
- Please see Andreas Tolk: "Beyond Technical Interoperability – Introducing a Reference Model for Measures of Merit for Coalition Interoperability." 2003 Command and Control Research and Technology Symposium, Washington, D.C., June 2003, in which merits and ideas are described in detail.
- I would think that collaboration is required for reuse to occur.
- They tend to tightly bounded for defense developments but loosely coupled when COTS (e.g., computer games) adapted for defense purposes.
- No. SourceForge is an example of their interdependence.
- Tightly bound collaboration produces the fastest results, but it is very expensive and limits the scope of reuse.

23. Which approach to collaboration is more important to you and your organization?



Comment Responses:

- N/A - organization is primarily assessment.
- N/A - both is equal important.
- This is after all the development has been completed through the collaborative environment.
- Also, synchronous is a subset, so we kill two birds with one stone.
- Communicating with humans is the best approach, rather than just getting static assets.

24. Which collaboration features (e.g., on-line chat, presentation view, RSS, etc.) are most important in the reuse context?

No Response (includes N/A and unresponsive input)	7
Asynchronous Features only	1
Primarily asynchronous features	2
Mix of synchronous and asynchronous features	1
Synchronous features only	4
Other responses	3
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	38.89%
Percent responsed asynchronous features only	5.56%
Percent responded primarily asynchronous features	11.11%
Percent responded mix of synchronous and asynchronous features	5.56%
Percent responded synchronous features only	22.22%
Other responses	16.67%

- VIS, teleconf, on-line chat.
- Web meeting.
- Presentation.
- On-line chat; FAQs.
- Wikis, threaded email - all need to be searchable discussion forums.
- Call me a dinosaur, but email and telephone.
- Because most reuse-motivated collaboration is asynchronous store-and-forward, asset metadata must be sufficiently detailed and complete to support that process.
- None of the above. Alignment of conceptual models is the most challenging task.

- Primarily the ability to identify a useful POC. Once I know who to contact, it matters less how we talk.
- Interaction need not be immediate to be useful: - Forums - Bug reports with maintainer feedback - User commentary to ease reuse (warning: users are quick to point out unusable assets, so the politics of providing this may be sensitive).

25. Should there be mechanisms for asset users to report on their experiences with an asset, and if so, should the repository itself provide that capability?

Negative Responses	1
Negative Responses (comments added)	0
Positive Responses (No comments added)	6
Positive Responses (Comments added)	9
No Response (includes N/A and unresponsive input)	2
Total Responses	18
Percent Negative Responses	5.56%
Percent Negative Responses (Conditions added)	0.00%
Percent Positive Responses	33.33%
Percent Positive Responses (Conditions added)	50.00%
Percent No Response (includes N/A and unresponsive input)	11.11%

- Yes. A log book approach.
- Yes, ratings and comments are important guides.
- Yes, if the repository manages the dissemination of an asset or artifact, there should be a mechanism to provide feedback.
- There is always a place for after action review. Yes.
- It is probably essential, and yes, the capacity should be provided
- Such mechanisms would clearly be useful. Whether or not the repository provides the functionality is an implementation detail.
- Yes, but the user reports should be tagged with user experience as well (if a book and a head bump together, and the result is a hollow sound, this sound does not always come from the book ...).
- Yes. If not the repository, then a registry that lists the asset.

- Ah, you read my mind. Yes, there should be an experiences section. But it shouldn't be a "special" section of a repository. It should just be part of an assets forum.
- Absolutely!

26. What features should a repository search facility have to specifically support M&S reuse searches?

No Response (includes N/A and unresponsive input)	4
Proposed search facility features (1-2)	5
Proposed search facility features (3 or more)	4
Other comments provided	5
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	22.22%
Percent proposed search facility features (1-2)	27.78%
Percent proposed search facility features (3 or more)	22.22%
Percent other comments provided	27.78%

- Up-to-date POC contact information.
- Google features.
- Make it simple to use...
- Key word, related items, user reviews.
- Syntactic and Semantic.
- Search criteria related to all aspects of the asset.
- Frequently used links, especially to linked or federated sites, are helpful.
- Ability to search on M&S-related criteria, such as simuland, resolution, and VV&A status.
- Connection conceptual capability (to be reused) with operational requirements (to be supported).
- Crawl-ability (openness to crawlers) and XML metatags based on something like MSC-DMS.
- Intelligent search (think "Google"): - spelling correction - "word family" search ("federations" will match "federation") - See - Boolean operators - API for web service connection.

- VV&A history and usage services. Hard to implement, but desirable, is some set of keywords that identify what's modeled in the asset.
- Unstructured queries dynamic navigation facetted navigation taxonomy definitions.

27. How should information access be limited to ensure that only users with appropriate authorization gain access?

No Response (includes N/A and unresponsive input)	5
Metadata Control	2
Encryption and Physical Access Control	2
Multiple Controls	5
Other responses	4
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	27.78%
Percent Metadata Control responses	11.11%
Percent Encryption and Physical Access Control responses	11.11%
Percent Multiple Control responses	27.78%
Other responses	22.22%

- Not should, MUST.
- CAC authorization, SSO.
- Use of groups.
- Permission sets.
- Access control by means of web server.
- Assets and asset metadata should have access levels, and only authorized users should be allowed to access them. An asset and its metadata might have different access levels.
- Secondary logins as needed to authenticate users for specific classes of assets.
- This cannot be solved. It has not been solved within the M&S within NATO or between operational systems.
- Cylinders of Excellence are developed this way. Is the goal of this effort to break that mold?
- What we're doing in the M&S Catalog: capturing security/releasability info about specific fields.
- Password control with encryption. Download protection similar to commercial software.

- Yes. Access controls should be in place. The repository should be split between publicly assessable and restricted. If it is all restricted, the usability greatly decreases.
- Depends on the network they are available on and the sensitivity of the data - assets should not be classified as higher levels than absolutely necessary. Developers need to be encouraged to avoid unnecessary classification and classifications should be periodically reviewed.

28. How should repository search mechanisms treat assets with different restrictions (e.g., freeware assets, intellectual property restricted assets, commercial assets) in response to a search?

No Response (includes N/A and unresponsive input)	2
Metadata oriented response	3
Access restriction based response	3
Discovery oriented (search process) response	5
Other responses	5
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	11.11%
Percent Metadata oriented response	16.67%
Percent Access restriction based response	16.67%
Percent Discovery oriented (search process) response	27.78%
Percent Other responses	27.78%

- Identify each asset.
- The restrictions on these assets should be discoverable along with their existence and how they may be acquired.
- Such restrictions should be included in the metadata and be includable in search criteria (i.e., "return only freeware").
- Allow the search to show all assets. Assets which are restricted when selected should provide information on how to obtain access to the asset.
- Each should be clearly identified OR be search under separate categories.
- Probably best done on retrieval rather than search.
- See Download.com for a good strategy.
- Search restrictions with appropriate user messaging.

- In the M&S / LVC community that we are referring to doesn't everything belong to the government? Freeware is free, assets belong to the government, intellectual property belongs to the government, restricted assets should be on the High Side, commercial assets should have been purchased.
- A multi-role search can help (customer who paid for it has all rights, academic international partner has only limited access). Also, a multi-box approach can help (like supported by OMG Model Driven Architecture): - conceptual idea (CIM) - logical model (PIM) - implemented code (PSM).
- a) Know the restrictions for each asset. b) Know the credentials of the end-user doing the search. c) If there are restrictions, have a mechanism to ensure that only qualified end-users get the restricted material.
- Repository should have a base level where all assets should be listed and their access/restrictions defined.
- Yes, that should be part of the search automatically. The user shouldn't have to indicate which part of the repository they are searching. It should be based on the user's access privileges.
- The user should be allowed to select these as search criteria.
- By clearly identifying rights for use.
- While legacy assets will need to enforce existing licensing, probably by limiting distribution to manual channels, a new license should be developed in the future that provides for open source for government reuse and all new government software should be developed under it.

29. Who should be empowered to place assets in a repository?

No Response (includes N/A and unresponsive input)	2
Asset Owner Oriented response	3
Combined Asset Owner and Central Authority Response	1
Central Authority Oriented Response	1
User Oriented Response	4
Other Responses (includes mixed responses)	7
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	11.11%
Percent Asset Owner Oriented response	16.67%
Percent Combined Asset Owner and Central Authority Response	5.56%
Percent Central Authority Oriented Response	5.56%
Percent User Oriented Response	22.22%
Percent Other Responses (includes mixed responses)	38.89%

- Repository users should be able to determine who placed an asset in the repository by the metadata.
- A review board.
- A registered user or designated repository asset manager.
- Asset owners (3) or designated agents.
- Restricting the ability to place assets in a repository can result in a pristine repository with no assets. List the depositor and contact information and caveat emptor. If model is used in organization, use organizational contact.
- The developer or owner, see download.com or sourceforge.net.
- Anyone with access to that repository.
- This question seems to imply that someone will approve the placement of assets. If the approver doesn't like the representation is it rejected? If proper CM is implemented then all assets can be entered. If based on an original then it is placed as a modification. If new it is listed that way.
- Best approach is a managed user-forum: everyone can post into the open section, but only a manager core can insert those into the repository).
- First, I DISAGREE with the premise (stated above #29). Assets do NOT have to be deposited before reuse. Only METADATA about the assets must be made available for discovery. This metadata must include a current POC of appropriate type. Then the potential end-user and the POC can work it out between themselves.
- Some governance is required to ensure compliance with repository formats and rules; and to ensure maintenance and scope.
- I would suggest that it be turned around and allow anyone willing to be an asset maintainer to deposit assets, as long they meet some very limited criteria, such as the asset must be M&S-related, and is a professional product. There should be the ability to reject an asset at any time, so that issues can be addressed.
- Anyone who has general access to the repository.
- Users, PEOs, PMs, developers.
- This will vary with the repository (2). Different repositories should have different levels of trust. Generally repositories should have three levels of users - administrators, contributors, and customers.

30. How should repository updates be executed and controlled?

No Response (includes N/A and unresponsive input)	3
Asset Owner Oriented response	2
Combined Asset Owner and Central Authority Response	2
Central Authority Oriented Response	2
User Oriented Response	4
Other Responses (includes mixed responses)	5
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	16.67%
Pecent Asset Owner Oriented response	11.11%
Percent Combined Asset Owner & Central Authority Response	11.11%
Percent Central Authority Oriented Response	11.11%
Percent User Oriented Response	22.22%
Percent Other Responses (includes mixed responses)	27.78%

- Using conventional configuration management methods and practices.
- A designated repository asset manager.
- Made by the same, owners or agents.
- Depends on nature of the assets and frequency of use – hard to generalize. Perhaps set schedule -- 6 months, yearly?
- By developer or owner. See download.com or sourceforge.net.
- Robust check-in / check-out mechanisms and controls.
- Updates would be based on the updating of the baseline standards being implemented. If this is a DoD site, DoD either conducts or contracts the updates based on changes to the standards.
- Users informed of updates.
- Management group driven by user inputs.
- What the DoD M&S Catalog does: requires each record to have a stable, unique "metacard" ID. Then an update can easily be matched up with what it replaces. Easier: each source can simply submit the latest version of ALL metacards each time, and the new batch replaces the old batch entirely, even if particular records didn't change. This works because we're dealing with metadata, not the assets themselves.
- The owner of asset should update but with governance defined by the repository managers.
- Maintainers must maintain their own systems. The forums should allow both the maintainer and the repository operators to monitor entries. The bulk of the effort must be on the maintainer, or the repository will be unwieldy and unmaintainable.

- Only original submitters and their designated representatives should be allowed to post updates.
- Periodic review is a NECESSITY! No model seems to work except a repository administrator polling asset owners to provide updates/retire assets.
- Some level of scanning will be required to maintain IA requirements. This has to be part of the submission process. Automation is highly desirable. All submissions must be attributable.

31. What level of quality control or developmental maturity should be required for assets to be submitted to or released from a repository ?

- None, but maturity should be clearly identified.
- Establish a process to review submitted asset before release.
- Depends on the asset - software source code requires stricter access and control versus reports.
- Limited to currently used assets for new submissions and maybe a warehouse/holding area for retired items.
- Allow assets from reasonable sources in. Removal best done with user response. Remove assets that have problem reports.
- See download.com or sourceforge.net.
- If we want to use this for support to operations and GIG conforming M&S support: as high as for C2 elements.
- The primary thing is that the actual level of QC or maturity should be IDENTIFIED so the re-user knows what to expect.
- Continuous and comprehensive. The only thing worse than a lack of information is information for which there is no historical data.
- Quality levels should be defined (e.g., research, prototype, pre-production, production, legacy) and V&V logbooks and/or TRLs should be used to define maturity.
- By using maintainers and feedback, the system will be Darwinian in nature, and self cleaning. The quality will get high as it can get. If an asset cannot fund its upgrades, then others may step in, including the government, to carry the asset. External pressure from the repository controllers to maintain the quality of the assets is not feasible, and shouldn't be attempted.
- User experiences with assets should establish the "market" for the assets.

- Probably better to allow submissions and cull those that are not used frequently or get bad reviews. A high quality product with little interest might be far less useful than a buggy one that makes an important breakthrough.
- This is a repository-by-repository decision. However, repository users should be able to determine by an asset's metadata what quality control and developmental maturity is associated with an asset.

32. What metadata items are needed to support each mode of reuse?

No Response (includes N/A and unresponsive input)	9
All metadata is applicable (no priority given)	1
Provided 1-2 priority items	2
Provides 3 or more specific items	1
Other Response	5
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	50.00%
Percent Responded No or minimal relationship	5.56%
Percent Responded Loosely related	11.11%
Percent Mixed Response	5.56%
Percent Other Responses	27.78%

- This question is difficult to answer without reference back to the modes of reuse.
- Those listed are more than enough.
- All, and you are missing the conceptual metadata mentioned before.
- All, but some parts ought to be mandatory: Name, Developer, Purpose and intended use, Version.
- How to make it work (How to - see Linux).
- Under which consideration it will run, max - min load, timing, etc.
- The most important item of all: CURRENT POC. In addition to that, for the purpose of finding a model we could modify to our needs, we've used: Usage: asset name, developer, purpose and intended use, creation/modification date, limitations, strengths. Technical: What environment does it run in, including version. [If you say "OPNET version 14.0", you've pretty much said everything.] General: What is being represented, and how?

- Appropriate to gauge whether it could be potentially re-used or adapted for the user's need.
- All of the ones listed.
- Not sure it varies as much by mode of reuse as opposed to what's being reused for what purpose.
- Information required will vary on a case by case basis. No change standalone use will probably require much less information than use that requires modifications and integration with other assets. Higher level categorizations such as "works with JNTC" might help limit information requirements.

33. It is possible, indeed likely, that for some assets the metadata describing the asset might be less sensitive than the asset itself. Should the metadata for assets, therefore, be accessible independently of the assets they describe?

No Response (includes N/A and unresponsive input)	5
Negative Responses	0
Positive Responses (No comments added)	7
Positive Responses (Comments added)	3
Other Responses	3
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	27.78%
Percent Negative Responses	0.00%
Percent Positive Responses (No comments added)	38.89%
Percent Positive Responses (Comments added)	16.67%
Percent Other Responses	16.67%

- Yes (7).
- The best rule of thumb for classified assets is not to reveal metadata to unclassified searches (2).
- Yes (see box idea of access based on OMG MDA).
- If necessary, it should be transparent for the user.

- Is there a reason for this distinction? The name of asset and its access controls should only be visible to those that have the privilege to see it or get access to the asset. A formal definition of the security controls should be documented, implemented, and tested.
- Absolutely. You can certainly describe some classified models to some level with unclassified metadata.

34. Some repository designs separate storage of the metadata entries from storage of the assets they describe in a manner similar to the separation of cards in a library card catalog from the books they identify. Could such separation affect the utility of the repository to a user in a positive or negative way, and if so, how?

No Response (includes N/A and unresponsive input)	7
Affects Negatively	0
Affects Positively	3
Mixed Response (Both positive and negative impact)	3
Other Responses (includes no impact)	5
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	38.89%
Percent Responded Affects Negatively	0.00%
Percent Responded Affects Positively	16.67%
Percent Mixed Response (Both positive and negative impact)	16.67%
Percent Other Responses (includes no impact)	27.78%

- Why? Google as search engine, download.com, sourceforge.net is repositories - with different "fidelity."
- Should not affect user at all, as long as he can appropriate access both.
- The separation could negatively affect utility if the separation allows the asset and its metadata to become unsynchronized (i.e., the metadata describes a different version of the asset than the one currently in the repository).
- Only positive for better management and safer sharing. Efficiency can be maintained by storing access results.
- POSITIVE: Have you lately tried to give outside users access to stuff on a secure network? By keeping the assets hidden and exposing only the metadata (kept on different machines), you reduce IA concerns and headaches.

- Only those with access to an asset should have the privilege to search the space for the metadata related to an asset. The mechanism for navigating and searching for the metadata should be verified to impose this restriction.
- It could affect the user negatively if the registry function is available, but the associated repository function for a desired asset isn't. However, I view that risk as lower than the challenges of maintaining a central repository.
- Asset owners are much more likely to describe holding, and still "hold the keys to access" vice posting items in a repository with no control.
- If the association is in danger of being lost then it could negatively affect the user, however, discovery of assets that allow the user to present additional credentials for access as in 33 would be useful.

35. What is the definition of success for a repository of reusable assets for you and your organization?

No Response (includes N/A and unresponsive input)	4
Management Oriented Responses	1
Technically Oriented Responses	3
User Oriented	3
Mixed Responses	7
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	22.22%
Percent Management Oriented Responses	5.56%
Percent Technically Oriented Responses	16.67%
Percent User Oriented Responses	16.67%
Percent Mixed Responses	38.89%

- Controlled access.
- Easy to search.
- Frequent usage.
- Percentage of searches that return a usable asset.
- Positive feedback on the repository itself.
- Most users who retrieve assets find them useful.
- That we lower the cost and increase quality.
- Assets are configuration managed.
- Sufficient asset metadata. Asset obtained in a timely manner.

- Current assets clearly identified and updated in a timely manner.
- Finding and using assets from a repository takes less time and effort, and provides a more capable or credible asset, than new development.
- The ability to integrate the asset without manipulation into an LVC scenario.
- The ability to find stuff to reuse OR reasonably conclude it doesn't exist.
- Reuse actually occurs. Sounds simple, but historically reuse has been a seldom successfully dream of technology.
- Vendors and developers consider it a positive thing to place assets on the repository
- Assets that are not fully formed are welcome, so that feedback makes them higher in quality.
- I can easily discover whether or not a usable asset exists and get rapid access to it, and the asset works as advertised.
- Small as well as large contributions are added, so that academic contributions are invited.
- A real community of users grows out of the use (where people actually recognize other people and working relationships form).
- Well-used and respected asset maintainers are recognized for their contribution to the M&S community.
- Cross-fertilization from other communities (such as SourceForge) are created, appreciated, and maintained.

36. What past examples of successful or unsuccessful reuse, either in your organization or elsewhere, can you identify?

Negative Responses (no example given)	2
Negative Responses (example given)	2
No Response or Ambiguous Response	9
Positive Responses (example given)	1
Positive Responses (no example given)	2
Other Responses	2
Total Responses	18
Percent Negative Responses (no example given)	11.11%
Percent Negative Responses (example given)	11.11%
Percent No Response or Ambiguous Response	50.00%
Percent Positive Responses (No example given)	5.56%
Percent Positive Responses (example given)	11.11%
Percent Other Responses	11.11%

- Items not updated or maintained.
- Successful - our integration platform that enables us to care less if it is 1516, 1.3, DIS, TENA, RPR-FOM, Specific FOM, Link 16 etc.
- In an unsuccessful reuse is the multiple requirements that require countless hours building gateways and bridges to allow different systems and architectures to "communicate" in an M&S or LVC environment.
- BOM and SRML examples come as close as we can get today to what I define as successful reuse.
- Extremely High Frequency (EHF) satellite communications (SATCOM) Time-Division Multiple Access (TDMA) Interface Processer (TIP): We found one developed by our sister organization (SPAWAR Pacific) and were able to adapt it to a new client's needs.
- Dozens of unsuccessful. No successful.
- CGFs - successful SNEs - not very; so a service approach is being taken.
- I may be thinking along different lines than you, but that's the point, isn't it? Here goes: - SourceForge - Craig's List - EBay - Linux - Google Forums.

37. What current obstacles to successful reuse exist?

No Response (includes N/A and unresponsive input)	4
Management Oriented Responses	6
Technically Oriented Responses	3
Mixed Responses	5
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	22.22%
Percent Management Oriented Responses	33.33%
Percent Technically Oriented Responses	16.67%
Percent Mixed Responses	27.78%

- Lack of incentives, programmatic motivators (5).
- Not Invented Here (5).
- Getting metadata updated properly.
- Lack of conceptual models (2).
- "The I can't find it therefore I'll build it syndrome."
- Metadata insufficiently detailed to support asset selection.
- Inadequate asset documentation to support developer understanding of an asset.
- Assumptions not documented, parameter sensitivity not recorded, V&V history incomplete.
- That a model is a purposeful abstraction of reality. Meaning that the model/system is built for a specific purpose and when using the model / system in another context, may violate the system/model, i.e. it will not work. Therefore the purpose/intention of usage of the model/system needs to be described and most desirable to be defined so that automatic configuration, validation etc. can be made...).
- "Lack of motivation for asset owners to expose their assets to discovery and to keep that discovery information current. (In other words, the business case for the asset owner.) In the case of the government, we're not allowed to charge for something the taxpayer already owns. In the case of industry, they want to keep things proprietary."
- The effort to set up the environment with the right assess controls, but with a feeling that all are invited - Setting up the site so that it can be updated without breaking it - Willingness to discard assets that are no longer viable, keeping the repository relevant as a whole

38. Are the most significant current obstacles to successful reuse best described as technical (i.e., mechanisms) or non technical (i.e. programmatic/cultural/political)?

No Response (includes N/A and unresponsive input)	2
Non-technical Response	9
Technical Responses	0
Mixed Responses	7
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	11.11%
Percent Non- Technical Responses	50.00%
Percent Technical Responses	0.00%
Percent Mixed Responses	38.89%

- Programmatic and political.
- Primarily non-technical (3).
- Both as they are closely linked (3).
- Non-technical obstacles are the most significant.
- There are both technical and non-technical obstacles that need to be resolved. It is hard to judge which category is most significant, but neither will work without attention to the other.
- Technical - bandwidth (i.e., terrain files), non-Technical – licenses.
- Technical in that model/systems are built for one purpose and used in other context.
- Cultural/political: Is that the user does not want to pay for models.
- What's the business case to make my stuff discoverable? Once I have a business case for it, I'll find a way to do it.
- Most M&S work is done under copyright restrictions, often imposed by the sponsor. The challenge will be to:
  - Have sponsors be willing to have pieces of developed systems be posted to the repository, the implementer willing to "give away" the tech that they developed, and a maintainer being recognized and funded. We need to have verbiage ready to hand the government to require developed assets to be posted
  - Allowing US versus international submissions, and the access controls that would impose

  - Free assets being offered where vendors are selling equivalent products, and the repository being blamed for the loss of potential revenue.
- Reuse is typically portrayed as cheap, you just do it - the reality is quite different. Government contracting generally discourages reuse, despite what is claimed. Most assets have lost much of their meaning by the time they are products so it requires the reuser to reverse engineer a lot of information.

39. How effective are policies and mandates requiring the development of reusable assets and the reuse of available assets likely to be?

No Response (includes N/A and unresponsive input)	6
Responded "Ineffective" (no qualification)	1
Responded "Ineffective" (with qualification)	7
Responded "effective" (no qualification)	0
Responded "effective" (with qualification)	3
Other or Mixed Responses	1
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	33.33%
Percent Responded "Ineffective" (no qualification)	5.56%
Percent Responded "Ineffective" (with qualification)	38.89%
Percent Responded "effective" (no qualification)	0.00%
Percent Responded "effective" (with qualification)	16.67%
Pecent Other or Mixed Responses	5.56%

- Unlikely, but we need to keep trying.
- Policies and mandates are likely to be ineffective until the non-technical obstacles are resolved.
- Don‘t know. I hope "very" -- but am not holding my breath.
- Generally not unless backed up by means of enforcement.
- None - policies and mandates won’t change anything. Money will.
- Poor at best. People just do what they want because it is easier.
- Ineffective, if not guided by an approved method rooted in mathematics.
- Policies alone not effective mechanism; resistance to mandating as it restricts innovative solutions.
- They are effective only if they come from the sponsor of the asset. Otherwise, there is little "teeth" in the mandate due to copyright restrictions. We will get submissions from academia, since much of their work is openly available. That's a good thing.

- This could be effective if organizations that institute the policies also enforce them. One significant challenge is the restriction on organizations developing assets that go beyond meeting their stated requirements.

40. Are the incentives to reuse assets (e.g., potential savings of time, reduction of cost, or increase in quality) greater than the disincentives (e.g. difficulty in finding suitable assets to reuse, dependence on external developers), and if not, why not?

No Response (includes N/A and unresponsive input)	5
Responded disincentives are greater (no qualification)	3
Responded disincentives are greater (with qualification)	1
Responded incentives are greater (no qualification)	1
Responded incentives are greater (with qualification)	3
Other or Mixed Responses	5
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	27.78%
Percent Responded disincentives are greater (no qualification)	16.67%
Percent Responded disincentives are greater (with qualification)	5.56%
Pecent Responded incentives are greater (no qualification)	5.56%
Percent Responded incentives are greater (with qualification)	16.67%
Percent Other or Mixed Responses	27.78%

- There are not yet sufficient incentives to maximize reuse where practical. One reason for this is that asset visibility is often limited to general description of M&S applications, rather than enabling evaluation of engineering artifacts without having to invest the time to acquire, use, and test the executable code.
- The answer varies by situation, sometimes yes and sometimes no.
- There are neither; as long as money is available to recreate assets, they will be recreated whether or not something reusable exists.
- It depends upon time, criticality, ease of access and full documentation.
- Yes. Instead of trying to find suitable assets to reuse an own repository has been made.
- Yes. If done correctly, once established, no one can develop without using artifacts and assets without acquiring them from the repository.
- Unknown, no major successes to point to.
- So far, it did not work ... and we always had the money for an alternative.
- To answer that question, ask this question: In general, do projects reuse assets or develop new ones (or do without)? If reuse does not happen, it's because the incentives are NOT greater than the disincentives.

- Incentives to reuse are great. Wouldn't it be nice if it were like shareware, where an asset wouldn't be necessarily free, but could reward the maintainer for their contribution? That would address the disincentive of asset contribution. I can see it now: "if you like this software, we suggest sending $10,000 US to _____. Thanks!"
- Not necessarily. But, your question looks at one side of the equation--from the consumer perspective. From the asset owner perspective, it's much harder to capture the benefit to the one making an asset available for reuse. Because, generally it's not a benefit derived by the asset owner, but the larger enterprise.
- Reusing what you know is very profitable and done everywhere, reusing what you don't know has very high barriers.

41. Do the incentives and disincentives to reuse assets differ in significant ways between government-developed and commercially-developed assets, and if so, how?

Negative Responses (no explanation given)	1
Negative Responses (explanation given)	1
No Response or Ambiguous Response	7
Positive Responses (no explanation given)	0
Positive Responses (explanation given)	7
Other Responses	2
Total Responses	18
Percent Negative Responses (no explanation given)	5.56%
Percent Negative Responses (explanation given)	5.56%
Percent No Response or Ambiguous Response	38.89%
Percent Positive Responses (No explanation given)	0.00%
Percent Positive Responses (explanation given)	38.89%
Percent Other Repsonses	11.11%

- Money/profit.
- Similar disincentives to reuse exist for both commercial and government developed assets.
- Absolutely. Commercial entities are driven solely by financial advantage.
- Yes, the incentives and disincentives differ. Commercially-developed assets are generally more expensive to reuse, but they are often better documented.
- Yes, commercially-developed has a business case behind - and though the assets are used are in the interests of the commercial organization.
- No, neither of the them currently have strictly enforced rules for development.

- Government should be the honest broker, commercial partners the implementation experts.
- Yes. Government: Illegal to charge for stuff the taxpayer already owns, so no profit motive to expose for reuse. Business: Does have a profit YES; incentive is greater in government to reuse to save time and cost. Industry - it is not in their commercial interest.
- Yes. The government-developed asset should have a huge incentive to reuse, particularly if they can control the access to the reuse. The commercially-developed asset needs to use an intelligent service- or license-based scheme to justify posting an asset. However, if the asset is a tool that that is attachable to a commercially-sold product, that becomes a viable approach to reuse.
- Absolutely. Commercial industry is much more likely to post assets for discovery if there's a profit motive. For the government-owner, it's almost a nuisance to answer queries from potential re-users.

42. Who should bear the cost of supporting a repository of reusable assets: the users of those assets, a central or independent organization, or someone else?

No Response (includes N/A and unresponsive input)	5
"Asset Users" Response	2
"Asset Developers" Response	1
Centralized Organization Response	5
Centralized Organization + Users Response	1
Other Responses (includes mixed responses)	4
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	27.78%
Percent "Asset Users" Response	11.11%
Percent "Asset Developers" Response	5.56%
Percent Centralized Organization Response	27.78%
Percent Centralized Organization + Users Response	5.56%
Percent Other Responses (includes mixed responses)	22.22%

- Costs should be met by a central organization that would also enable sharing of extant assets (2).
- Independent.
- A new, Title 10 independent structure is needed. The set-up should be done with central money, then each re-use contributes a little bit to the costs.

- A central organization should be responsible for the repository itself, but individual organizations should be required to provide in-kind support to maintain information on individual assets.
- Reusers, because they are the ones who eventually get the benefit of reusable products.
- Asset developers should share the cost with M&S managers at varying levels; a balance between centralization and decentralization is probably the most practical and workable approach.
- Both users and the organization that maintains the repository
- How about communities of interest that involve both users and providers, as well as their customers -- might be by user community (Analysis, T&E) or by asset content (Missiles, boats, etc.).
- The ones that benefit from such repository. See downloads.com and sourceforge.net as good examples of reusable assets.
- Not the users or a central organization should maintain it. They can't. Assets should have a maintainer, and they should keep it up to date, or pass the baton to someone who will. The repository will collapse under its own weight if those who didn't develop an asset try to maintain it.
- Since the benefit is derived from the larger enterprise, the expectation typically will be to let the larger enterprise (e.g., PEO, Service M&S office, etc.) bear at least a portion of the cost. Any other solution appears to be the asset owner to be a "tax" levied on their program.

43. Who should be responsible for completing the required metadata for an asset to be placed into a repository: the asset-developing organization, the repository support organization, or someone else?

No Response (includes N/A and unresponsive input)	3
"Asset Developers" Response	6
"Asset Users + Developers" Response	2
Centralized Organization Response	2
Centralized Organization + Developers Response	5
Other Responses (includes mixed responses)	0
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	16.67%
Percent "Asset Users" Response	33.33%
Percent "Asset Developers" Response	11.11%
Percent Centralized Organization Response	11.11%
Percent Centralized Organization + Developers Response	27.78%
Percent Other Responses (includes mixed responses)	0.00%

- Owner of asset.
- The asset developing organization (4).
- Asset-developing governed by the support organization (2) in accordance with the requirements for use.
- Asset developing organization, with quality review by the repository administrator (2) The asset-developing organization should prepare the metadata, and the repository support organization should ensure that the metadata is sufficiently complete and detailed before accepting an asset for the repository.
- In practice, I think it will have to be shared: (a) The asset-developing organization can be required to make metadata available, but (b) the repository (Catalog) will probably have to maintain "human contact" with the development community so people (humans) will actually carry through.
- Both producers and users should contribute to asset metadata.
- The one that develops the asset - or the organization that wants to share such assets- i.e. community driven. See sourceforge.net and downloads.com.
- Independent, academically-sound organizations (like a V&V organization making sure that all is there and supported as it should be).
- Repository support org. That's the only way you will maintain configuration control.

- The asset maintainers should initially provide the metadata. The statistics-based metadata should then be controlled by the repository organization, and as much of it as possible should be maintained automatically.
- Must be started by asset developer but should be augmented with user feedback in Web 2.0 style.

44. What would you add to or remove from the list of reasons for repository failure?

No Response (includes N/A and unresponsive input)	6
No additions or deletions	2
Proposed deleting items	1
Proposed adding items	8
Other Response	1
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	33.33%
Percent no additions or deletions	11.11%
Percent proposed deleting items	5.56%
Percent proposed adding items	44.44%
Percent Other Responses	5.56%

- I would add lack of reusable assets for some situations.
- Documentation is different from metadata and it's critical for reuse.
- IPR.
- Failure to properly maintain. This could be a lack of funding issue.
- Lack of education regarding reusability (due to the lack of a rigorous theory on reuse).
- Lack of champions to keep people interested and involved. (Reference: "Diffusion of Innovations" by Rogers).
- Lack of marketing there-use concept.
- These are all good reasons for failure. You don't need more reasons. The architecture should be made to be as self-maintaining as possible. I would suggest that the maintainers start with SourceForge package and modify it from there, so that it is more asset related and has more access controls. Use Google search! Don't reinvent it. Pay for it if needed. That addresses much of the metadata and searching issues. Incentive should not come from the repository maintainers, but from the government,

the contributors, and the users. The repository should be seen as a conduit of information and assets, not a self-promoting entity.

- Non-intuitive search.
- Remove lack of incentive, it is up to the repository developers to create something that improves the capability of organizations to achieve their missions, artificial incentives are distorting.

45. A restructured version of this questionnaire will be circulated later within the broader M&S community. What questions would you add to or delete from this questionnaire?

No Response (includes N/A and unresponsive input)	6
No additions or deletions	2
Proposed deleting items	1
Proposed adding items	8
Other Response	1
Total Responses	18
Percent No Response (includes N/A and unresponsive input)	33.33%
Percent no additions or deletions	11.11%
Percent proposed deleting items	5.56%
Percent proposed adding items	44.44%
Percent Other Responses	5.56%

- See longer version of questionnaire prepared before reducing question list.
- Some questions seem somewhat repetitive.
- Must define some terms better - it might be obvious for the inventors of this questionnaire – Can't remember now but it was about software engineering practices.
- Also why are interoperability standards limited to HLA TENA when it is an open question, there are others as well CORBA is one...
- More questions regarding the conceptual modeling are needed.
- As only conceptual and logical models support the composition of models, which is as important and harder to accomplish than the interoperability of simulation systems.
- DELETE whatever it takes to get it down to 20 questions or fewer.
- How should COTS computer games and data be reused? To what extent is your organization re-using COTS Computer Games products?
- The questionnaire was too long, and it didn't indicate how long it was going to be or if you could save your answers and come back later to finish. I like the open-ended questions, so the questionnaire doesn't steer the answers in a particular direction.

Since this is for a workshop, there doesn't seem to be any way to volunteer to help with a particular issue, although that may not be an option you want to offer.

- I'm passionate about this, and it took an effort to complete. For a larger audience, this needs to be half as long.
- Probably needs to be shorter. You could ask whether users had experience with existing repositories, if not many questions could be skipped.

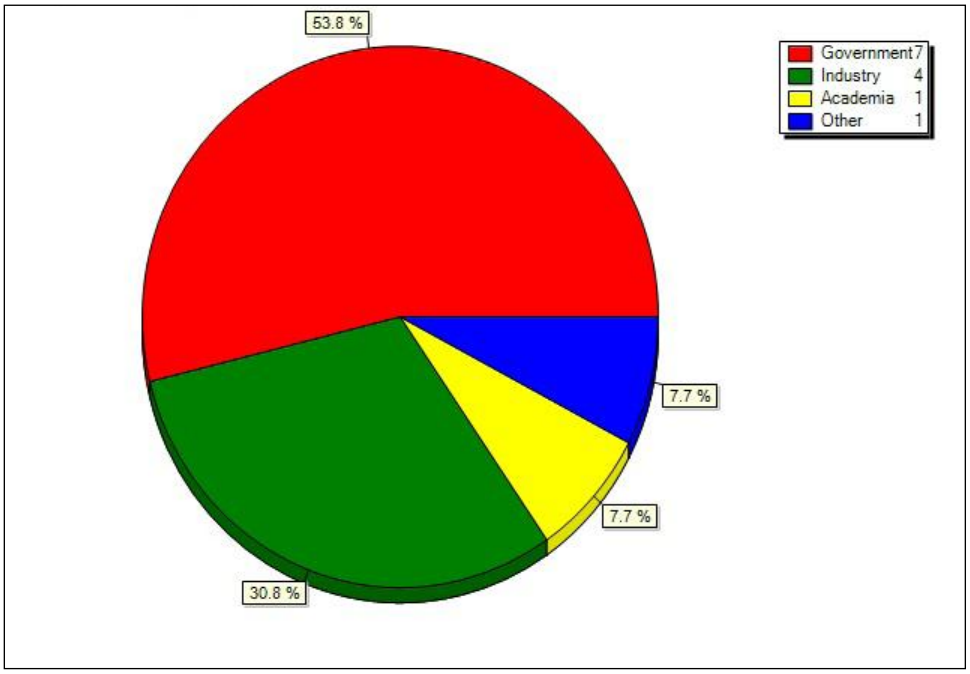
46. In your opinion, what is the most important action to be taken to enhance M&S reuse mechanisms?

- Educate sponsors that reuse is not free. Developing a reusable asset costs more than developing a non-reusable asset. Supporting a repository has a cost. Reusing an asset, while perhaps less costly than developing one, nevertheless has a cost for discovery, selection, education, and integration.
- With M&S community input establish process and standards for the storing and discovering of reuse assets.
- Obtain a clear understanding of what the user needs; technology is available to address those needs.
- That someone wants to pay for it. Compare the Gaming industry where each vendor have their own game-engine - there is no need to have a common one - since common means not tailored for a specific usage which means that it is to general instead of being specific. If it is not in the spec from the one paying that it should be reusable, it will never be.
- Architecture Translation. Allowing any architecture class, component, or object to be re-used in a different architecture.
- Find a clear cut success case for a major and minor system.
- Development of a mathematically sound reuse theory that unifies the various technical approaches and ideas. The current efforts on a Joint Composable Object Model (JCOM) looks into this direction, but needs to embrace all solutions, not just a convenient sub-set of contributors. Some ideas are summarized in Tolk, A., and C.D. Turnitsa. (2009). An Extended Interoperability Framework for Joint Composability. Fall Simulation Interoperability Workshop, Orlando, FL, September 2009.
- Define and set up a business-level motive for both sources and repositories (Catalogs) to keep metadata current.
- Mandated repositories.

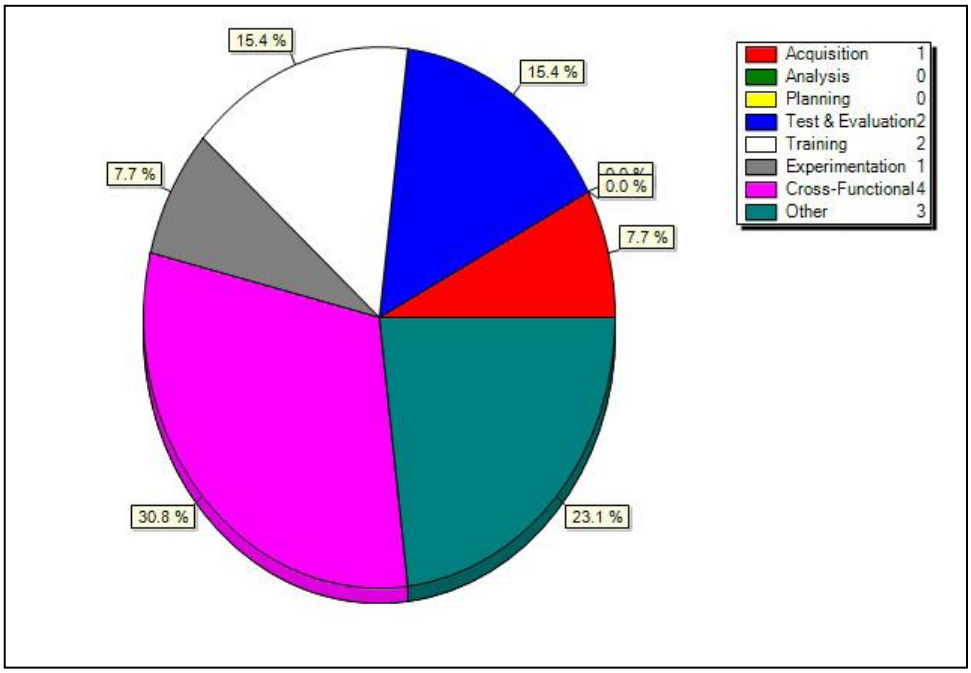
- Communicating and marketing the re-use mechanisms to developers and users as well as training to re-use assets.
- Make it feel community-driven, rather than government driven. The community wants to reuse assets, and they will make that happen. The government insisting on reuse will cause a great many waivers, and stifle its use.
- Bringing current registry/repository contents up to date. There is currently little trust in those registries and repositories because of outdated content.
- Develop the capability to reuse assets have a higher level of abstraction.

D. 2 SECOND QUESTIONNAIRE RESULTS

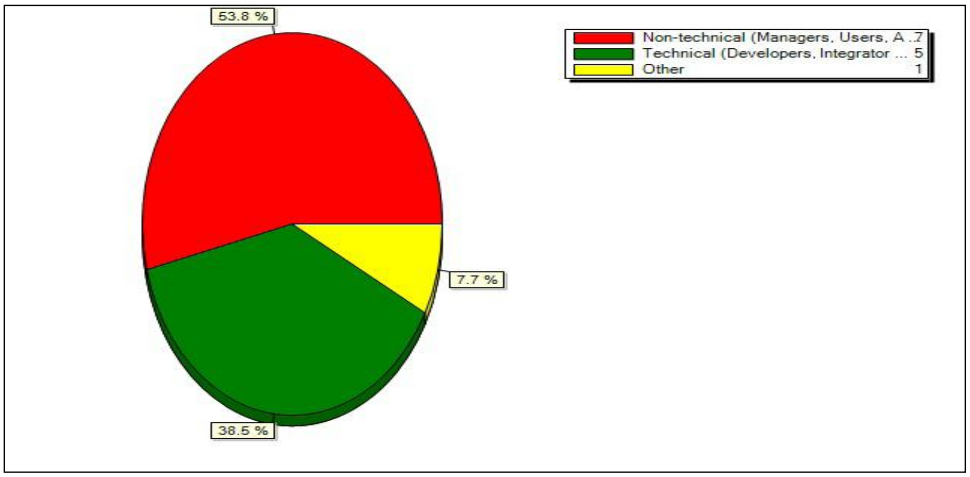
1. Please identify your organization type?



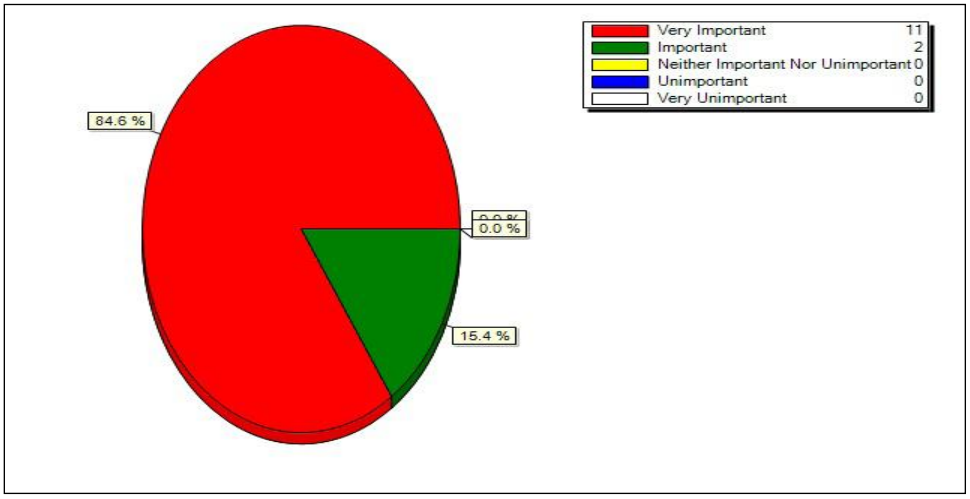
2. Choose your M&S community of interest.



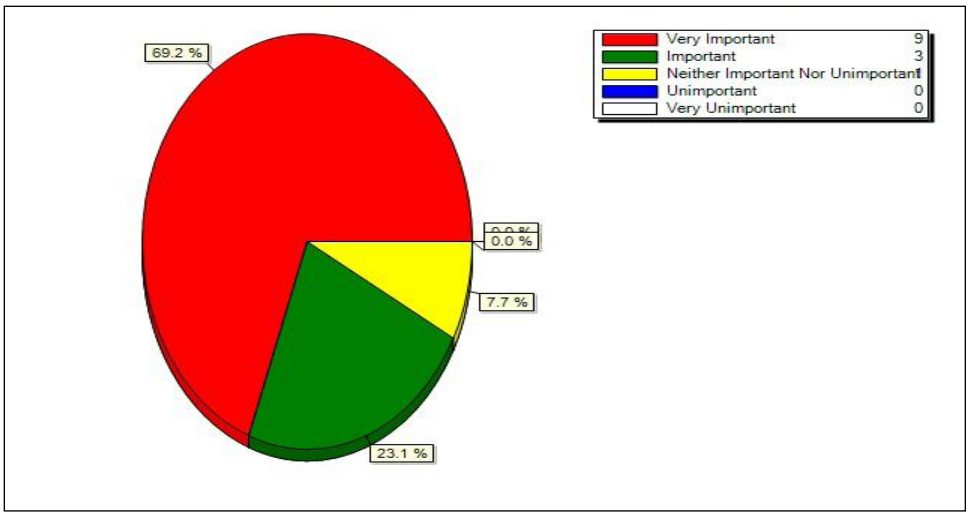
3. Please choose your role.



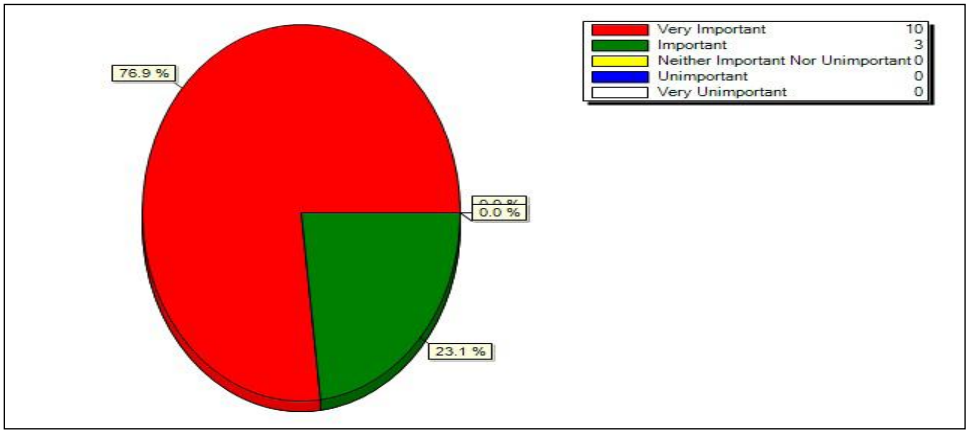
4. How important is the reuse of M&S assets to you and your organization in your LVC M&S projects?



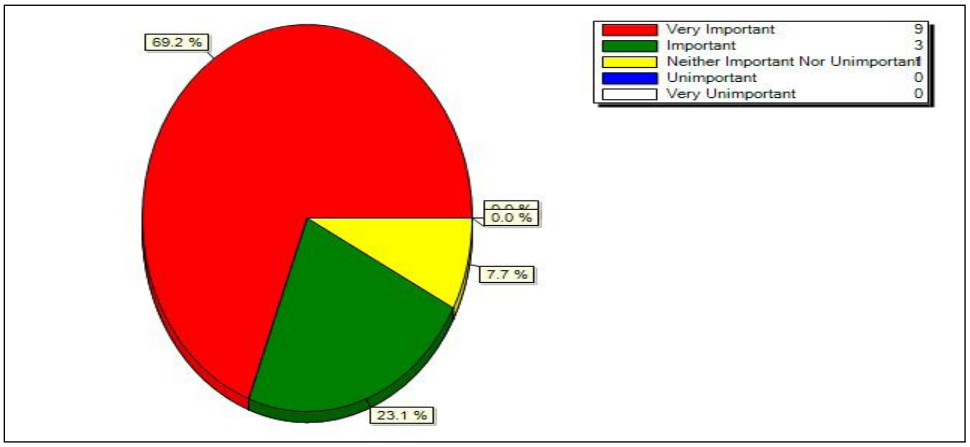
5. How important is reusing concept assets (e.g., modeling methods, model specifications, conceptual models)?



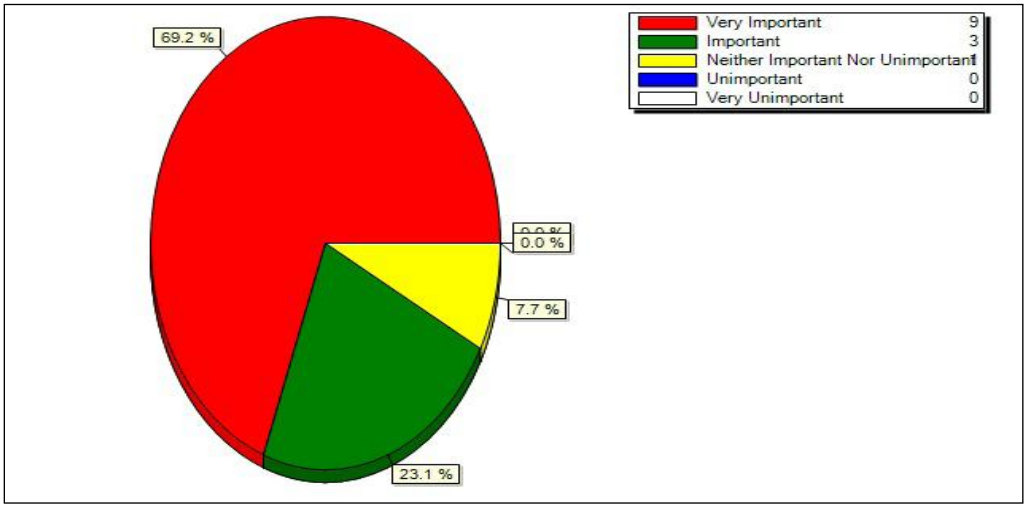
6. How important is reusing software assets (e.g., components, modules, middleware, standalone models)?



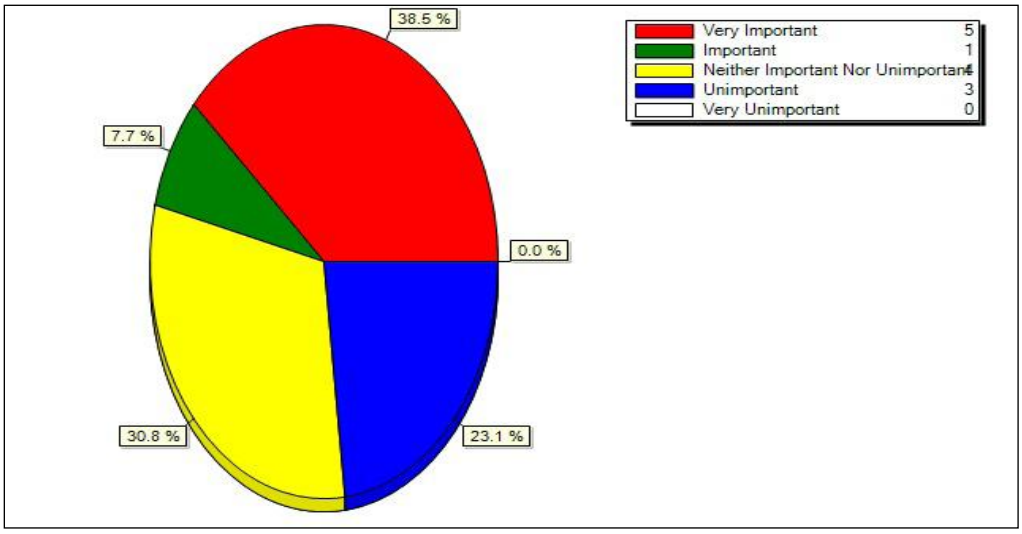
7. How important is reusing distributed simulation assets (e.g., federates, federations) to support M&S?



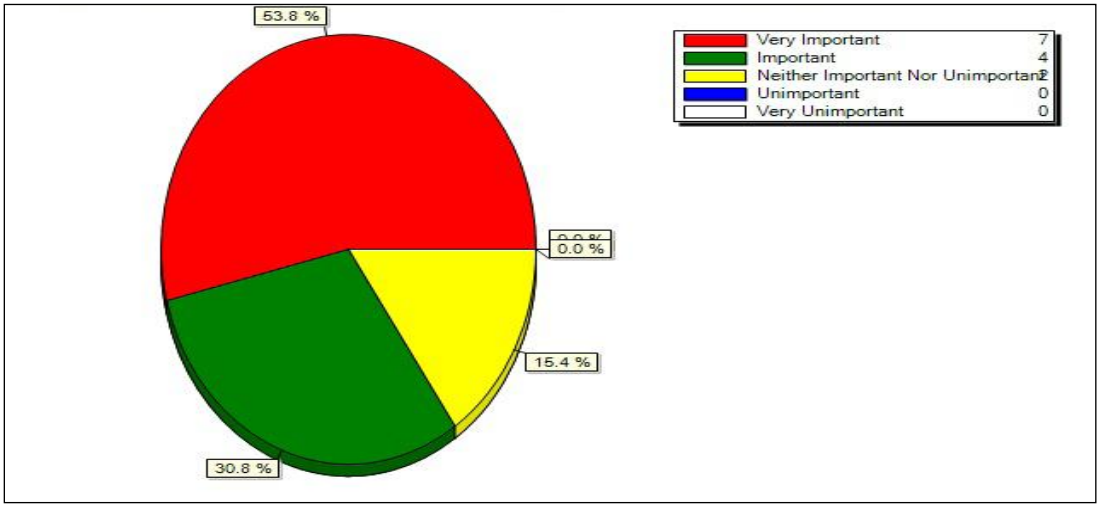
8. How important is reusing data assets (e.g., terrain data, system performance data) to support your M&S projects?



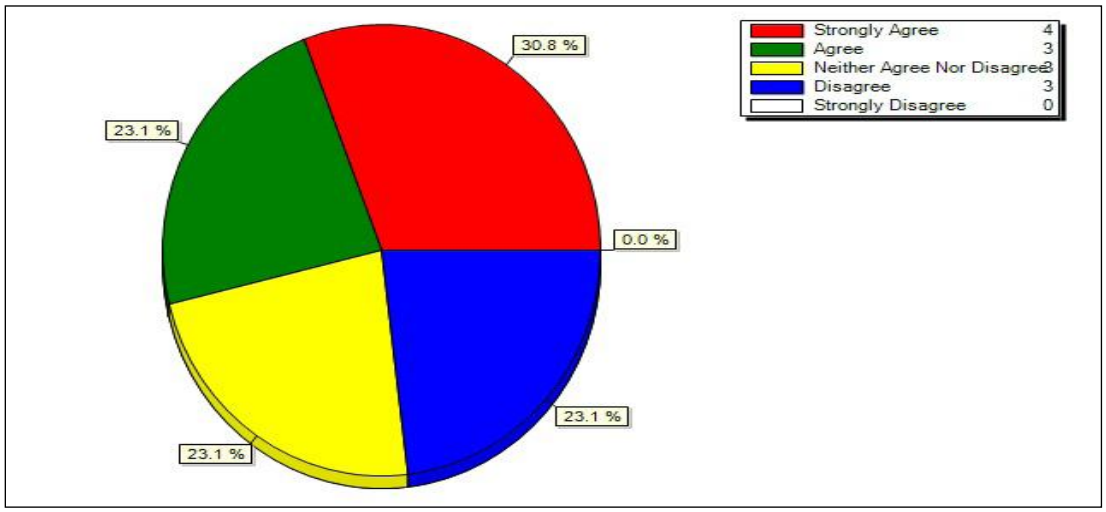
9. How important is reusing M&S capabilities offered as web services to support your LVC M&S projects?



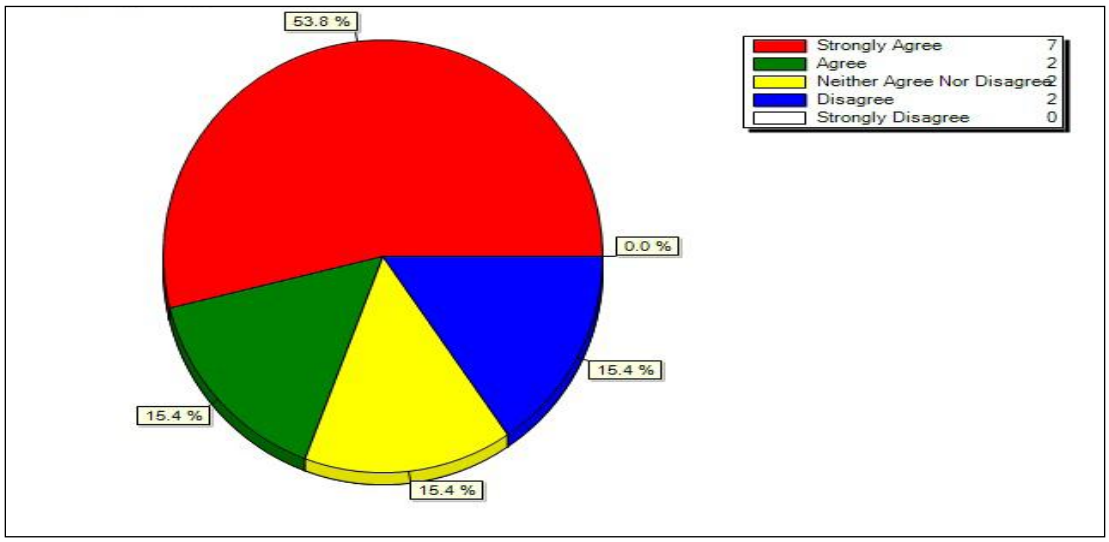
10. How important is reusing support tools (e.g., data loggers, execution monitors) to support your LVC M&S projects?



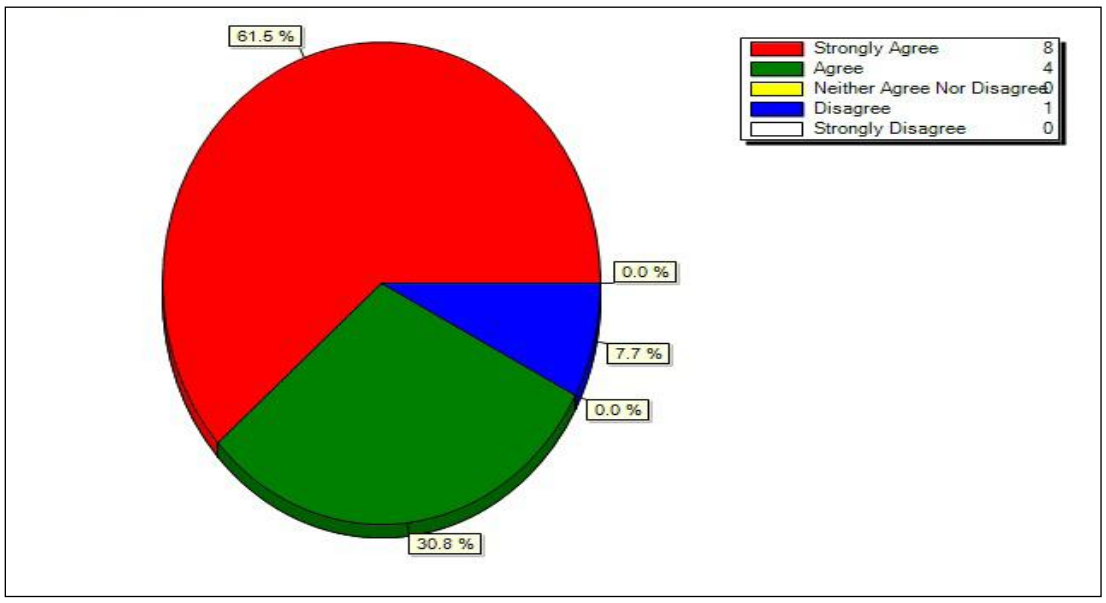
11. My organization has significant experience using one or more existing M&S repositories.



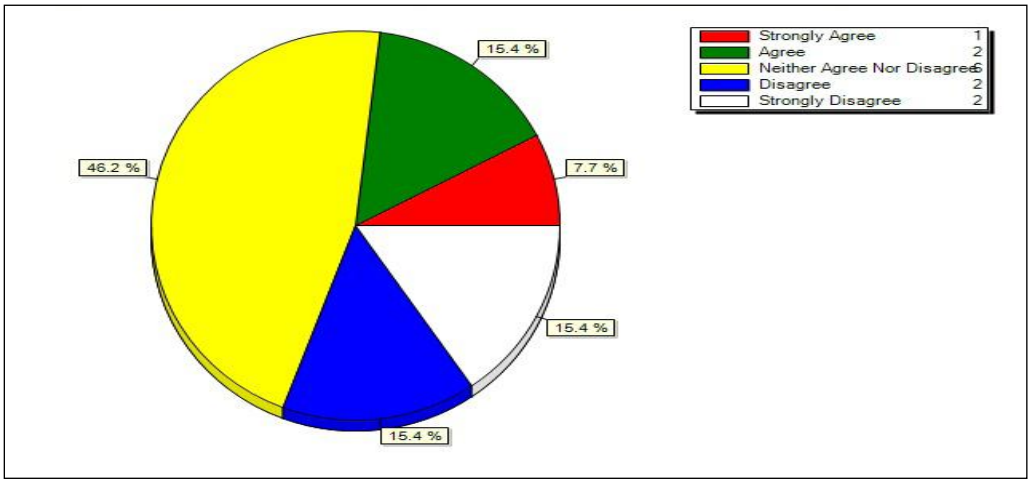
12. A repository of M&S assets must deliver selected assets to users.



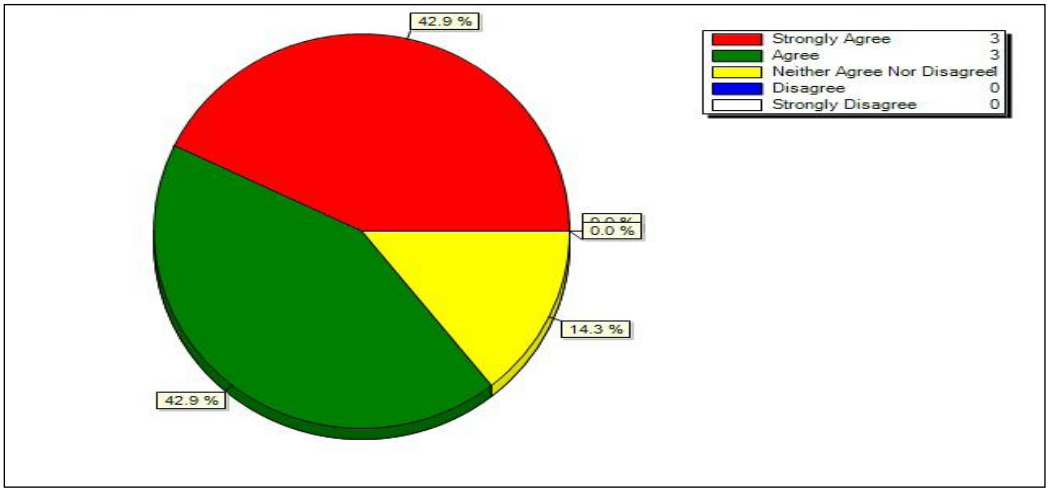
13. A repository of M&S assets must manage the configuration of stored assets.



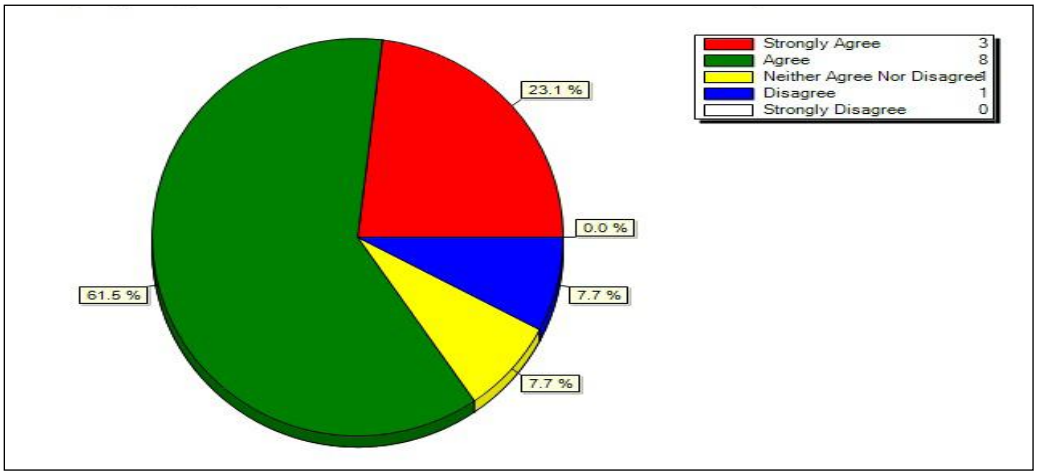
14. The M&S repositories used my organization have effectively supported our reuse requirements.



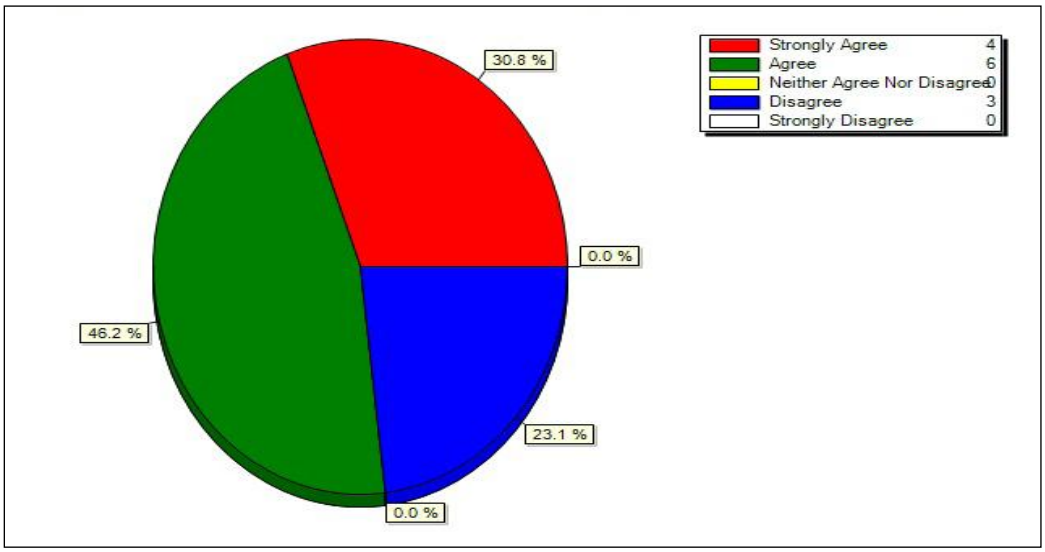
15. A repository of M&S assets should collect and maintain statistics on the discovery process.



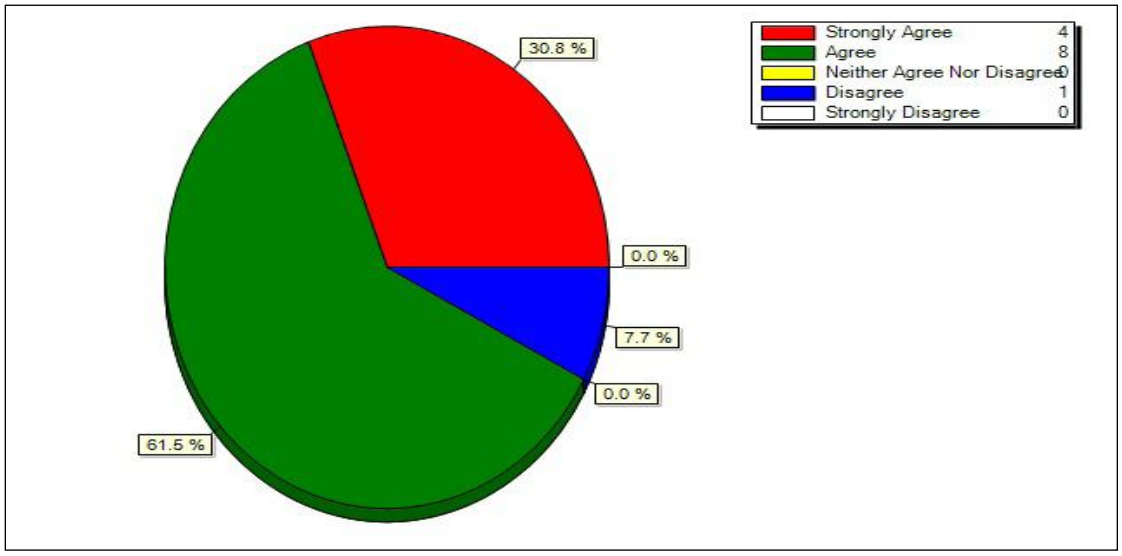
16. A repository of M&S assets should collect and maintain information on the experiences of the reuse.



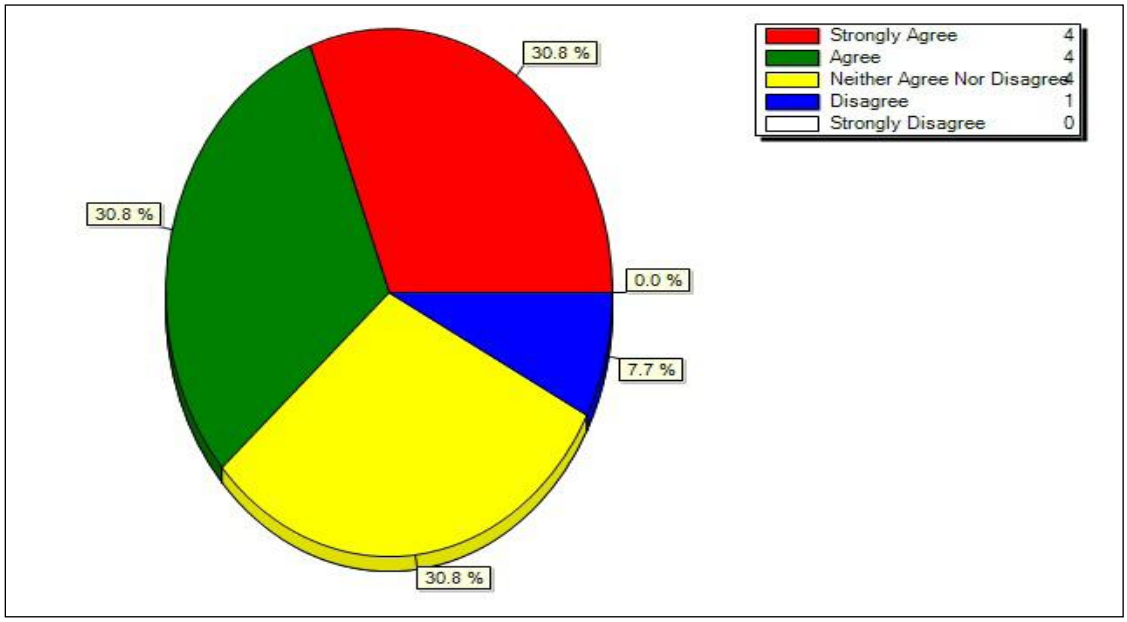
17. A search mechanism to find suitable assets within an M&S repository should be customized to M&S.



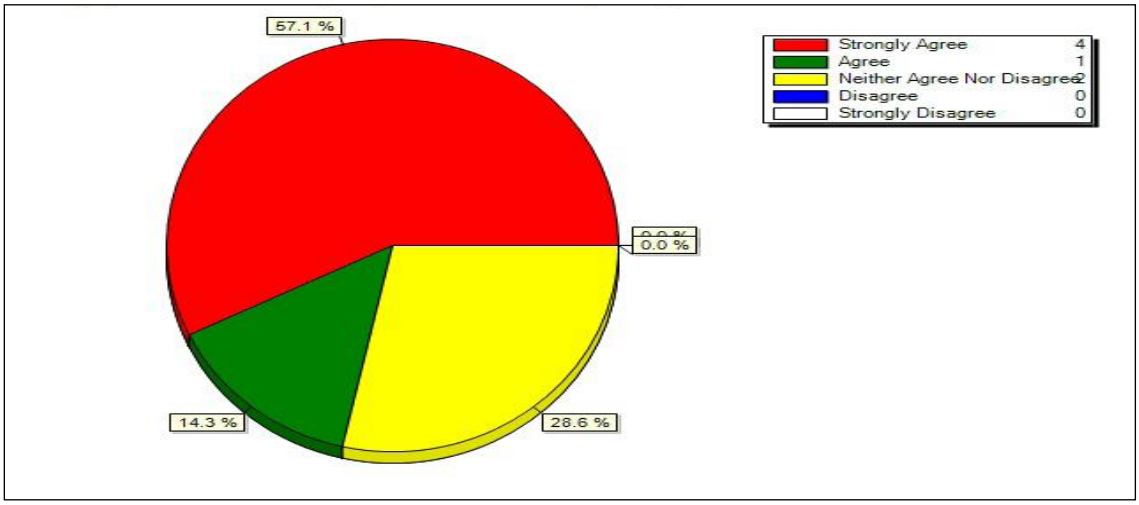
18. An M&S repository search capability should employ predefined taxonomically organized common keywords.



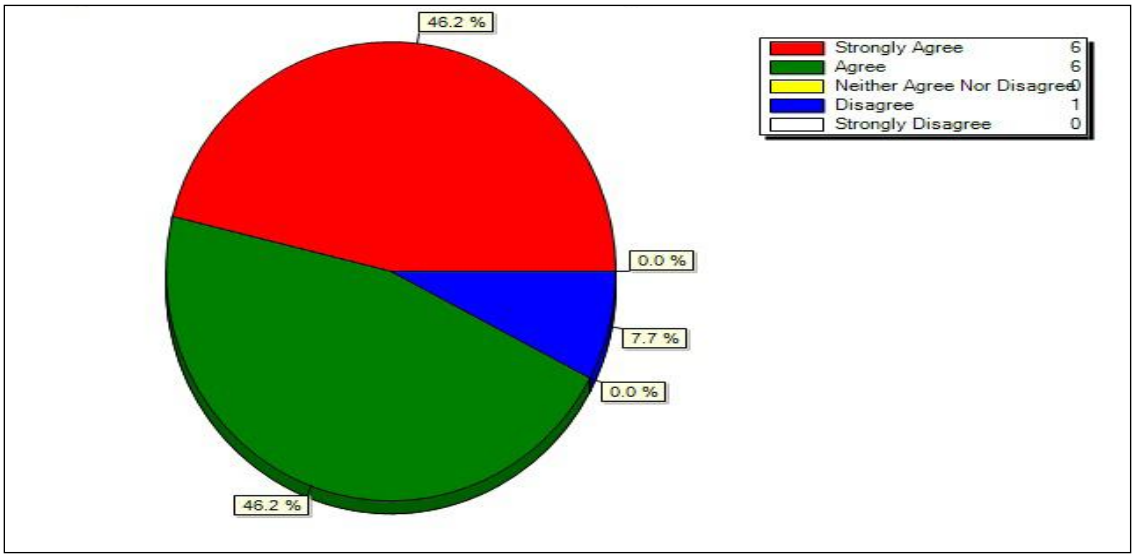
19. Assets with proprietary use restrictions (e.g., commercial assets) should be included in repositories.



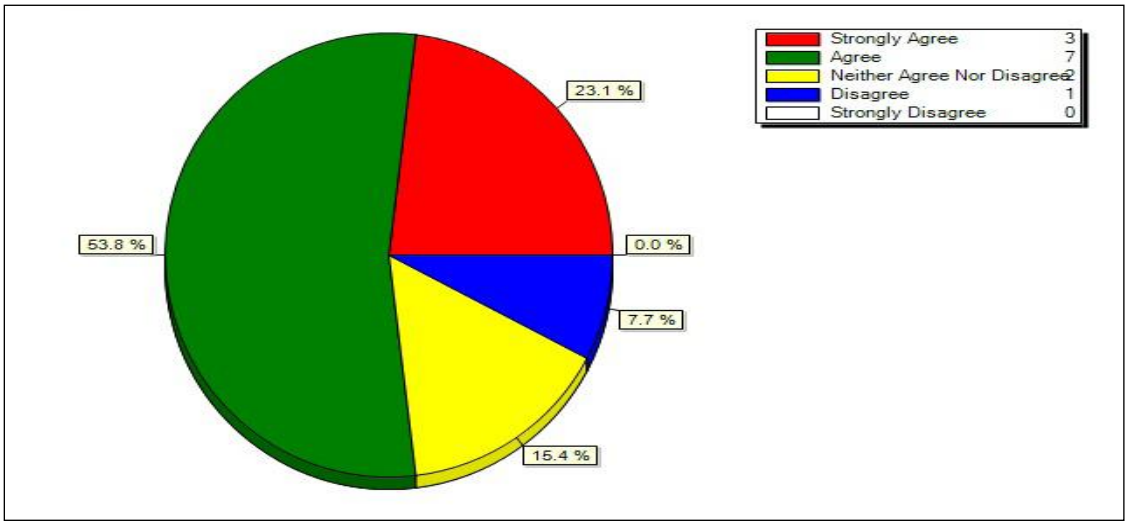
20. Upload of assets to a repository should be controlled by a configuration control board which examines the …



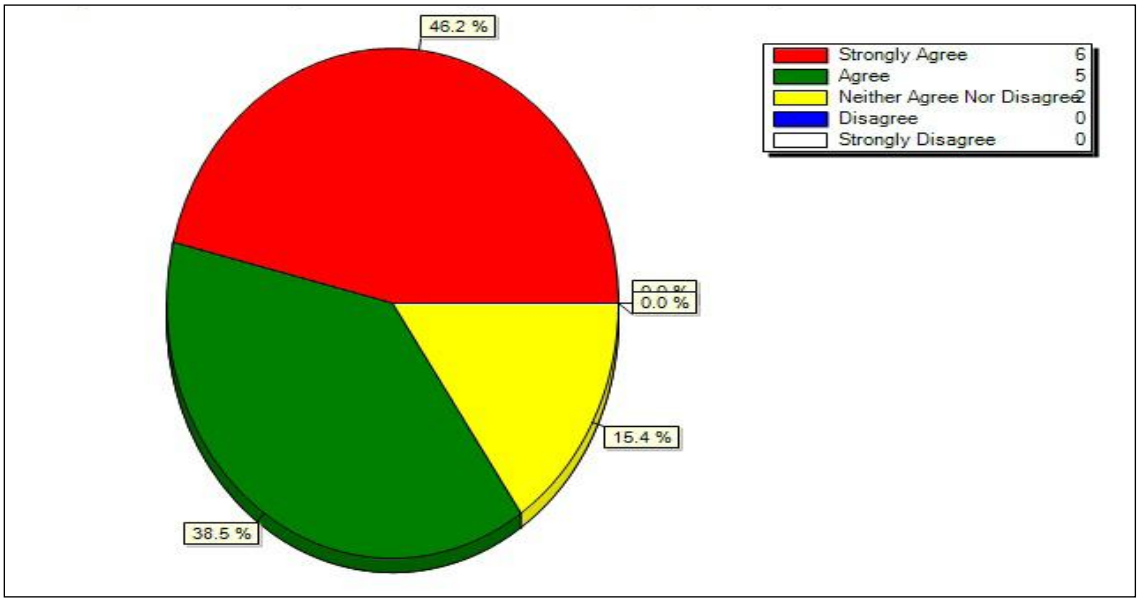
21. Users who have downloaded assets should be automatically informed when a new version of those assets are available.



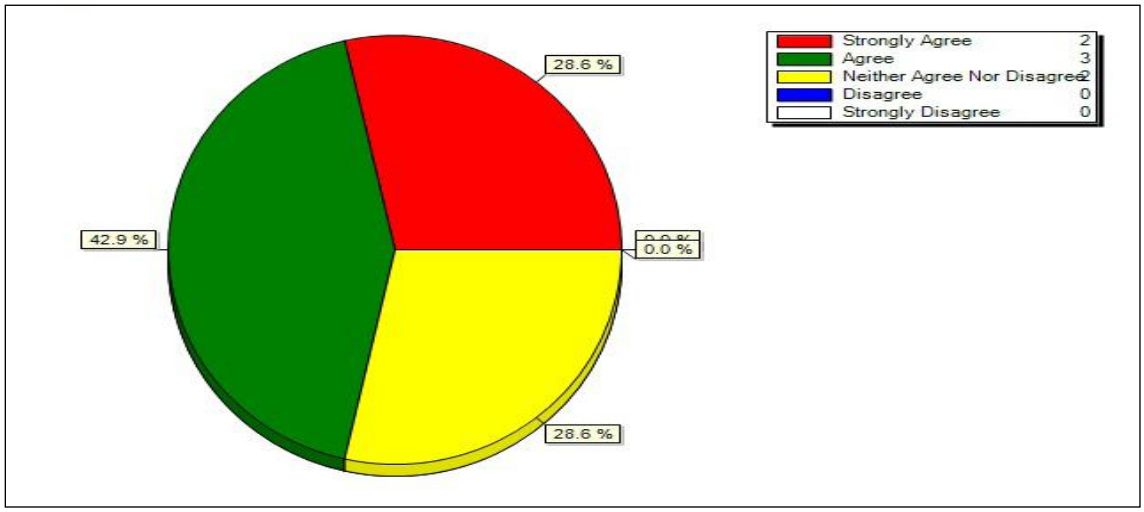
22. Assets that are not perfect may nevertheless be reusable and should be accepted into repositories.



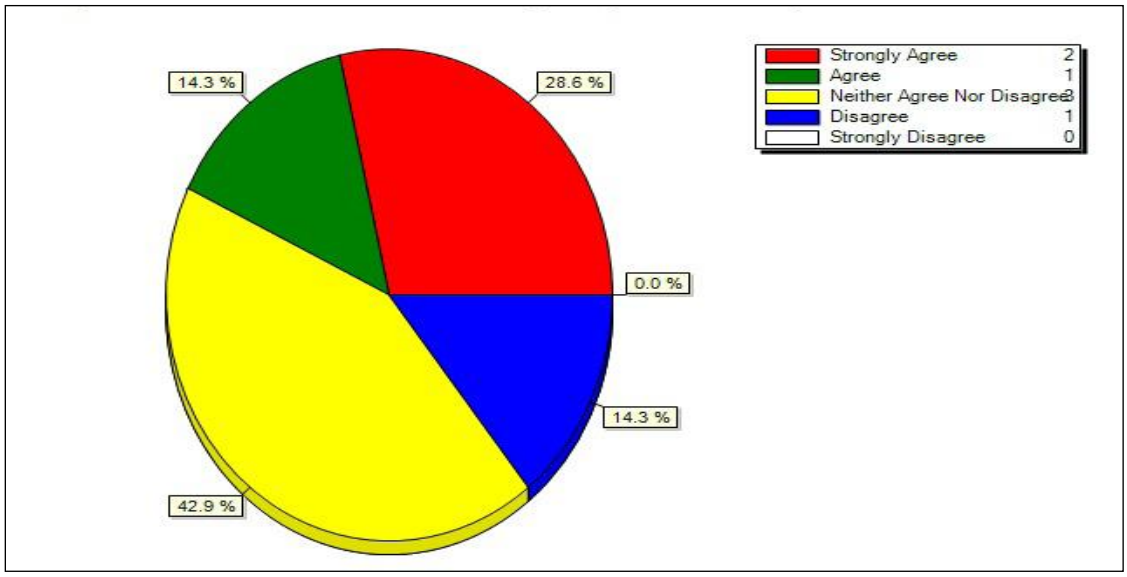
23. Incentives for developers and vendors to place assets in a repository are important to successful reusable repositories.



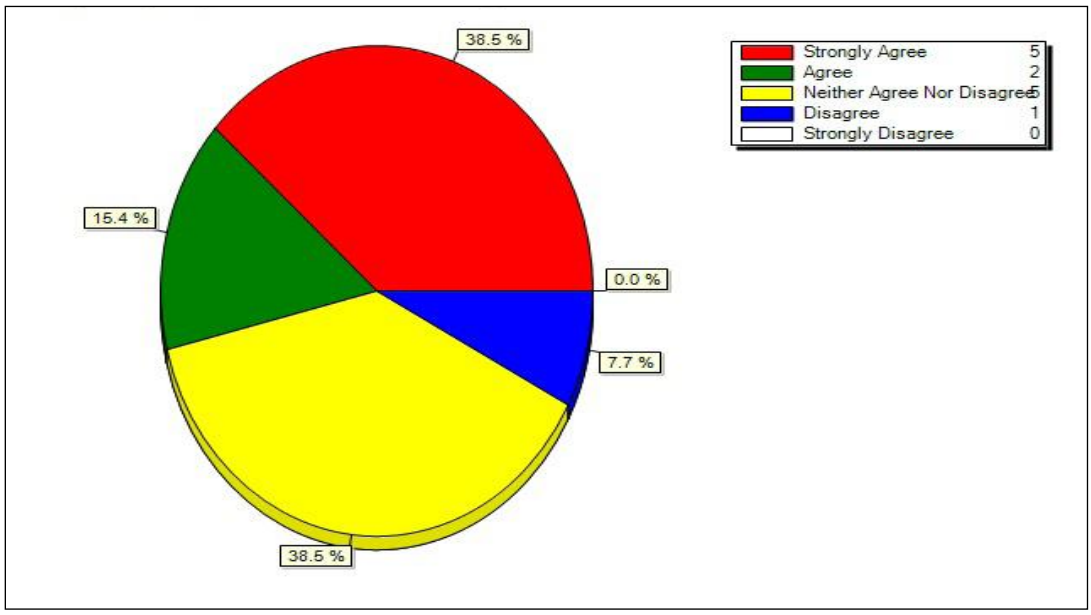
24. The incentives and disincentives to reuse differ significantly between the M&S communities of interest.



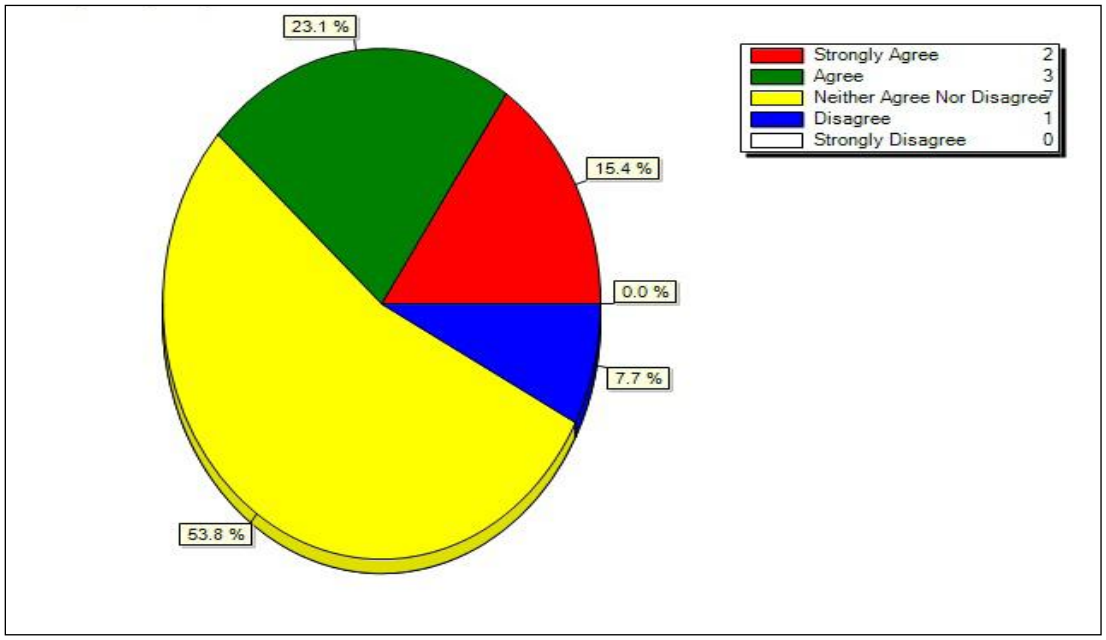
25. The incentives and disincentives to reuse differ significantly between the military services.



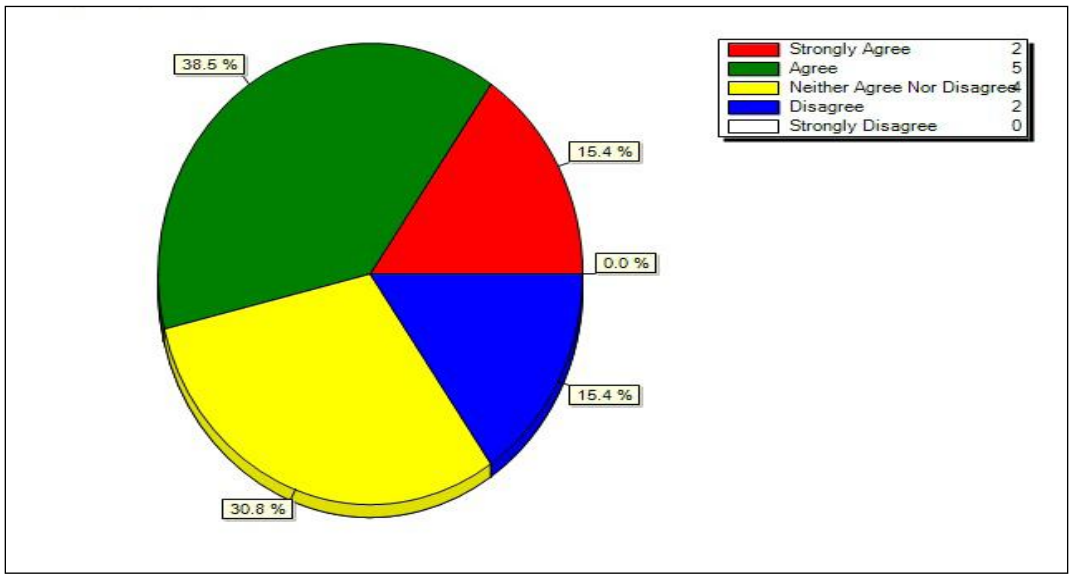
26. M&S repositories fail due to lack of funding.



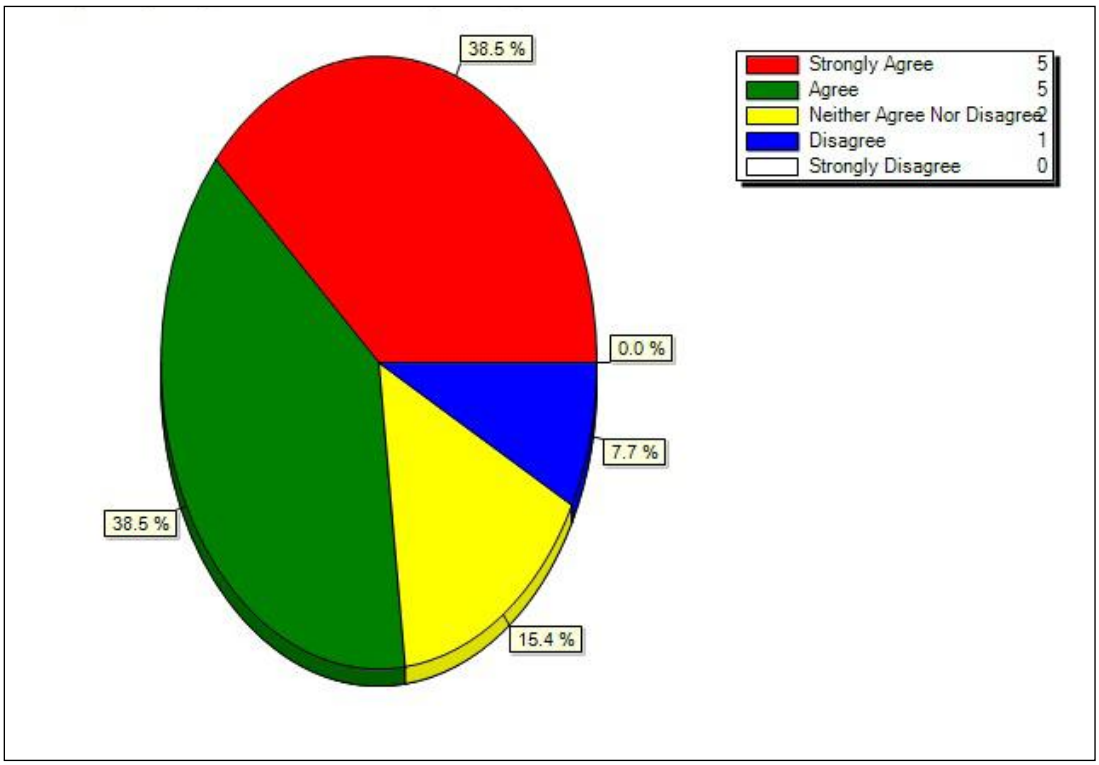
27. M&S repositories fail due to insufficient metadata.



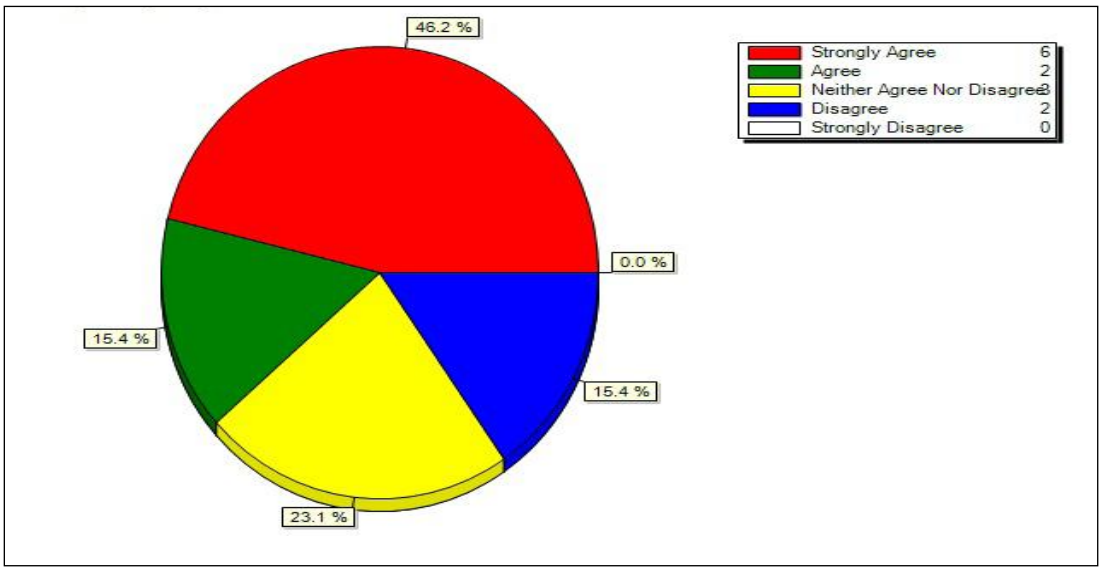
28. M&S repositories fail due to non-intuitive search.



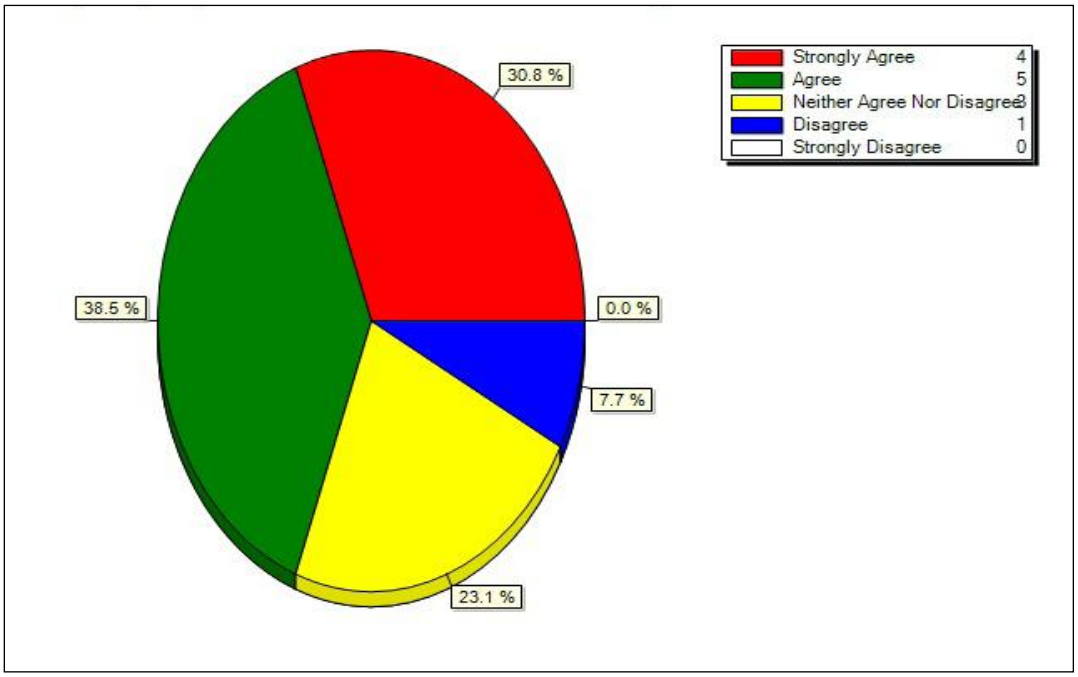
29. M&S repositories fail due to inability to easily access assets.



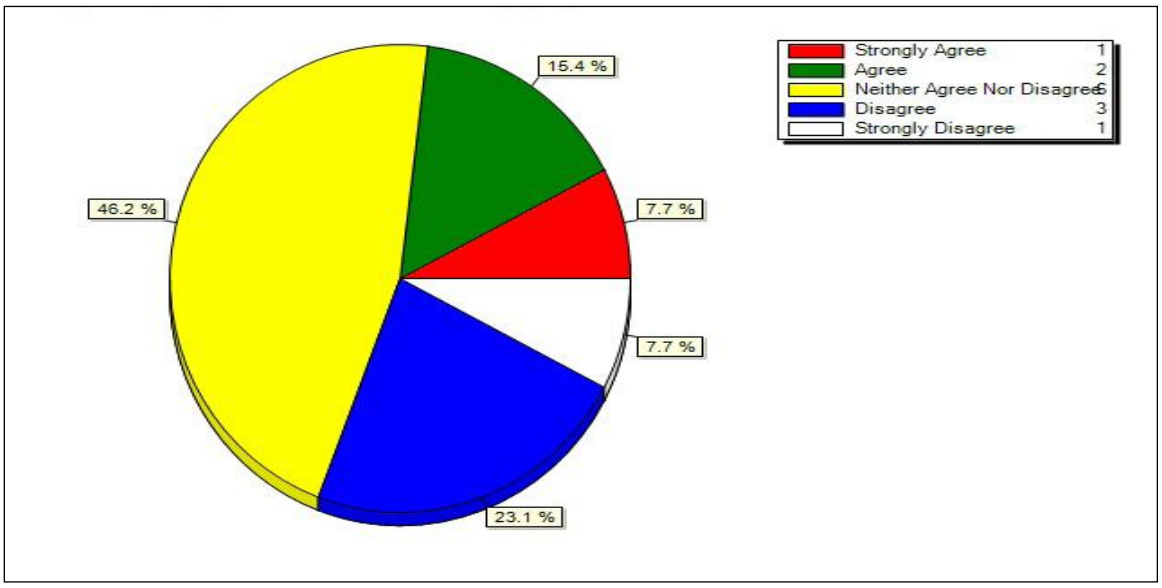
30. M&S repositories fail due to lack of incentives.



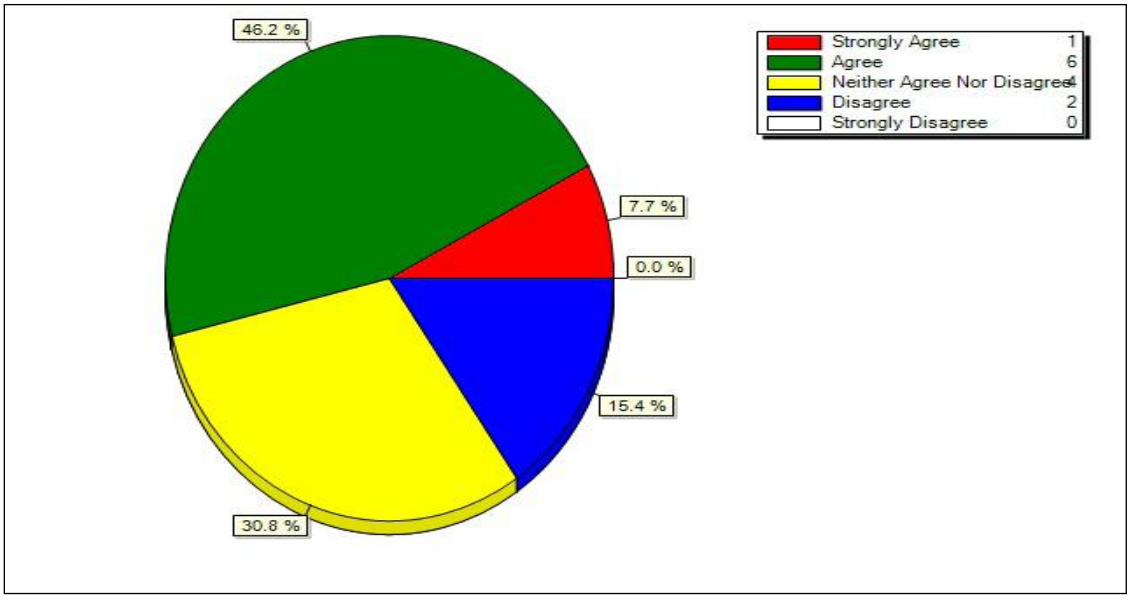
31. M&S repositories fail due to lack of suitable assets for some applications



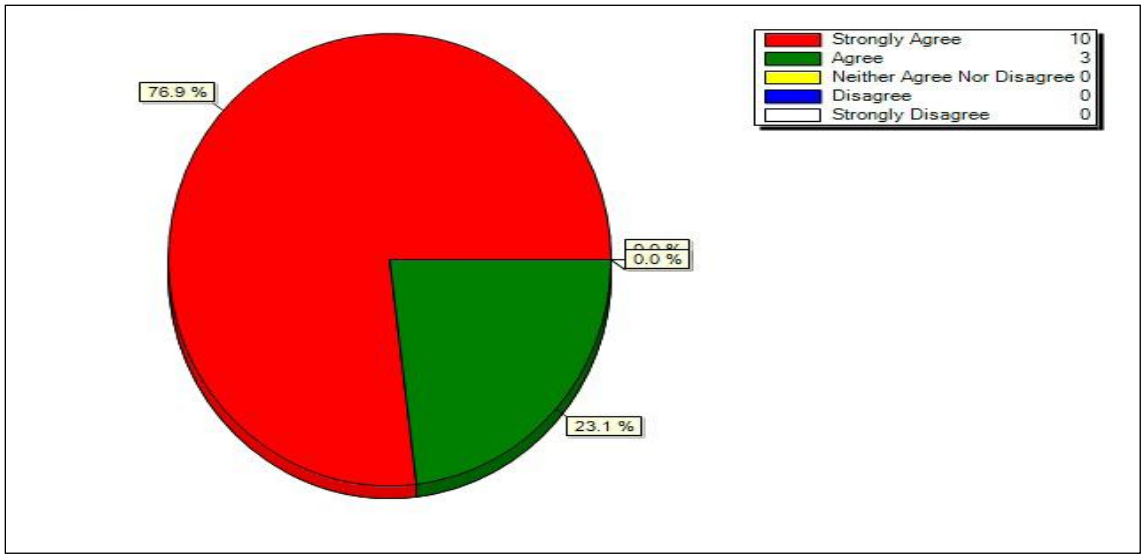
32. M&S repositories fail due to intellectual property restrictions.



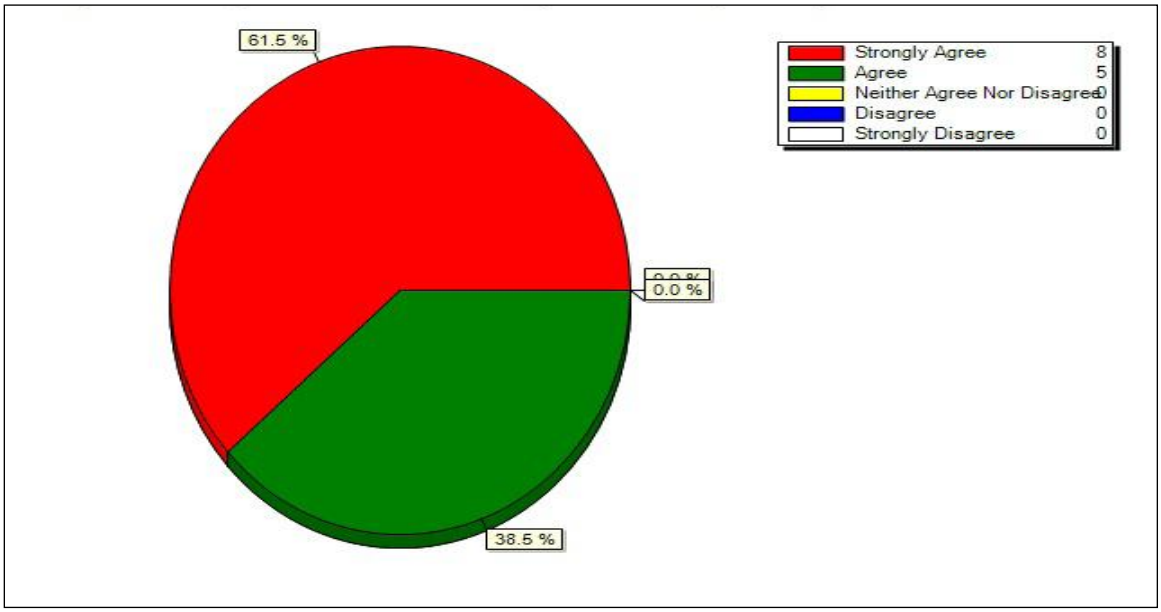
33. Increased quality compared to new development is important to successful reuse.



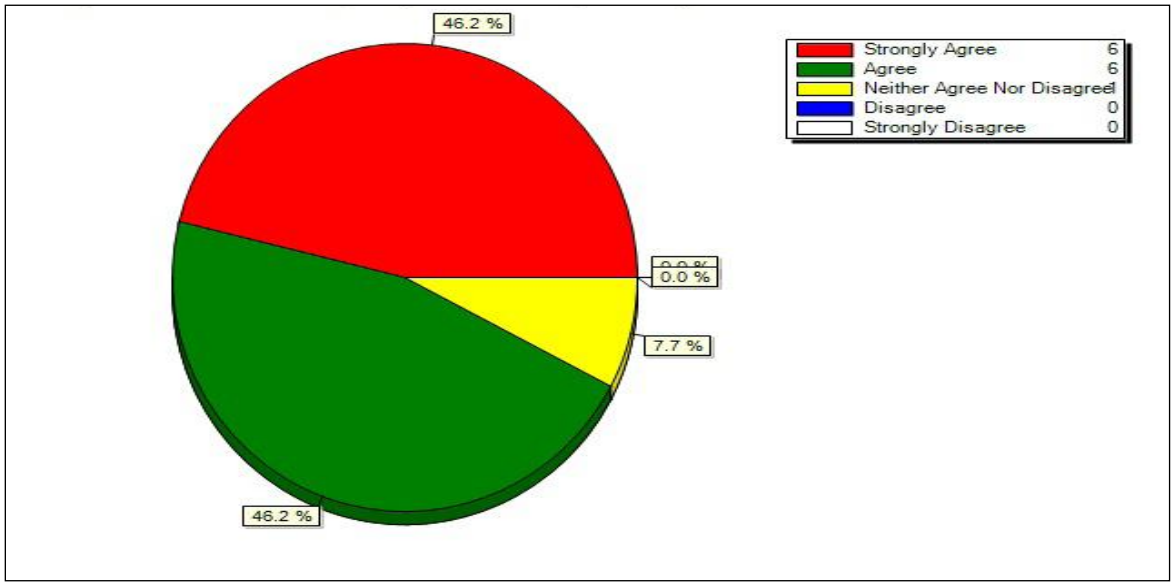
34. Lower cost to reuse an asset compare to new development is important to successful reuse.



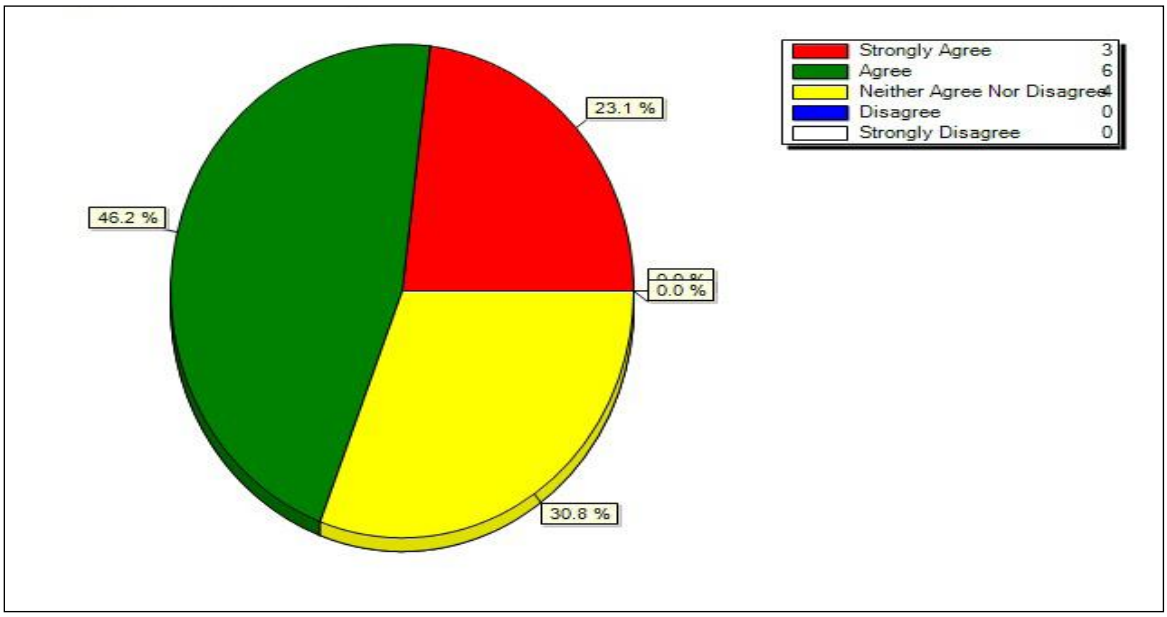
35. Faster development time to reuse an asset compare to new development is important to successful reuse.



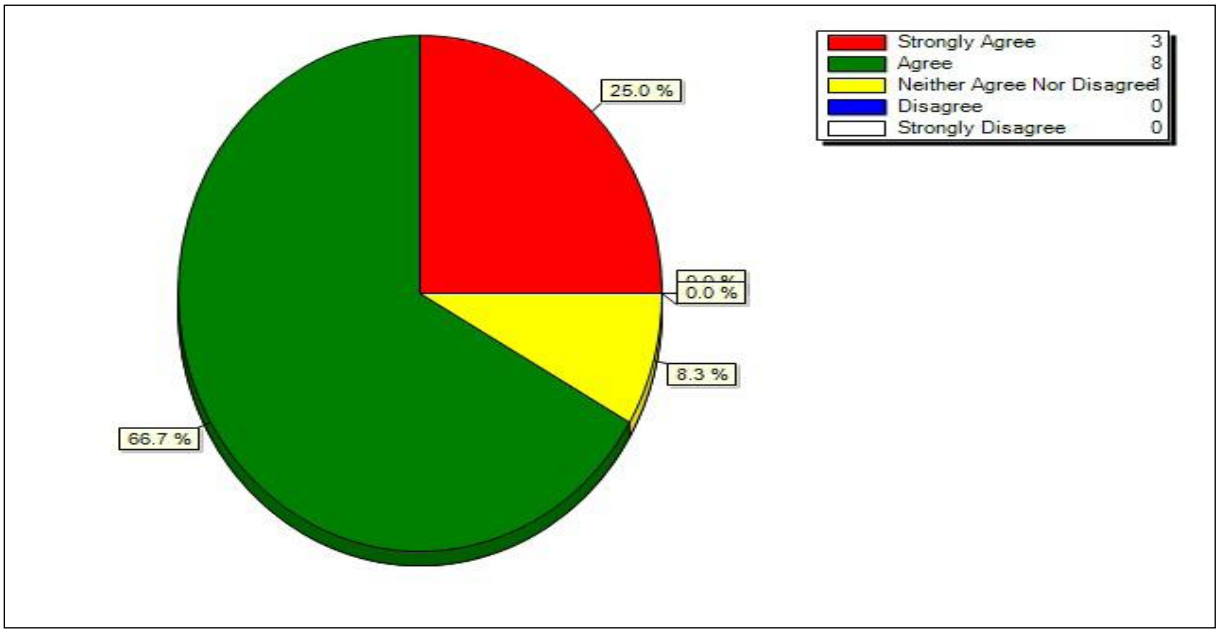
36. Increased model credibility compared to new development is important to successful reuse.



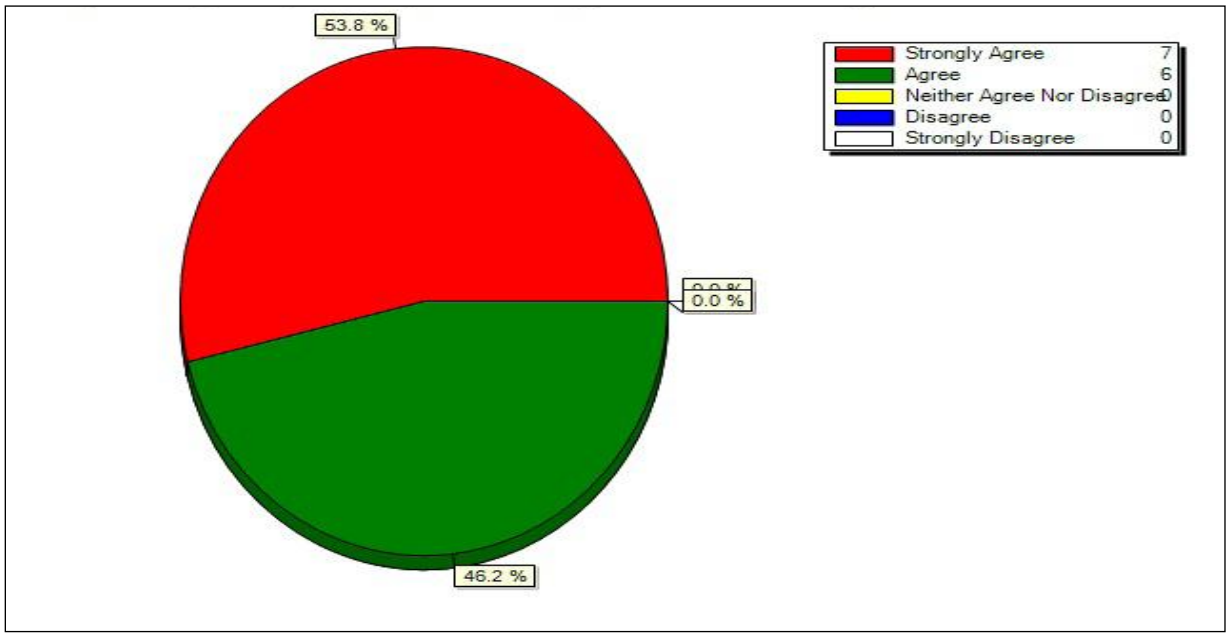
37. Application-specific assumptions and abstractions in a model are an obstacle to successful reuse.



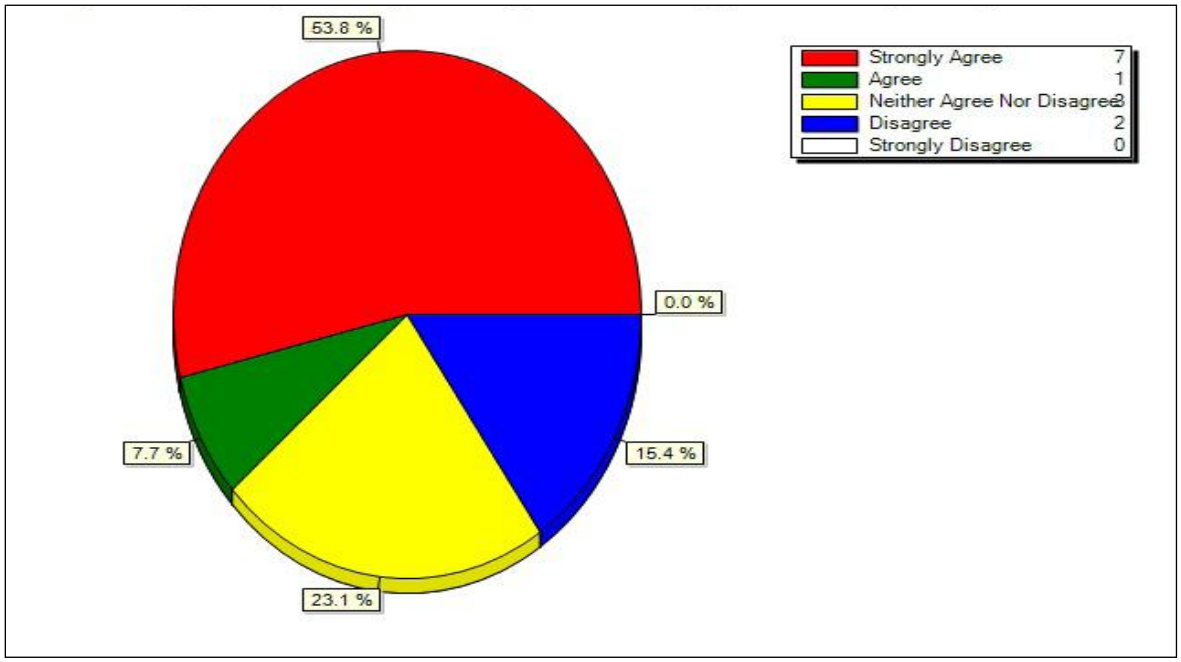
38. Enhancing M&S reuse requires educating sponsors that reuse is not free, for both the developer and the user.



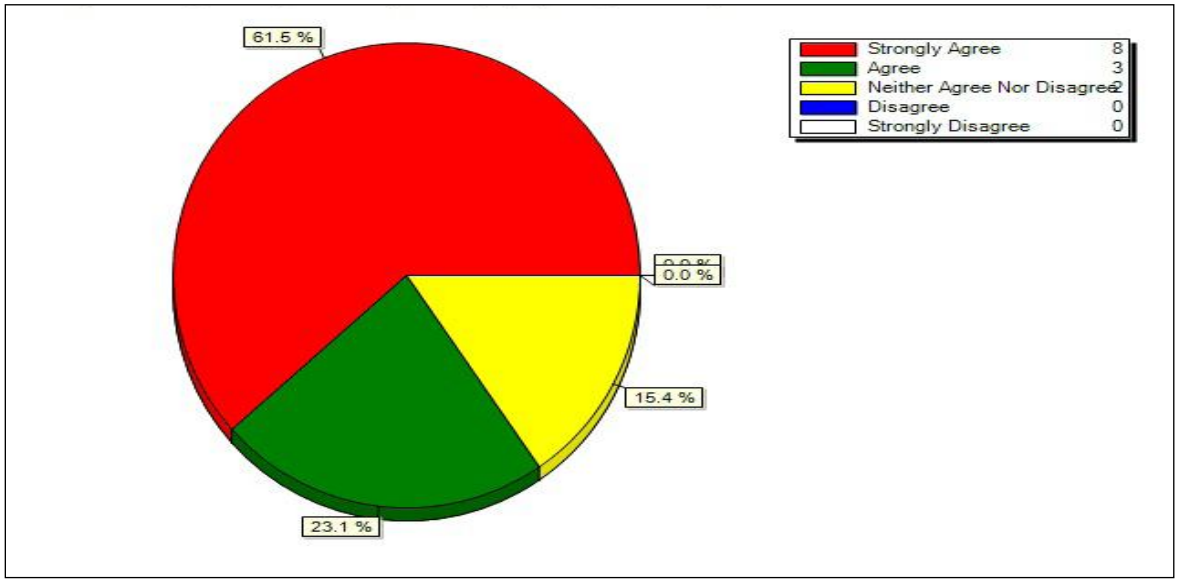
39. Enhancing M&S reuse requires establishing processes and standards support for reuse within the M&S community of interest.



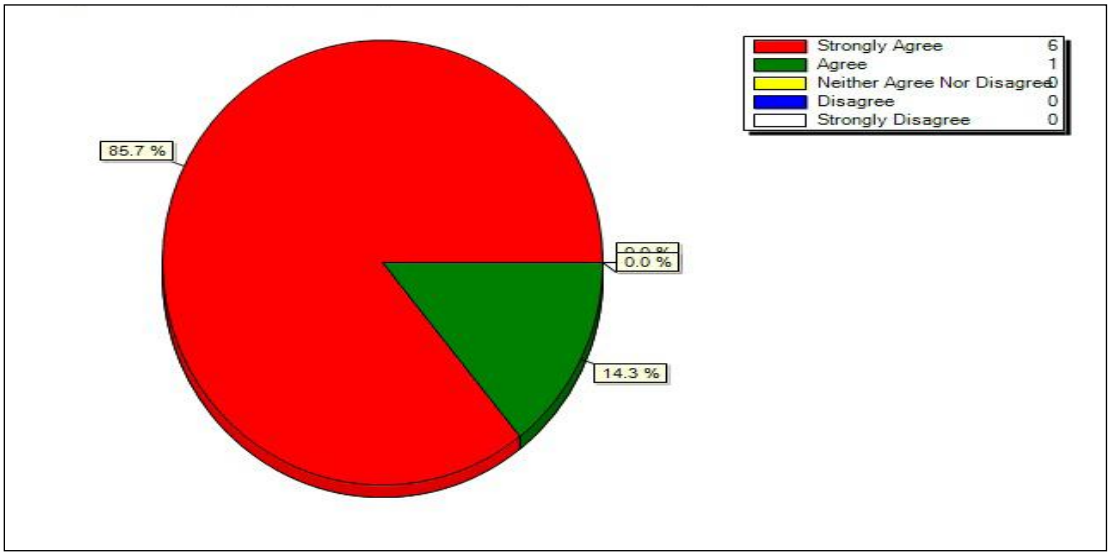
40. Enhancing M&S reuse requires enabling cross-architecture (e.g., HLA and TENA) reusability of asset …



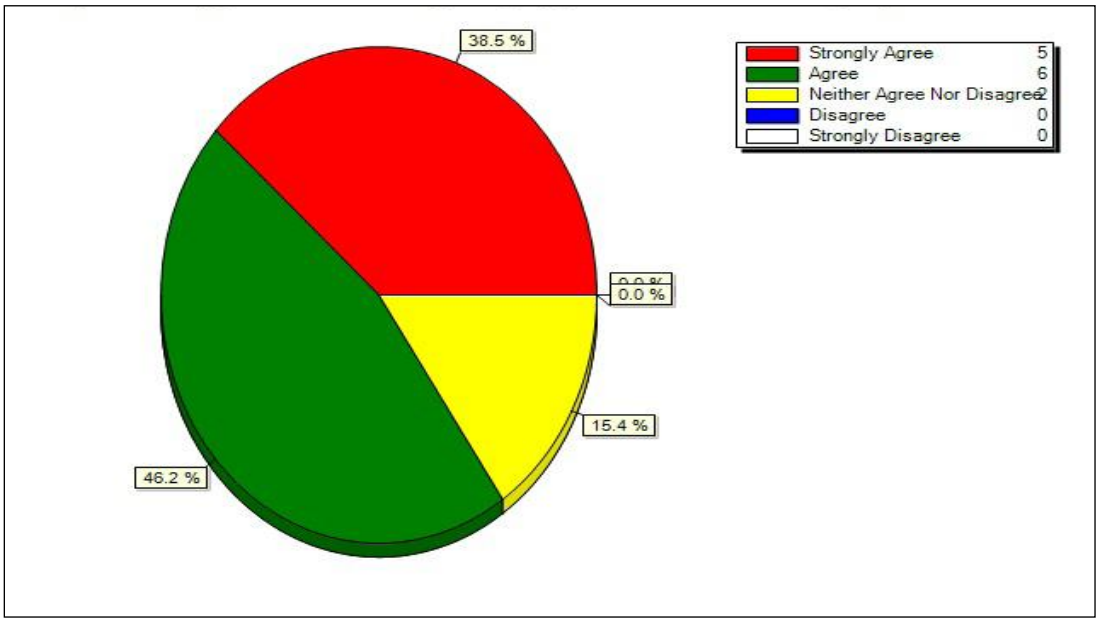
41. Enhancing M&S reuse requires keeping repository contents up to date.



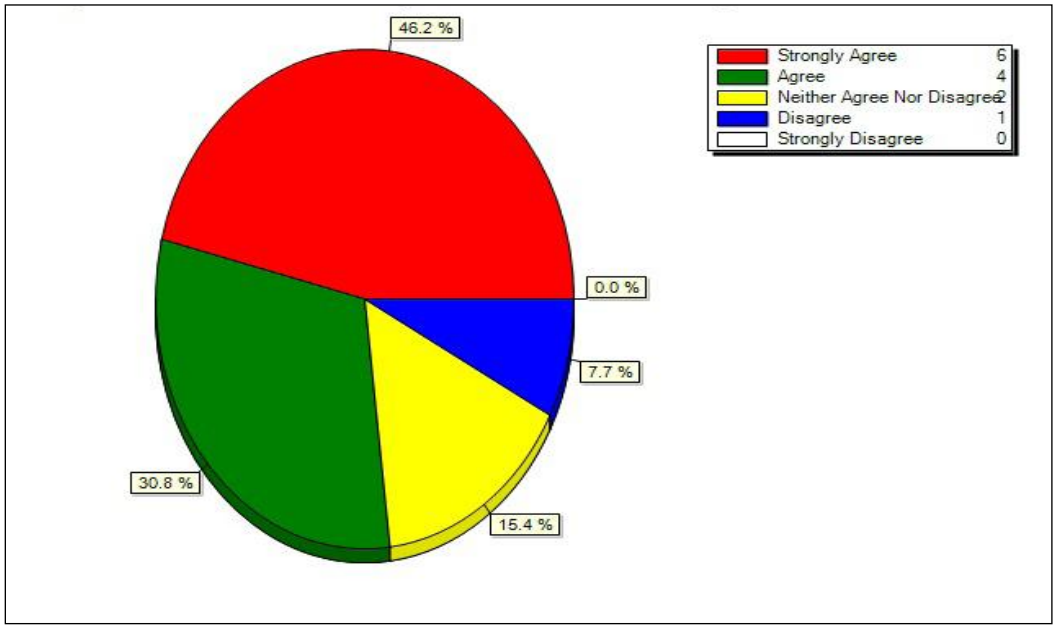
42. The cost of acquiring and reusing an asset is important when selecting an asset for reuse.



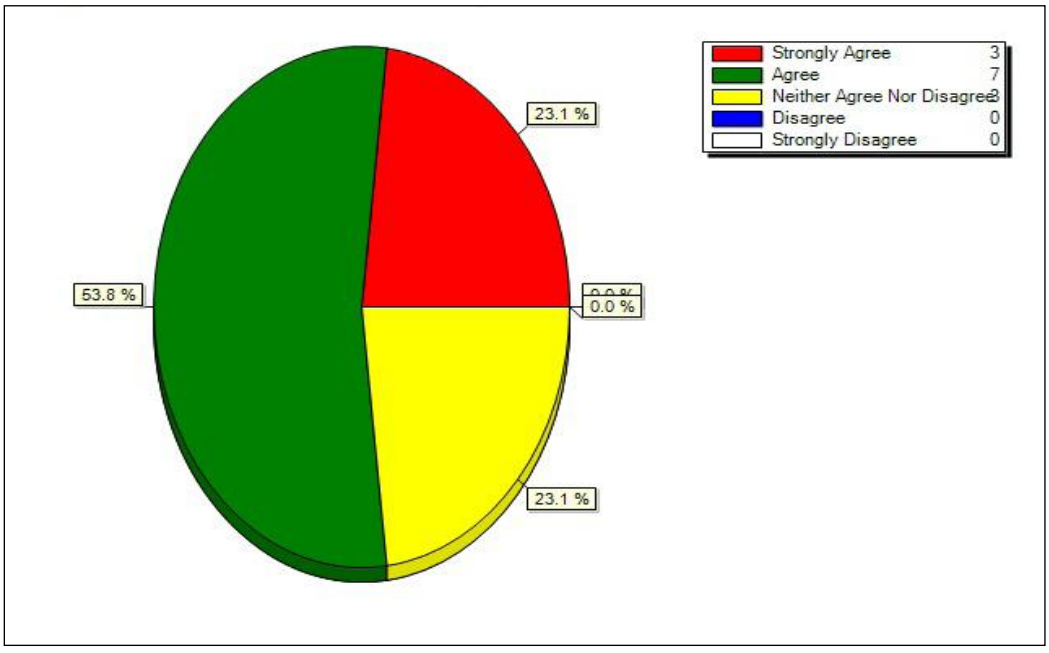
43. Both small (e.g., a statistical subroutine) and large (e.g., a full semi-automated forces system) asset …



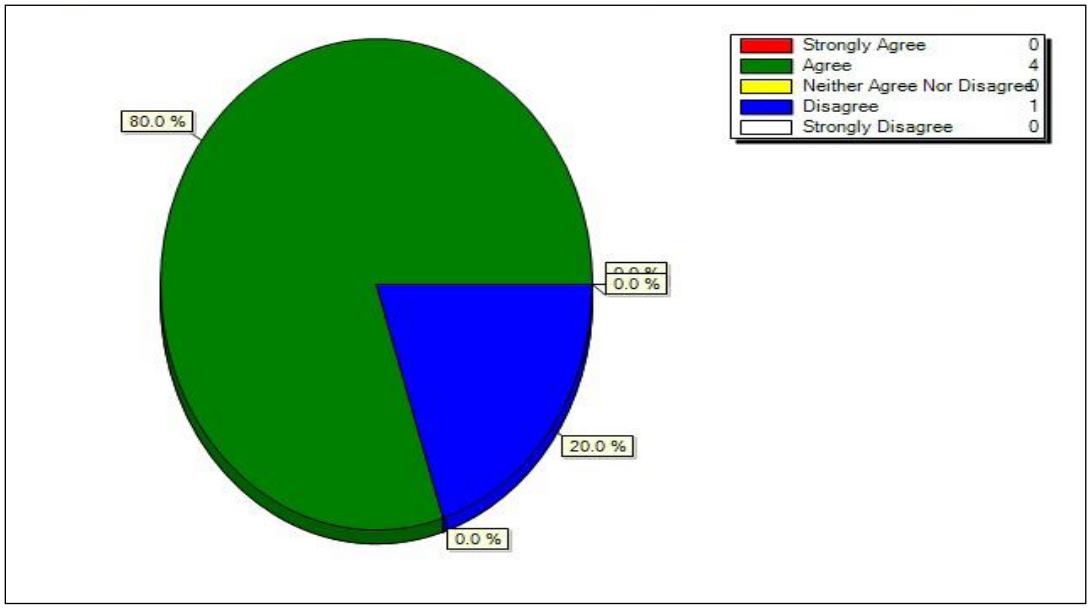
44. The metadata for model assets must provide verification and validation history.



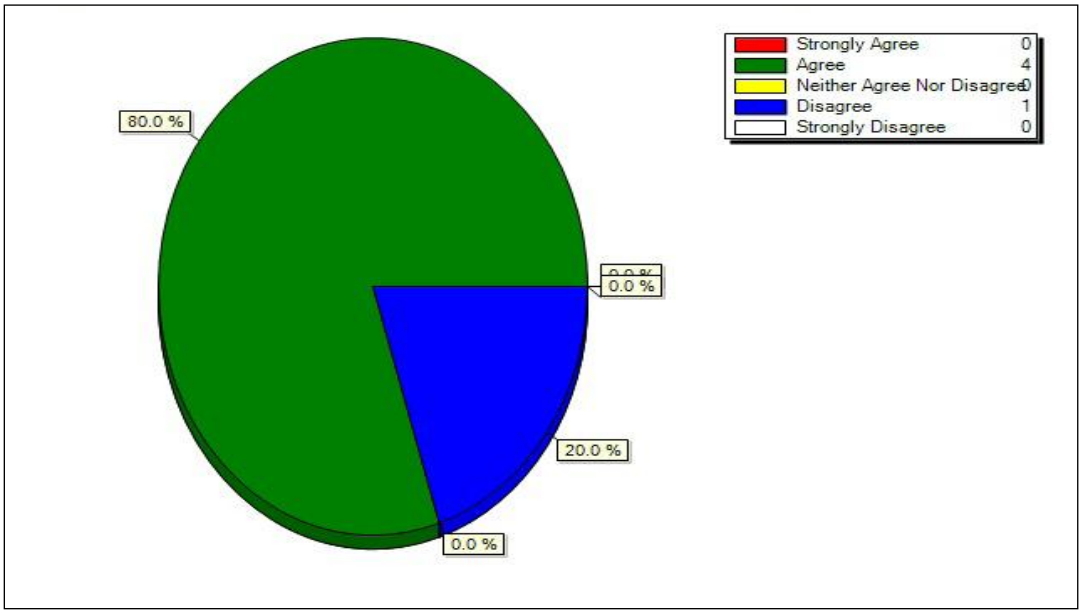
45. Access restrictions on an asset's metadata may be different from access restrictions on the asset itself.



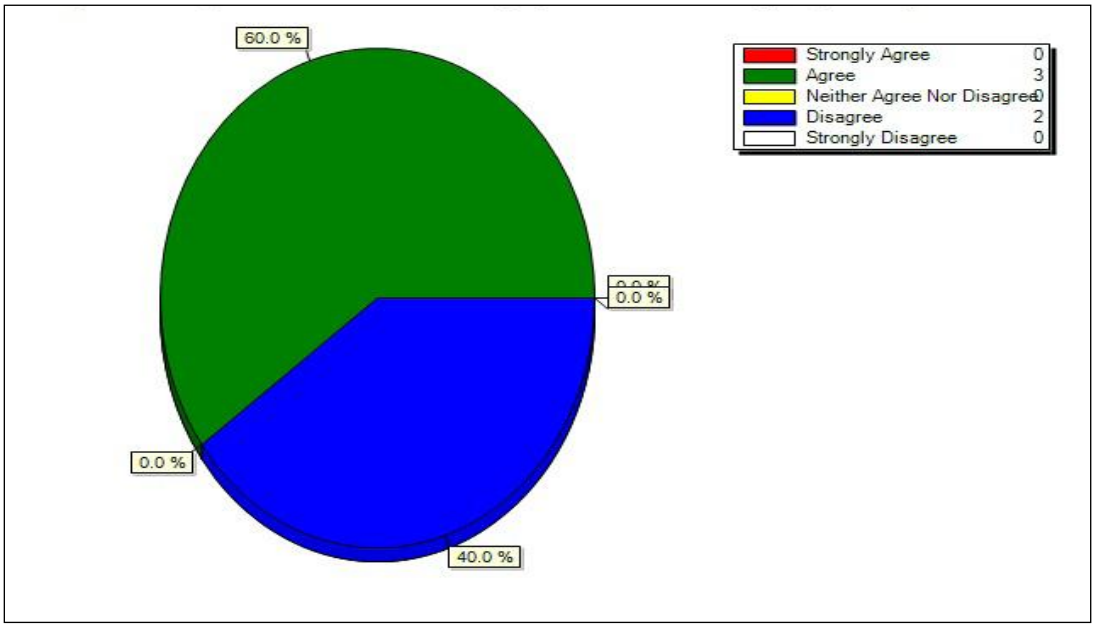
46. Reuse collaboration is primarily asynchronous (reusers studying documentation of downloaded assets).



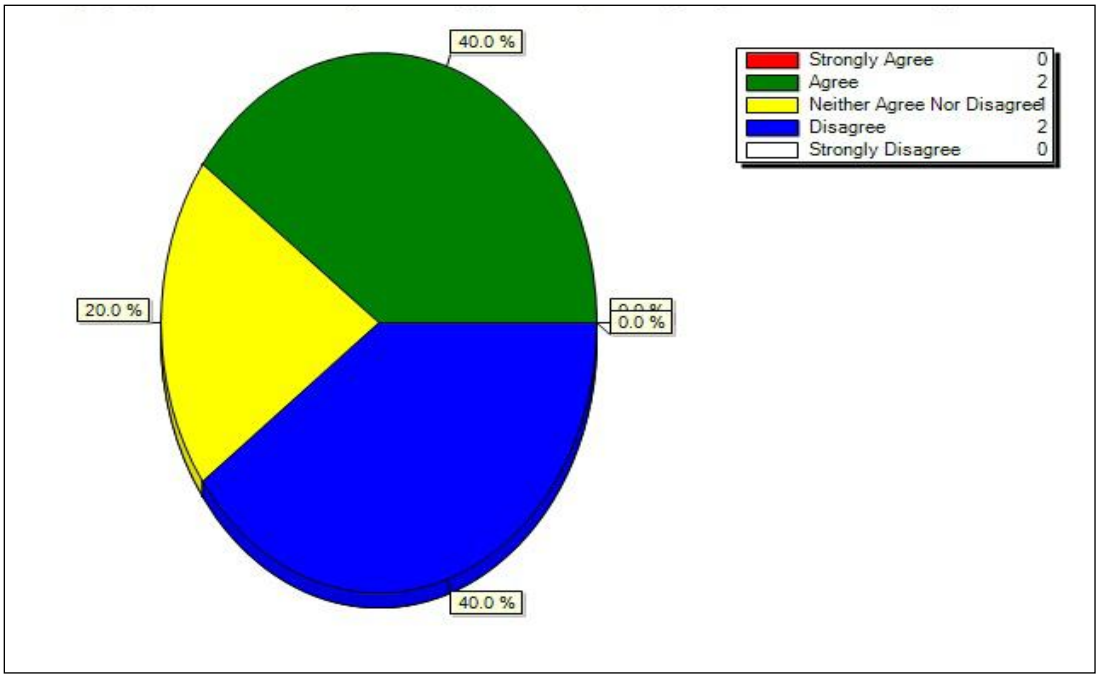
47. When reusing software assets in my organization, the assets are typically modified prior to reuse.



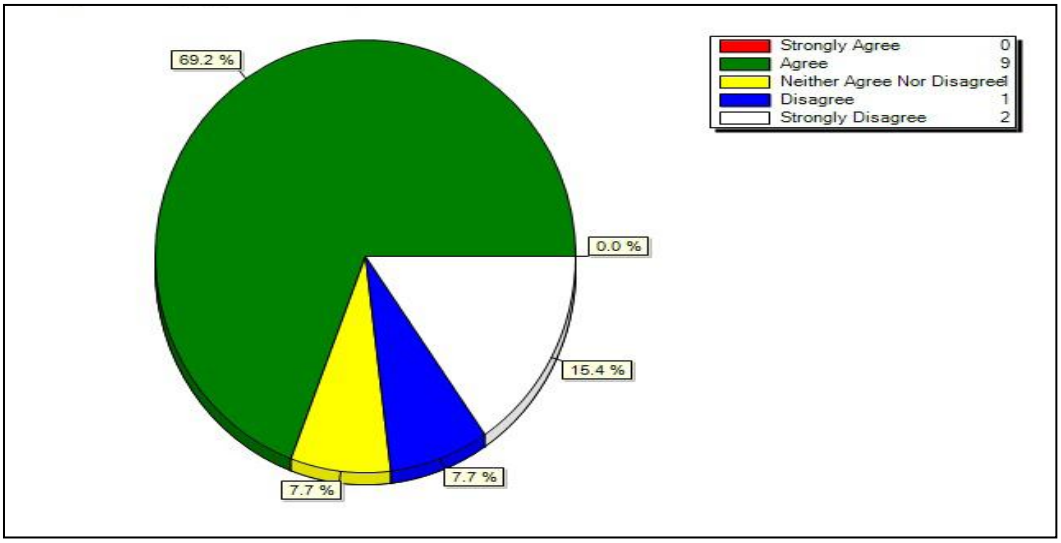
48. When reusing distributed simulation assets in my organization, the assets are typically modified prior to reuse.



49. My organization reuses complete models (e.g., OneSAF) more frequently than it reuses model components.



50. In total, my organization has experienced more successful than unsuccessful instances of reuse.



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APPENDIX E: M&S REUSE LEXICON

E.1 DESCRIPTION AND PURPOSE

This document defines key terminology related to the reuse of software and data. The terms are defined as they are used generally in the US Live-Virtual-Constructive M&S community and specifically in the LVC Architecture Roadmap Implementation Task A-3 Asset Reuse team.

This lexicon was provided to persons attending the Common Capabilities Workshop on November 4-5, 2009. It was intended to provide a common set of terms and definitions to facilitate interaction and collaboration at that workshop. It supports the Reuse Questionnaire that was completed by participants at that workshop by defining key terms in that questionnaire.

E.2 LEXICON TERMS

Accreditor. A role; a person or organization that accredits assets for use and reuse for specific purposes or categories of purposes; responsible for certifying that a federation has been verified and validated [Cutts, 2009]; authorizes the use of the federation for its intended use. Synonym: accreditation authority.

Adjunct tool. Software and/or hardware used to provide part of a simulation environment or to transform and manage data used by or produced by a simulation environment. Differentiated from model in that a tool does not model anything [MSCO, 2009]. Synonyms: tool, support tool, utility.

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

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

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

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

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

Component. (1) A reusable software package or module that encapsulates a set of related functionality and communicates with other components via an interface [Wikipedia, 2009a]. (2) Encapsulated unit of software with a known set of inputs and expected output behavior where the implementation details may be hidden or unknown; it is an interchangeable element of a system that conforms to a specification [Morse, 2004]. Compare to: module (which has less stringent criteria), asset (a component is one type of asset).

Composability. The capability to select and assemble simulation components in various combinations into simulation systems to satisfy specific user requirements [Petty, 2003a]. Relates to reuse in that the components being composed may be assets discovered and retrieved from a repository, and thus effective reuse mechanisms can contribute to enabling composability.

Conceptual model. (1) A model that documents those aspects of a real-world or notional system to be simulated, including entities and their interactions. May be expressed in a variety of notations, including expository text, mathematical equations, and UML diagrams [Petty, 2009c]. (2) A description of what a model or simulation system will represent, the assumptions limiting those representations, and other capabilities needed to satisfy the user's requirements [IEEE, 2003].

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

Data model. (1) Abstract but formal representation of entities or objects (distinguishable persons, places, things, events, or concepts) about which information is kept, their properties, and relationships among the entities and/or properties. May be constructed to describe high-level or detailed concepts (conceptual and logical data models) or instantiations of data structures such as XML documents or relational databases (known as physical data models) [MSCO, 2009]. (2) Abstract representation of the structure of data, used to define or document that structure [Adelman, 2005]. Most data modeling methods are based on diagrammatic notations, such as entity-relationship diagrams or UML [Petty Data, 2009a].

Defense Discovery Metadata Specification. A standard for discovery metadata elements for resources that have been posted to repositories [Wikipedia, 2008].

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

Discovery services. Services that enable the formulation of search activities within shared space repositories (e.g., catalogs, directories, registries), providing the means to articulate

the required service arguments, provide search service capabilities, locate repositories to search, and return search results [DoD, 2008].

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

Federate. In HLA, single application within a federation that interacts with other federates. May be a model or a tool. Synonyms: application (TENA), member application (DSEEP) [IEEE, 2008].

Federate developer/integrator. A role; a person or organization that creates reusable assets; an individual or organization responsible for integrating a simulation into the federation; responsible for ensuring the simulation is compliant with federation agreements [Cutts, 2009].

Federation. In HLA, named set of interacting federate applications, a common object model, and software infrastructure through which they communicate that are used as a whole to achieve some specific objective [MSCO, 2009]. Synonyms: logical range (TENA), simulation environment (DSEEP) [IEEE, 2008].

Federation engineer/integrator. A role; a person or organization that selects, integrates, and tests federates within a federation (or in DSEEP terms, the member applications within a simulation environment), and in the process of doing so may reuse assets of various types; responsible for negotiating the majority of federation agreements between all participants; expert in the chosen middleware/infrastructure so as to resolve integration issues [Cutts, 2009].

Federation manager. A role; a person or organization responsible for managing a federation execution, including coordinating federation participants; may be a domain subject matter expert rather than a federation engineer [Cutts, 2009].

Federation tester. A role; a person or organization that tests (verifies and validates) an asset; responsible for establishing the test criteria to ensure that the federation is meeting requirements [Cutts, 2009].

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

Information technology support/hardware engineer. A role; a person, or organization responsible for network configuration, support software installation, hardware configuration, and troubleshooting to support a federation [Cutts, 2009].

Interface specification. Set of structures and/or classes including properties, methods, and/or events which serve to provide a well-defined agreement for which applications (M&S software and adjunct tools), federations, components and/or services can connect and communicate [MSCO, 2009].

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

Metadata. (1) Data about data; specification of the content, meaning, structure, and use of the data [Adelman, 2005]. (2) Information describing the characteristics of data; data or information about data; descriptive information about an organization's data, data activities, systems, and holdings [DoD, 2004]. (3) Searchable data that describes the function and use of an artifact [Gustavson, undated]. If the artifact is a model, rather than data, sometimes called a metamodel [Petty Data, 2009a]. (4) Structured, encoded data that describe characteristics of information-bearing entities to aid in the identification, discovery, assessment, and management of the described entities [Association, 2000]. Compare to: discovery metadata, (which is more specific), structural metadata (which is more specific).

Metamodel. (1) A model of a model; an abstraction of another model, relating more generic concepts [DoD, 2007]. (2) Metadata about a model [Petty Data, 2009a].

Middleware. Software that connects or integrates other software modules or components, typically providing a set of communications or interaction functions that may be invoked by the linked modules [Wikipedia, 2009b].

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

Model. A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process [DoD, 2007].

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

Modeling and simulation data. (1) Representation of real-world facts or concepts in a format usable by models during simulation. Differentiated from a model in that M&S data is generally not itself executable, but is rather input to a model that can be executed. May be operational data, data specifically derived from operational data that has been formatted or augmented for M&S use, or synthetic data created for M&S use [MSCO, 2009]. (2) Data produced by a model during a simulation that provides a synthetic view of reality [MSCO, 2009].

Modeling and simulation data model. A data model that describes modeling and simulation data [MSCO, 2009].

Modeling and simulation service. A service that provides a capability useful in modeling and simulation [MSCO, 2009]. May or may not itself be a model or simulation [MSCO, 2009].

Modeling and simulation software. Software that implements a model or simulation [MSCO, 2009].

Modeling and simulation software component. A software component used as part of modeling and simulation software. May be source code, binary or byte code, or remote procedures; can be used to construct models and/or provide functionality for simulation systems [MSCO, 2009].

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

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

Net-centric environment. A framework for full human and technical connectivity and interoperability that allows all DoD users and mission partners to share the information they need, when they need it, in a form they can understand and act on with confidence, and protects information from those who should not have it [DoD, 2005].

Program manager. A role; a person or organization that monitors, guides, and controls development and/or reuse projects and processes; manages to schedule and budget, allocates personnel, ensures establishment and adherence to program level processes [Cutts, 2009].

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

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

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

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

Repository. A system that accepts, stores, and provides access to assets that may be reused. Typically includes both hardware (e.g., disk storage) and software (e.g., configuration management) aspects. May store software (components or modules), artifacts, metadata, data, or

other assets. Compare to: catalog (which specifically stores discovery metadata), registry (which specifically stores metadata schemas), storehouse (which is generic for storage systems).

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

Resource. An asset that is recognized as reusable [Gustavson, undated].

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

Role. A related and coherent set of actions, responsibilities, and authorities which a person or organization may undertake as part of the overall process of developing a federation and/or reusing assets. One of several perspectives a person or organization may have on those processes. Reuse roles include accreditor, federate developer/integrator, federation engineer/tester, federation manager, federation tester, information technology support/hardware engineer, program manager, security engineer, sponsor, user/operator, verification and validation agent [Cutts, 2009].

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

Security engineer. A role; a person or organization responsible for establishing security requirements for a federation and for any facilities in which federation members are housed; responsible for security issues related to software, personnel, and storage media used in a federation [Cutts, 2009].

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

Shared space. A mechanism that provides data storage and access capabilities for users within a given network space; provides virtual or physical access to any number of data sets (e.g., catalogs, Web sites, registries, classification networks, document storage, or databases) [DoD, 2008].

Simulation. (1) Executing a model over time [DoD, 2007]. (2) A technique for testing, analysis, or training in which real world systems are used, or where a model reproduces real world and/or notional systems, processes, or phenomena [DoD, 2007].

Simulation environment. (1) A set of interconnected M&S support elements (infrastructure) and resources used to conduct an event [MSCO, 2009]. (2) In a distributed simulation, a set of interoperating member applications, e.g., an HLA federation or a TENA logical range [IEEE, 2008]. (3) A generic term for the category of modeling and simulation implementation types whose specific instances are live, virtual, and constructive [Petty Environments, 2009b]. Synonyms: Modeling and simulation environment.

Sponsor. A role; a person or organization that provides programmatic support to the development, maintenance, or use of assets; an individual or organization for which a federation is being developed, likely responsible for funding and contract issues [Cutts, 2009].

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

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

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

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

User/operator. A role; a person or organization responsible for running a simulation during integration, testing, and execution [Cutts, 2009].

Verification and validation agent. A role; a person or organization responsible for verifying and validating an asset or federation. [Cutts, 2009].

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APPENDIX F: REPOSITORY ASSESSMENT SCORESHEETS

The scoresheets included in the following tables reflect the results of the assessments of M&S catalogs, repositories, and registries conducted as part of this effort. As these tables indicate, sites which fell into these three categories were scored according to the weights assigned to use cases as applicable to each category. Although the results in no way reflect on the success or the overall usefulness of any of these facilities, they do indicate how well each of them represents the desired functionality associated with M&S catalogs, repositories, and registries, and collectively describe where centers of excellence reside within the facilities surveyed. Scoring is relative to each category and includes raw and weighted scores. The weighting of use cases by category was influenced by the following factors as agreed upon by members of the study team:

- Support for the Network-Centric Data Strategy;
- Feedback from the LVC Common Capabilities Workshop;
- Questionnaire responses received; and
- Use Case complexity and granularity.

This analysis was performed using a quantitative method based on subject matter expertise from the study team's background and knowledge. The weights were developed by consensus of the expert study team and reviewed by doing pair-wise comparisons of "is 'a' more important than 'b'?" As the study team did this consensus review of weights and likelihoods, some values changed without dramatic change to the results. Some of the lower rated assessments, where the ratings were close, shifted in order.

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Table F-1: Modeling and Simulation Information System Assessment Sheet

Use Case ID	Use Case Name	Catalog Weight	Raw Score	Weighted Score	Comments
UC 12	Utilize Service	3	0	0	Authorized users can register resources.
UC 11	Assess Asset	4	2	8	Authorized users can modify metadata by going through an approval process.
UC 07	Submit Metadata Entry	4	2	8	Can click thru to get full report of metadata on specific asset.
UC 09	Edit Metadata	4	2	8	Metadata is presented as an HTML table, one asset at a time.
UC 08	Retrieve Metadata	4	2	8	Keyword search returns results sorted by title, date, node or type. There is no relevance ranking algorithm. Target of search can include Air Force, Army, MDA and Navy sites in addition to MSCO site.
UC 10	Transform Metadata	4	0	0	Can save previous search parameters and reuse.
UC 05	Discover Asset	7	1	7	No function to generate an index.
UC 06	Save Discovery Parameters	3	2	6	Can subscribe to groups -- equivalent of an E-mail listserv.
UC 04	Assemble Metadata Index	4	1	4	Unable to test. Site does not appear to offer native support of synchronous collaboration.
UC 02	Collaborate Asynchronously	1	2	2	User ID/Password access required to modify data. Unregistered users can browse and search.
UC 03	Collaborate Synchronously	1	0	0	Metadata search can include Air Force, Army, MDA, Navy and C4ISR sites.
UC 01	Access Portal	6	1	6	User ID/Password authentication controls access.
UC 20	Access Federated Portal	4	1	4	Site provides "Data Administrator" and "Site Administrator" functions. We don't have an account authorized to see those functions.
UC 19	Secure Assets	5	2	10	E-Mail link & phone provided to "Request Assistance." Help page FAQ for Search only.
UC 21	Manage Repository	7	1	7	Authorized users can register resources.
UC 22	Support Repository	7	1	7	Authorized users can modify metadata by going through an approval process.
	All Use Cases	**136**	**23**	**85**	

Table F-2: US Army Modeling and Simulation Resource Repository Assessment Sheet

Use Case ID	Use Case Name	Catalog Weight	Raw Score	Weighted Score	Comments
UC 12	Utilize Service	3	0	**0**	No support.
UC 11	Assess Asset	4	1	**4**	Metadata includes date last modified/viewed and comments.
UC 07	Submit Metadata Entry	4	2	**8**	Authorized users can register resources.
UC 09	Edit Metadata	4	2	**8**	Authorized users can modify metadata by going through an approval process.
UC 08	Retrieve Metadata	4	1	**4**	Can use advanced search to retrieve selected metadata in HTML format. Individual pages containing 10 results can be copied to Word or E-Mail.
UC 10	Transform Metadata	4	1	**4**	Metadata is presented for 10 models at a time in "Element Name: <value>" format. Parsing would be required to reuse data.
UC 05	Discover Asset	7	1	**7**	Keyword search returns results sorted by title or date. There is no relevance algorithm. Target of search can include Air Force, DoD and Navy sites.
UC 06	Save Discovery Parameters	3	2	**6**	No support.
UC 04	Assemble Metadata Index	4	1	**4**	Catalog is rendered as set of 115 web pages. The pages can only be accessed one at a time. The index can be restricted to content of five types. Results can be sorted by title, date, type or record ID. Catalog entries can be clicked to navigation to subject page.
UC 02	Collaborate Asynchronously	1	2	**2**	Jumps to AKO M&S Collaboration Site and also provides E-Mail link to "Request Assistance" address.
UC 03	Collaborate Synchronously	1	1	**1**	Relies on AKO chat.
UC 01	Access Portal	6	2	**12**	User ID/Password access required to modify data. Unregistered users can browse and search.
UC 20	Access Federated Portal	4	1	**4**	Metadata search can include Air Force, DoD and Navy sites.
UC 19	Secure Assets	5	2	**10**	User ID/Password authentication controls access.
UC 21	Manage Repository	7	1	**7**	No functionality other than metadata fields and help pages.
UC 22	Support Repository	7	1	**7**	No functionality other than metadata fields and help pages. E-Mail link provided to "Request Assistance."
	All Use Cases	**136**	**23**	**88**	

Table F-3: M&S Catalog Assessment Sheet

Use Case ID	Use Case Name	Catalog Weight	Raw Score	Weighted Score	Comments
UC 12	Utilize Service	3	1	3	CAC-based identity management over a secure web connection.
UC 11	Assess Asset	4	2	8	The M&S Cat provides the capability to review metacards that describe assets located in other locations. Metrics describing utilization and metacard inventory are collected automatically. There is a mechanism for entry and display of narrative user feedback.
UC 07	Submit Metadata Entry	4	2	8	The M&S Cat provides entry of metadata through a batch uploading process.
UC 09	Edit Metadata	4	0	0	No apparent capability.
UC 08	Retrieve Metadata	4	2	8	The M&S Cat provides search, browse, and discovery of metacards using keywords search and MSC-DMS filtering.
UC 10	Transform Metadata	4	0	0	No apparent capability.
UC 05	Discover Asset	7	2	14	MSC-DMS-based search and discovery.
UC 06	Save Discovery Parameters	3	0	0	No apparent capability.
UC 04	Assemble Metadata Index	4	2	8	The M&S Cat is an assembly of searchable metadata.
UC 02	Collaborate Asynchronously	1	0	0	No apparent capability.
UC 03	Collaborate Synchronously	1	0	0	No apparent capability.
UC 01	Access Portal	6	2	12	The M&S Cat is the portal through which assets are discovered. User access requires a CAC.
UC 20	Access Federated Portal	4	0	0	No apparent capability.
UC 19	Secure Assets	5	1	5	Using MSC-DMS-based metadata, information about asset rights and controls are presented to the user.
UC 21	Manage Repository	7	2	14	Based on personal discussion with M&S Cat's responsible executive, the infrastructure is managed as a CM-controlled product and, while they have not been reviewed, governance plans are in place.
UC 22	Support Repository	7	2	14	Training material is posted to assist sources with the batch uploading process.
	All Use Cases	**136**	**20**	**94**	

Table F-4: 3CE Knowledge Repository Assessment Sheet

Use Case ID	Use Case Name	Catalog Weight	Raw Score	Weighted Score	Comments
UC 12	Utilize Service	3	0	0	Nothing outside basic store-and-forward functions.
UC 11	Assess Asset	4	1	4	
UC 07	Submit Metadata Entry	4	1	4	No mechanism to independently submit metadata into a metadata repository. Work flow seems to be based on a "pull" mechanism consisting of data calls
UC 09	Edit Metadata	4	1	4	Must be done offline with submission to 3CE KR help desk
UC 08	Retrieve Metadata	4	2	8	Can download spreadsheet with containing full metadata content
UC 10	Transform Metadata	4	0	0	Not supported
UC 05	Discover Asset	7	1	7	AKO search engine works to discover the 3CE directory within AKO keyword search
UC 06	Save Discovery Parameters	3	0	0	
UC 04	Assemble Metadata Index	4	1	4	3CE uses its own unique schema, not compliant with MSC-DMS. The catalog is searchable with the AKO engine. Metadata index is assembled in Excel spreadsheet - simple flat file rather than a database.
UC 02	Collaborate Asynchronously	1	2	2	AKO supports email bulletin board, store-and-forward collaboration. AKO has support for RSS feedback wings
UC 03	Collaborate Synchronously	1	1	1	AKO has a good IM function.
UC 01	Access Portal	6	2	12	Single portal though AKO sign-on. Loosely coupled to GIG services
UC 20	Access Federated Portal	4	1	4	3CE Knowledge repository is cross-linked to Army MSRR, but not to provider sites.
UC 19	Secure Assets	5	2	10	Assets are security at unclassified level with appropriate access and distribution control
UC 21	Manage Repository	7	2	14	Repository itself is well documented with online help guide. Change control process is documented. Last update is 7 June 09. JANUS[2] shows up on the list, should be reflected as obsolete.
UC 22	Support Repository	7	2	14	Support is facilitated by using AKO services. Repository itself is well documented with online help guide. Fulltime staff assigned to maintain artifacts in stored in repository
	All Use Cases	**136**	**26**	**88**	

[2] JANUS is an interactive, digital simulation of combined-arms warfare named after the Roman god, Janus, who guarded Rome's city gates. http://states.ng.mil/sites/MA/News/Pages/JANUS%20Simulation%20Tests%20Paraguayan%20Military.aspx

Table F-5: Joint Data Architecture Data Catalog Assessment Sheet

Use Case ID	Use Case Name	Catalog Weight	Raw Score	Weighted Score	Comments
UC 12	Utilize Service	3	0	**0**	
UC 11	Assess Asset	4	1	**4**	No federated repositories; no role-based mechanism.
UC 07	Submit Metadata Entry	4	1	**4**	No federated repositories; no role-based mechanism.
UC 09	Edit Metadata	4	1	**4**	No federated repositories; no role-based mechanism.
UC 08	Retrieve Metadata	4	2	**8**	DataCat can output MSC-DMS 1.1 records for the purposes of publishing it out to the M&S Catalog, but uses its own asset categorization scheme.
UC 10	Transform Metadata	4	2	**8**	DataCat can output MSC-DMS 1.1 records for the purposes of publishing it out to the M&S Catalog
UC 05	Discover Asset	7	0	**0**	
UC 06	Save Discovery Parameters	3	0	**0**	
UC 04	Assemble Metadata Index	4	0	**0**	
UC 02	Collaborate Asynchronously	1	0	**0**	
UC 03	Collaborate Synchronously	1	0	**0**	
UC 01	Access Portal	6	0	**0**	
UC 20	Access Federated Portal	4	0	**0**	
UC 19	Secure Assets	5	0	**0**	
UC 21	Manage Repository	7	0	**0**	Not really applicable since this was a prototype.
UC 22	Support Repository	7	0	**0**	Not really applicable since this was a prototype.
	All Use Cases	**136**	**11**	**28**	

Table F-7: Live Training Transformation (LT2) Portal Assessment Sheet

Use Case ID	Use Case Name	Repository Weight	Raw Score	Weighted Score	Comments
UC 16	Upload Asset	7	2	14	Asset developers can upload artifacts and submit through workflow for CCB approval
UC 15	Modify Asset	3	2	6	Product line rather than a bazaar model. Strong version control and requirements traceability. Component releases are done as product line deliverables by supplier organizations. This gets full score because change requests and CCB actions are all online, easy to access.
UC 17	Manage Asset	6	2	12	Strong capabilities including document review and CCB actions
UC 18	Develop Artifact	3	1	3	Lots of good online forms for metadata, but actual authoring is done offline.
UC 13	Acquire Asset	6	2	12	CTIA repository has two levels of access
UC 14	Download Asset	7	2	14	Bundles CTIA services into a single download file - requires Oracle to be installed, with specific version of Java. Straightforward distribution process.
UC 12	Utilize Service	3	0	0	
UC 11	Assess Asset	4	2	8	Comprehensive issue tracking and resolution functionality, with online form to submit problem report, follow-up directly with developer. Can subscribe to specific issues by category, POC, etc. Provides online survey for = user feedback.
UC 07	Submit Metadata Entry	4	2	8	
UC 09	Edit Metadata	4	1	4	Looks like this is done off-line. Component Working Group preapproves changes before metadata/changes are submitted.
UC 08	Retrieve Metadata	4	1	4	Menu-drive access to metadata. Does not use MSC-DMS schema to organize metadata.
UC 10	Transform Metadata	4	0	0	Not Done
UC 05	Discover Asset	7	1	7	This is the best laid-out repository I have yet encountered. Easy traversal with efficient search engine. However, is not MSC-DMS compliant
UC 06	Save Discovery Parameters	3	0	0	No support for saved search terms. User may select search parameters, but these are not persistent either.
UC 04	Assemble Metadata Index	4	1	4	Metadata is up-to-date, well-organized. No direct linkage to external catalogs. Component Working Groups acts as the QC for metadata submissions.
UC 02	Collaborate Asynchronously	1	2	2	Supports internal forums and collaboration sites.
UC 03	Collaborate Synchronously	1	1	1	External link to contractor Webex Site. No internal services.
UC 01	Access Portal	6	2	12	
UC 20	Access Federated Portal	2	0	0	No evidence that this repository has any connection to other sites (e.g. TENA, OneSAF) - there is a lot of great information in this repository, but it appears to be pretty much self-contained.
UC 19	Secure Assets	5	2	10	LT2 Portal Security Policy is the governing document, and appears to be enforced as is. Unclassified repository, artifacts are Distribution D, with some material restricted as FOUO.
UC 21	Manage Repository	7	2	14	Configuration Management Process (CMP) metrics available online. Numerous documents govern process, including LT2 Component Handover Process and LT2 Product Line Concept of Operations.
UC 22	Support Repository	7	2	14	Clearly a well-supported repository. Provides online survey to gain user feedback. Help desk is all asynchronous and online.
	All Use Cases	**196**	**30**	**149**	

Table F-8: Forge.mil Assessment Sheet

Use Case ID	Use Case Name	Repository Weight	Raw Score	Weighted Score	Comments
UC 16	Upload Asset	7	2	14	A new "Project" must be created (with administrator approval) into which assets (source code, documents, task lists, wiki, etc.) can be organized. There is no capability to upload the asset to another repository.
UC 15	Modify Asset	3	2	6	
UC 17	Manage Asset	6	2	12	Strong tools for CM of assets. Uses Subversion tool to manage source code.
UC 18	Develop Artifact	3	1	3	Templates are not provided but repository permits user-created templates to be stored and used by other authorized users.
UC 13	Acquire Asset	6	2	12	Assets within Forge.mil can be acquired with appropriate permissions. There is no capability to acquire an asset from another repository.
UC 14	Download Asset	7	1	7	Connection to Forge.mil is through a secure website, which requires the user to have a functional CAC. These security measures provide confidence that the download is genuine. However, this is not a federated approach since there appear to be no mechanisms to discover assets in other repositories. Distribution agreement signature could be made a precondition for download access.
UC 12	Utilize Service	3	2	6	CAC-based identity management over a secure web connection.
UC 11	Assess Asset	4	2	8	Utilization metrics are generated automatically based on user activities and can be tailored. Feedback is collected using a system-created wiki or by posting new documents. Support reporting and resolution of problems and issues.
UC 07	Submit Metadata Entry	4	0	0	No apparent capability.
UC 09	Edit Metadata	4	0	0	No apparent capability.
UC 08	Retrieve Metadata	4	0	0	No apparent capability.
UC 10	Transform Metadata	4	0	0	No apparent capability.
UC 05	Discover Asset	7	1	7	Has an internal search engine, Not MSC-DMS compliant.
UC 06	Save Discovery Parameters	3	0	0	No apparent capability.
UC 04	Assemble Metadata Index	4	0	0	No apparent capability.
UC 02	Collaborate Asynchronously	1	2	2	Document storage, discussion boards, project wiki, task lists, etc.
UC 03	Collaborate Synchronously	1	0	0	No apparent capability.
UC 01	Access Portal	6	1	6	Access to Forge.mil is direct. No apparent access from a federated portal.
UC 20	Access Federated Portal	2	0	0	No apparent capability.
UC 19	Secure Assets	5	1	5	Controls placed on assets are based the permissions granted to users. No apparent capability to manage data rights or implement proper IA.
UC 21	Manage Repository	7	2	14	Much of the infrastructure is documented in user guides and training materials.
UC 22	Support Repository	7	2	14	Robust training guides are available asynchronously. Forge.mil offers facilitated online synchronous training twice per month. It's unknown whether the Forge.mil support staff have adequate skills to maintain the repository.
	All Use Cases	**196**	**23**	**116**	

Table F-9: MATREX Integrated Development Environment Assessment Sheet

Use Case ID	Use Case Name	Repository Weight	Raw Score	Weighted Score	Comments
UC 16	Upload Asset	7	1	7	Everything here is tightly versioned. Uses AMRDEC FTP Server for uploads
UC 15	Modify Asset	3	1	3	Indirect submission
UC 17	Manage Asset	6	2	12	Strong CM and version practices according to published CM plan.
UC 18	Develop Artifact	3	2	6	Very strong online support for documentation of requirements and architecture.
UC 13	Acquire Asset	6	1	6	Core Assets only: specific MATREX components acquired separately from the proponent.
UC 14	Download Asset	7	1	7	SE process Assets only: executable components acquired offline separately from the proponent. Uses AMRDEC FTP Server on a case by case basis.
UC 12	Utilize Service	3	1	3	Not an online execution environment, but decent online environment for systems and software engineering processes.
UC 11	Assess Asset	4	2	8	Users can provide online comments on artifacts stored in the IDE. System generates automated test cases from sequence diagrams
UC 07	Submit Metadata Entry	4	1	4	Indirect submission. Would best be combined with MSRR or M&S catalog.
UC 09	Edit Metadata	4	1	4	Indirect submission.
UC 08	Retrieve Metadata	4	2	8	
UC 10	Transform Metadata	4	0	0	Not done.
UC 05	Discover Asset	7	1	7	Lucene Search Module supports basic and advanced search. Provides pick list with available terms. No direct linkage to MSC-DMS.
UC 06	Save Discovery Parameters	3	1	3	Not directly supported. Must build SQL database queries offline.
UC 04	Assemble Metadata Index	4	1	4	SQL Database driven, so this is supported to the extent that the metadata exists. Focus is really on systems engineering artifacts.
UC 02	Collaborate Asynchronously	1	2	2	MATREX IDE site has a bulletin board and collaboration functions. Since all users need to have an AKO account, then could probably use AKO IM tools.
UC 03	Collaborate Synchronously	1	1	1	MATREX uses STEM server (similar to VIS). Not directly coupled to repository.
UC 01	Access Portal	6	2	12	Uses AKO sign-on. User has to register separately through an RDECOM sponsor. Registration process is simple, and person requesting access can site Government project sponsor/COTR if not an RDECOM sponsor.
UC 20	Access Federated Portal	2	1	4	Has a place to put link to other sites, No evidence of RSS feed. MSIAC link no longer works. Links to Army MSRR
UC 19	Secure Assets	5	2	10	Unclassified/CUI/FOUO level
UC 21	Manage Repository	7	2	14	Good CM. Asset kept under version control, with traceability to requirements. Maintains program information and user manuals online.
UC 22	Support Repository	7	2	14	Well supported repository. Has an online tutorial "IDE Basics".
	All Use Cases	**196**	**30**	**139**	

Table F-10: TurboSquid Assessment Sheet

Use Case ID	Use Case Name	Repository Weight	Raw Score	Weighted Score	Comments
UC 16	Upload Asset	7	1	**7**	Upload available and straightforward. However, it is not secure and does not use GIG services.
UC 15	Modify Asset	3	2	**6**	Downloaded assets are in standard formats and can be modified by purchasers using standard tools.
UC 17	Manage Asset	6	1	**6**	Assets are proprietary and copyrighted. They can be modified by customers for their purposes, but not resold as assets or redistributed in any form.
UC 18	Develop Artifact	3	2	**6**	Supporting files (e.g., documentation) can be associated with assets. Nearly all assets can be manipulated using standard 3D modeling tools.
UC 13	Acquire Asset	6	2	**12**	Acquisition of assets is via direct on-line download. Process is easy (standard on-line purchase), but requires payment.
UC 14	Download Asset	7	1	**7**	Download available and straightforward. Both assets and "previews" (e.g., jpg renderings of models) downloadable. Payment, not authorization, required. Not secure.
UC 12	Utilize Service	3	0	**0**	No M&S services, no GIG.
UC 11	Assess Asset	4	1	**4**	Visual assessment of 3D model appearance well-supported, but usability assessment uneven. Documentation of assets (products) varies, some extensive, others minimal or nonexistent.
UC 07	Submit Metadata Entry	4	2	**8**	Model metadata consists of: category, keywords, free text description. Uploadable with asset.
UC 09	Edit Metadata	4	1	**4**	Editing metadata requires re-uploading.
UC 08	Retrieve Metadata	4	1	**4**	Metadata retrieval = asset discovery, i.e., discovering assets retrieves metadata and retrieving metadata discovers assets.
UC 10	Transform Metadata	4	0	**0**	Model metadata consists of: category, keywords, free text description. Not transformable.
UC 05	Discover Asset	7	1	**7**	Asset search modes: keyword, publisher, category, product type, format compatibility, price. Keyword and publisher are Google-style search, others are hierarchical browsing. No extended search capabilities (no saved searches, no logical operators, no explicit keyword vocabularies).
UC 06	Save Discovery Parameters	3	0	**0**	No search save capability. List of recent searches maintained.
UC 04	Assemble Metadata Index	4	0	**0**	No evidence of this capability.
UC 02	Collaborate Asynchronously	1	2	**2**	Conventional topical on-line forums allow customers/users to collaborate asynchronously. Access is via portal.
UC 03	Collaborate Synchronously	1	1	**1**	On-line chat and telephone support available via portal. Do not appear to be with asset publisher.
UC 01	Access Portal	6	2	**12**	Single, easy-to-use portal accesses all assets and support.
UC 20	Access Federated Portal	2	0	**0**	No federated portals.
UC 19	Secure Assets	5	2	**10**	Copyrighted proprietary assets downloadable only upon purchase.
UC 21	Manage Repository	7	2	**14**	Most aspects of use case explicit or implicit in web site capabilities or content.
UC 22	Support Repository	7	2	**14**	Most aspects of use case explicit or implicit in web site capabilities or content.
	All Use Cases	**196**	**26**	**124**	

Table F-11: US Navy Modeling and Simulation Resource Repository Assessment Sheet

Use Case ID	Use Case Name	Repository Weight	Raw Score	Weighted Score	Comments
UC 16	Upload Asset	7	2	14	Authorized users can upload software and documents
UC 15	Modify Asset	3	2	6	
UC 17	Manage Asset	6	2	12	
UC 18	Develop Artifact	3	1	3	V&V Tool invokes online
UC 13	Acquire Asset	6	2	12	
UC 14	Download Asset	7	2	14	
UC 12	Utilize Service	3	1	3	Web 2.0 implementation limited to store and forward
UC 11	Assess Asset	4	2	8	
UC 07	Submit Metadata Entry	4	2	8	
UC 09	Edit Metadata	4	2	8	
UC 08	Retrieve Metadata	4	2	8	
UC 10	Transform Metadata	4	0	0	No apparent capability.
UC 05	Discover Asset	7	1	7	Robust search capability but not based on MSC-DMS.
UC 06	Save Discovery Parameters	3	0	0	No apparent capability.
UC 04	Assemble Metadata Index	4	2	8	Metadata is assembled but not based on MSC-DMS.
UC 02	Collaborate Asynchronously	1	2	2	
UC 03	Collaborate Synchronously	1	0	0	No synchronous collaboration capabilities.
UC 01	Access Portal	6	2	12	CAC Card required
UC 20	Access Federated Portal	2	1	4	Federated portals are offered to the user via the search interface. However, a simple test of the federated search capability did not produce expected results.
UC 19	Secure Assets	5	0	0	There is no specific mechanism to control distribution of assets using IP or other provenance criteria.
UC 21	Manage Repository	7	2	14	
UC 22	Support Repository	7	2	14	
	All Use Cases	**196**	**32**	**157**	

Table F-12: TENA Repository Assessment Sheet

Use Case ID	Use Case Name	Repository Weight	Raw Score	Weighted Score	Comments
UC 16	Upload Asset	7	2	14	Upload available and easy to use. No federated repositories.
UC 15	Modify Asset	3	2	6	Downloaded assets can be modified and uploaded.
UC 17	Manage Asset	6	2	12	Versioning built into repository. Development tools available.
UC 18	Develop Artifact	3	2	6	Non-asset artifacts are mostly standard office-format documents. Diagrammatic Object Model design tool available.
UC 13	Acquire Asset	6	1	6	Repository asset acquisition straightforward. No links to federated repositories or non-TENA asset types.
UC 14	Download Asset	7	2	14	Download mechanism easy and fast. Access controlled through developer-designated security levels.
UC 12	Utilize Service	3	0	0	No web or GIG services evident.
UC 11	Assess Asset	4	2	8	Email address provided for users to submit feedback on assets (and support). Feedback also possible by using help desk items, which can be read and "watched" by users.
UC 07	Submit Metadata Entry	4	1	4	Metadata submitted with asset upload. No separate submission of metadata, no submission to federated repositories.
UC 09	Edit Metadata	4	2	8	Submitted metadata easy to edit.
UC 08	Retrieve Metadata	4	1	4	Repository metadata easy to search. No separate retrieval (i.e., download) of metadata.
UC 10	Transform Metadata	4	0	0	No metadata export or conversion.
UC 05	Discover Asset	7	2	14	Assets discovered via (1) project browsing, or (2) keyword search of metadata or asset content. Easy to use. No search of federated repositories.
UC 06	Save Discovery Parameters	3	0	0	No search save capability.
UC 04	Assemble Metadata Index	4	0	0	No user-selectable metadata export. Export may be possible but requires programmer action.
UC 02	Collaborate Asynchronously	1	2	2	Email reflector allows users to collaborate asynchronously. Access is via portal. No document storage.
UC 03	Collaborate Synchronously	1	0	0	No synchronous collaboration mechanisms evident.
UC 01	Access Portal	6	2	12	Single, easy-to-use portal accesses all assets and support.
UC 20	Access Federated Portal	2	0	0	No federated portals.
UC 19	Secure Assets	5	2	10	Citizenship and authorization required prior to downloading key assets.
UC 21	Manage Repository	7	2	14	Most aspects of use case explicit or implicit in web site capabilities or content.
UC 22	Support Repository	7	2	14	Most aspects of use case explicit or implicit in web site capabilities or content.
	All Use Cases	**196**	**29**	**148**	

Table F-13: DoD Metadata Registry Assessment Sheet

Use Case ID	Use Case Name	Registry Weight	Raw Score	Weighted Score	Comments
UC 16	Upload Asset	7	2	14	Assets being uploaded are metadata information resources using a package submission tool.
UC 15	Modify Asset	3	2	6	Modifications are performed locally and then the package is resent.
UC 17	Manage Asset	6	2	12	Uploaded assets can identified as developmental or release.
UC 18	Develop Artifact	3	2	6	Provides mechanisms to include relevant documentation and schemas within the package.
UC 13	Acquire Asset	6	2	12	Account required.
UC 14	Download Asset	7	2	14	
UC 12	Utilize Service	3	2	6	Search and discovery services are provided.
UC 11	Assess Asset	4	2	8	Roles are assigned and permissions are granted based on role.
UC 07	Submit Metadata Entry	4	2	8	This is the primary purpose of the DoD MDR.
UC 09	Edit Metadata	4	2	8	Through the portal, asset descriptions can be edited.
UC 08	Retrieve Metadata	4	2	8	This is the primary purpose of the DoD MDR.
UC 05	Discover Asset	7	2	14	Yep.
UC 06	Save Discovery Parameters	3	0	0	No.
UC 04	Assemble Metadata Index	4	2	8	Yes.
UC 02	Collaborate Asynchronously	1	2	2	email, phone.
UC 03	Collaborate Synchronously	1	0	0	No apparent capability.
UC 01	Access Portal	6	2	12	Portal-based.
UC 19	Secure Assets	3	1	3	Security of assets is based on role assigned.
UC 21	Manage Repository	7	2	14	Excellent management discipline including working groups, community forums, and training materials.
UC 22	Support Repository	7	2	14	Excellent management discipline including working groups, community forums, and training materials.
	All Use Cases	**180**	**36**	**169**	

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APPENDIX G: ABBREVIATIONS AND ACRONYMS

3CE	Cross Command Collaboration Environment
3D	Three dimensional
AAR	After Action Review
ACE	Advanced Collaborative Environment
ACM	Association for Computing Machinery
AFAMS	U.S. Air Force Agency for Modeling and Simulation
aka	also known as
AKO	Army Knowledge Online
AMRDEC	Aviation and Missile Research Development and Engineering Center
AMSO	Army Modeling and Simulation Office
ANSI	American National Standards Institute
API	Application Programmer Interface
ARMS	Automated Records Management System
ATEC	Army Test and Evaluation Command
BOM	Base Object Model
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CADM	Core Architecture Data Model
CAC	Common Access Card
CGF	Computer Generated Forces
CIO	Chief Information Officer
CIM	Computation Independent Model
COI	Community of Interest
CM	Configuration Management
CMP	Configuration Management Process
CMU	Carnegie Mellon University
CNA	Center for Naval Analyses
COOP	Continuity of Operations
COTS	Commercial Off-the-Shelf
CTIA	Common Training Instrumentation Architecture
CUI	Controlled Unclassified Information
DARS	Defense Acquisition Regulations System
DataCat	Data Catalog
DDMS	Department of Defense Discovery Metadata Specification
DIS	Distributed Interactive Simulation
DISA	Defense Information Systems Agency
DoD	Department of Defense
DSEEP	Distributed Simulation Engineering and Execution Process
DTDs	Document Type Definitions

ECHO DEP	Exploring Collaborations to Harness Objects in a Digital Environment for Preservation
EHF	Extremely High Frequency
FAQ	Frequently Asked Questions
FCS	Future Combat Systems
FEDEP	Federation Development and Execution Process
FOM	Federation Object Model
FOUO	For Official Use Only
FTP	File Transfer Protocol
GFE	Government Furnished Equipment
GIG	Global Information Grid
GSA	Google Search Appliance
HLA	High Level Architecture
HLT	High-Level Task
HTML	HyperText Markup Language
IA	Information Assurance
IBM	International Business Machines
ID	Identification
IDE	Integrated Development Environment
IEEE	Institute of Electrical and Electronics Engineers
I/ITSEC	Interservice/Industry Training, Simulation and Education Conference
IM	Instant Message
IP	Intellectual Property
JATTL	Joint Advanced Training Technologies Laboratory
JCOM	Joint Composable Object Model
JDA	Joint Data Alternatives
JDA2	Joint Data Alternatives 2
LT2	Live Training Transformation
LVC	Live-Virtual-Constructive
LVCAR	Live-Virtual-Constructive Architecture Roadmap
MATREX	Modeling Architecture for Technology, Research and EXperimentation
M&S	Modeling and Simulation
MDA	Missile Defense Agency
MDR	Metadata Registry
MoD	Ministry of Defence/Ministry of Defense
MSC-DMS	Modeling and Simulation Community of Interest Discovery Metadata Specification
MSIAC	Modeling and Simulation Information Analysis Center

MSIS	Modeling and Simulation Information System
MSRR	Modeling and Simulation Resource Repository
NCDS	Net-Centric Data Strategy
NCES	Net-Centric Enterprise Services
NDIIPP	National Digital Information Infrastructure and Preservation Program
NMSO	Navy Modeling and Simulation Office
NSWC	Naval Surface Warfare Center
NSWCDD	Naval Surface Warfare Center Dahlgren Division
OASD (NII)	Office of the Assistant Secretary of Defense, Network and Information Integration
OCLC	Ohio College Library Center
OMG	Object Management Group
OMRC	Object Model Resource Center
OneSAF	One Semi-Automated Forces
OPNET	Optimized Network Engineering Tools
OSD	Office of the Secretary of Defense
OV	Operational View
OV-1	Operational View One
PEO	Program Executive Office
PIM	Platform Independent Model
PIVOMS	Primary Integrated View of Models & Simulations
PM	Program Manager
PSM	Platform Specific Model
POC	Point of Contact
RDECOM	Research Development and Engineering Command
RLG	Research Libraries Group
RPR FOM	Real-time Platform Reference Federation Object Model
RSS	Really Simple Syndication
SAAS	Software as a Service
SATCOM	Satellite communications
SE	Synthetic Environment
SEDRIS	Synthetic Environment Data Representation and Interchange Specification
SEI	Software Engineering Institute
SOA	Service Oriented Architecture
SPAWAR	Space and Naval Warfare Systems
SISC	Simulation Interoperability Standards Committee
SISO	Simulation Interoperability Standards Organization
SME	Subject Matter Expert
SSO	Single Sign On
STRI	Simulation Training and Instrumentation

TDMA/TIP	Time-Division Multiple Access Interface Processer
TENA	Test and Training Enabling Architecture
TRADOC	Training and Doctrine Command
TTCP	The (originally Tripartite) Technical Cooperation Program
UAH/CMSA	University of Alabama Huntsville Center For Modeling, Simulation, and Analysis
UC	Use Case
URI	Uniform Reference Identifier
US	United States
UIUC	University of Illinois Urbana-Champaign
XML	Extensible Markup Language
VV&A	Verification, Validation, and Accreditation
Wiki	What I Know Is

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