LVC Common Capabilities

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ABSTRACT

The Live Virtual Constructive Architecture Roadmap (LVCAR) report recommended actions to promote the sharing of tools, data, and information across the Enterprise; and to foster common formats and policy goals to promote interoperability and the use of common M&S capabilities. This paper presents the results of these efforts.

The systems engineering framework effort evaluated how the Distributed Simulation Engineering and Execution Process (DSEEP), IEEE 1730, could be extended to multi-architecture environments, focusing on identifying and addressing issues that only arise as a result of integrating multiple architectures. We detail extensions to the DSEEP that address these issues.

The federation agreements effort analyzed existing federation agreement documents and literature about such agreements, identifying all agreements the LVC community has deemed valuable. We decomposed these agreements into individual elements in an XML schema. We present the process, resulting schema, and guidance for using the template.

The reusable tools and common data storage formats effort extensively researched existing tools and formats. We evaluated potential and existing tool business models, identified the benefits and barriers of each model for the DoD, and determined the current business model for each category. Based on this analysis, we recommended actions to improve reuse of tools by category. We prioritized the needs for common data storage formats with the LVC community, and recommended actions to move toward common formats for the highest priority categories.

The asset reuse effort developed use cases for reuse mechanisms and criteria for evaluating the ability of existing mechanisms to support the use cases. Based on this analysis, we developed an implementation plan to improve mechanisms for the reuse of M&S assets.

Our results provide the LVC community with improved multi-architecture interoperability mechanisms and concrete plans for additional improvements in the future.

ABOUT THE AUTHORS

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1 BACKGROUND

DoD has made great strides employing distributed applications of interoperable live, virtual, constructive (LVC) simulations. Pursuing local success, however, has encouraged development of disparate architectures, redundant applications, and uncorrelated representations. These shortcomings compound problems, e.g., bridges and gateways proliferate, functionality of mixed-architecture federations is limited, and incompatibilities frustrate common object model use and benefits. In general, current models and simulations seamlessly communicate, pass data, and coordinate services only in restrictive circumstances, often depending upon dedicated or interconnected networks.

The LVCAR Implementation task being executed by JHU/APL is intended to promote the sharing of tools, data, and information across the Enterprise; and to foster common formats and policy goals to promote interoperability and the use of common M&S capabilities.

This paper reports the results of several subtasks known collectively as LVC Common Capabilities whose objective is to develop a set of products that facilitate cross-architecture communication and collaboration, and reduce divergence and duplication among LVC user communities.

2 SYSTEMS ENGINEERING PROCESS

The objective of this subtask was to develop a common systems engineering process model for mixed-architecture LVC simulation environment development and execution that would:

- Leverage an existing systems engineering process framework,
- Identify issues unique to mixed-architecture development and define best practices for addressing those issues, and
- Align issues/best practices with corresponding activities in the process framework.

While each of the major simulation architectures[1] possesses a supporting process model, there is no corresponding user guidance for the development and execution of multi-architecture LVC simulation environments. This was identified as a significant problem during the LVCAR effort, as evidence suggested that the misunderstandings and miscommunications that occurred among disparate architecture-specific teams during a multi-architecture development resulted in increased technical problems and costly rework. To address this problem, the Systems Engineering Process subtask focused on the development of a common systems engineering process model to support multi-architecture development.

Early in the project, it was decided that leveraging and modifying/extending an existing systems engineering process standard was preferable to building an entirely new process. Several generalized and widely recognized systems and software standards (e.g., EIA-632, ISO/IEC 15288) were considered. However, it was quickly recognized that direct reuse of any process standard outside of the M&S domain would require an excessive amount of tailoring. For that reason, an emerging Institute of Electrical and Electronics Engineers (IEEE) standard (IEEE 1730) was selected as the foundation for the desired process. The name of this standard is the Distributed Simulation Engineering and Execution Process (DSEEP). The DSEEP represents an architecture-neutral tailoring of best practices in the systems and software engineering communities to the M&S domain. An illustration of the seven primary DSEEP development and execution steps is provided in Figure 1.

The overarching strategy for this subtask was to overlay the technical issues that are unique to (or at least exacerbated by) multi-architecture development on top

[1] For the purposes of this subtask, this includes Distributed Interactive Simulation (DIS), the High Level Architecture (HLA), and the Test and Training Enabling Architecture (TENA).

of the more generalized steps and activities defined in the DSEEP. The intent was for the overlay to define a "how to" guide for developing and executing multi-architecture simulation environments, based on perceived best practices for issue resolution.

The identification of the multi-architecture specific issues and associated solutions was based on an extensive literature search, focusing mainly on reports, technical papers, and journals published by a variety of M&S organizations. The focus of this search was case studies of multi-architecture development projects that documented the technical issues that were encountered, and the solutions that were put into place. This body of knowledge (BOK) was augmented with the personal experiences of the team assembled for this subtask and feedback captured at the LVCAR Common Capabilities Workshop held at JHU/APL in November 2009. The result of this data collection effort was a total of 43 technical issues and solutions that were directly related to multi-architecture development.

The mapping of these issues and solutions to the developmental activities defined in the DSEEP is shown in Table 1. This mapping, along with the additional activity inputs and outputs necessary to address the multi-architecture concerns, fully defined the desired overlay. Most of the multi-architecture issues impacted the middle three steps of the process (design, development, and integration/test), although all DSEEP steps were affected to some degree.

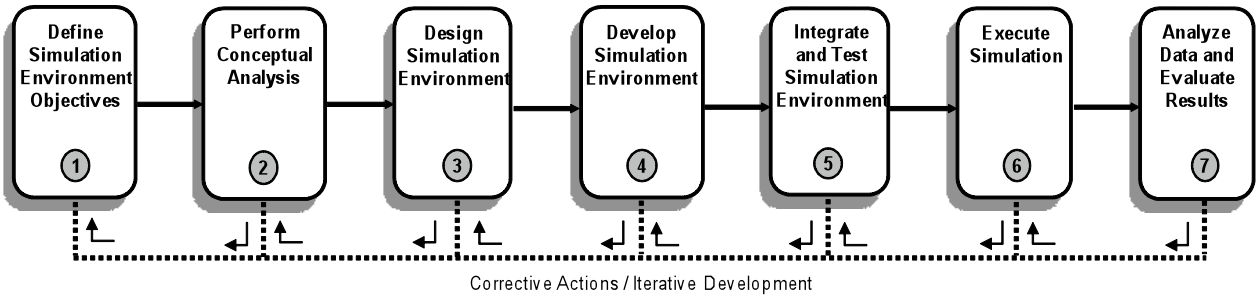

Figure 1. DSEEP Top-Level View

Table 1. DSEEP Multi-Architecture Issue Distribution

Step	(1) Define Simulation Environment Objectives (2 issues)	(2) Perform Conceptual Analysis (2 issues)	(3) Design Simulation Environment (22 issues)	(4) Develop Simulation Environment (7 issues)	(5) Integrate and Test Simulation Environment (7 issues)	(6) Execute Simulation (1 issue)	(7) Analyze Data And Evaluate Results (2 issues)
Activities	Identify Users/Sponsor Needs **(no issues)** Develop Objectives **(no issues)** Conduct Initial Planning **(2 issues)**	Develop Scenario **(no issues)** Develop Conceptual Model **(no issues)** Develop Simulation Environment Requirements **(2 issues)**	Select Member Applications **(2 issues)** Design Simulation Environment **(14 issues)** Design Member Applications **(1 issue)** Prepared Detailed Plan **(5 issues)**	Develop Simulation Data Exchange Model **(2 issues)** Establish Simulation Environment Agreements **(1 issue)** Implement Member Application Designs **(2 issues)** Implement Simulation Environment Infrastructure **(2 issues)**	Plan Execution **(2 issues)** Integrate Simulation Environment **(1 issue)** Test Simulation Environment **(4 issues)**	Execute Simulation Environment **(1 issue)** Prepare Simulation Environment Outputs **(no issues)**	Analyze Data **(no issues)** Evaluating Feedback Results **(1 issues)**

The next planned activity for the DSEEP multi-architecture overlay is standardization. The overlay will serve as the baseline for a defined series of open comment rounds within SISO.

3 COMMON FEDERATION AGREEMENTS TEMPLATE

The objective of this subtask was to develop an architecture-independent template for establishing federation agreements that can be supplemented by potential architecture-specific extensions, recognizing that:

- All LVC developments need to establish federation agreements, but there is no standard/convention for the structure or content.
- Projects currently develop their own mechanisms for such agreements, thus reducing the opportunity for reuse.
- A common template, with flexibility for architecture-specific extensions, facilitates some uniformity in how agreements are documented, facilitating reuse both within and across user communities, and enabling tool support.

To achieve this objective, the Federation Agreements Template team:

- Analyzed existing federation agreement documents and literature about such agreements, identifying all agreements the LVC community has deemed valuable;
- Developed a set of roles relative to federation agreements to drive associated use cases for eliciting additional agreements;
- Evaluated the pros and cons of previously used and potential formats for the template;
- Held two workshops to solicit both broad and detailed input to the agreements;
- Decomposed the identified agreements into individual elements in an XML schema; and
- Produced a user's guide and manual for the schema.

The detailed process and interim products were previously reported in (Morse, 2010).

3.1 Federation Agreements XML Schema

The agreements identified were grouped into eight categories as defined in Table 2.

Table 2. Federation Agreement Categories

Category	Description
Metadata	Information about the federation agreements document itself.
Design	Agreements about the basic purpose and design of the federation.
Execution	Technical and process agreements affecting execution of the federation.
Management	Systems/software engineering and project management agreements.
Data	Agreements about structure, values, and semantics of data to be exchanged during federation execution.
Infrastructure	Technical agreements about hardware, software, network protocols, and processes for implementing the infrastructure to support federation execution.
Modeling	Agreements to be implemented in the member applications that semantically affect the current execution of the federation.
Variances	Exceptions to the federation agreements deemed necessary during integration and testing.

Due to its size and complexity, the schema is physically decomposed into eight files, one for each category. There are 53 agreements with 74 elements (not accounting for simple and complex types, and attribute groups) for a total of 3287 lines in the whole schema.

Figure 2 provides an excerpt from a sample federation agreements document (Coolahan, 2009) illustrating the responsibilities for a member application under the Design Agreements.

```
<fedagree:memberApps>
    <fedagree:memberApplication id="popModelFederate">
      <cpe-item xmlns=http://cpe.mitre.org/dictionary/2.0
                name="cpe:/o:jhuapl:sparrows:1.0">
        <title>JHU APL Sparrows version 1.0</title>
      </cpe-item>
      <instance>
        <description>Population model for PACER Bioterrorism
            federation. Utilizes the initial list of infected
            persons, population data, and TAZ
            data.</description>
        <responsibilities>
          <responsibility>Model the progression of smallpox in
            all infected individuals through contagion,
            death/recovery.</responsibility>
          <responsibility>Model the vaccination of individuals
            stochastically</responsibility>
          <responsibility>Calculate fatalities</responsibility>
          <responsibility>Calculate number of people who
            recover with vaccine</responsibility>
          <responsibility>Calculate number of people who
            recover without vaccine</responsibility>
        </responsibilities>
      </instance>
    </fedagree:memberApplication
</fedagree:memberApps>
```

Figure 2. Extract from Sample Federation Agreements Document

3.2 Federation Agreements User's Guide

To aid users in understanding the schema, its development, and its application, the team produced a short User's Guide. The Guide provides details on how elements of existing XML schemas such as the Modeling and Simulation (M&S) Community of Interest – Discovery Metadata Specification (MSC-DMS, 2008) were reused to develop the template. The Guide describes design patterns within the schema that provide the flexibility to include agreements inline or by reference to an external document. Primarily, the Guide summarizes the categories and agreements, and their associated guidance extracted from the schema itself as illustrated in Figure 3. The detailed information on every single element is provided in the Programmer's Reference, available in HTML.

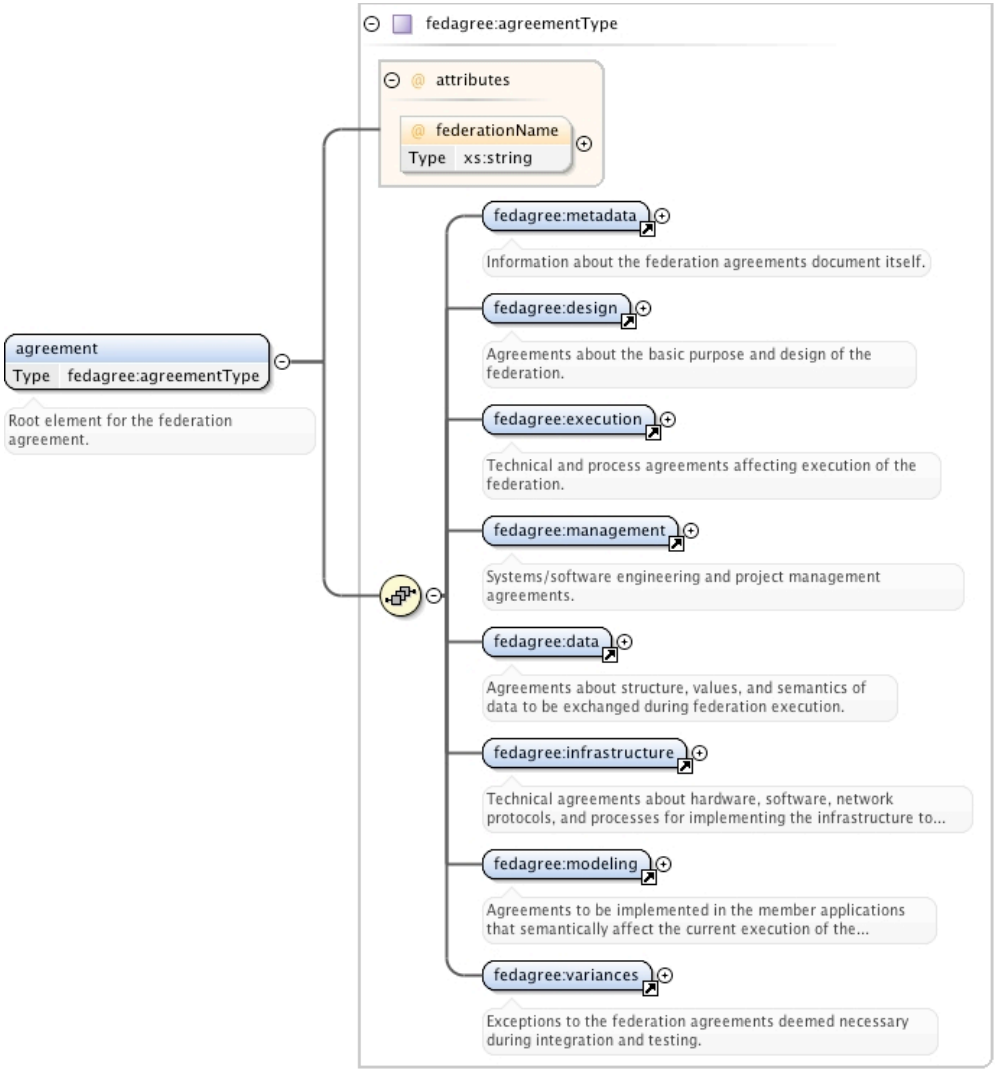

Figure 3. Excerpt from User's Guide

3.3 Federation Agreements Programmer's Reference

The Programmer's Reference was generated in a two-stage process. First, guidance statements for each element in the schema were added as annotations to the respective implementing elements in the documentation. This assured that even without a separate guiding document, the guidance statements would be available to those directly generating conformant documents or programmers using the schema to develop tools for federation agreement documentation. Second, an automated tool was used to generate a comprehensive, cross-indexed programmer's reference in HTML. This reference includes not only the technical documentation and guidance statements, but also examples of conformant element use and navigable hierarchical diagrams of the inter-relationship between elements.

4 REUSABLE TOOLS AND COMMON DATA STORAGE FORMATS

The objective of this subtask was to examine the various options associated with efficient, effective sharing of tool resources for LVC applications, and recommend the most beneficial approach or approaches, including benefits and barriers. The subtask had two sub-objectives:

- Identify a corporate approach or approaches for LVC tool management using the above systematic methodology and implement the preferred approach driven by the areas of greatest need.
- Examine the 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.

4.1 Reusable Tools

To achieve the first sub-objective, the study team:

- Identified and categorized current government, open source, and commercial LVC development tools;
- Identified the set of business models currently in use for these tools and business models that could potentially be adopted;
- Developed a weighted taxonomy of benefits and barriers applicable to the DoD and evaluated the business models against the taxonomy;
- Determined strategies for improving the state of the market in each category based on the current state of the market;
- Solicited broad and detailed input into tools use and reuse by engaging the community through online questionnaires and two workshops; and
- Designed short-term pilots to support determination of feasibility of some approaches not currently used widely such as open source.

The detailed process and interim products were previously reported in (Morse, 2010a).

4.2 Business Models

The study team began this analysis by concurrently establishing a set of candidate business models and developing an inventory of existing LVC tools. These business models were drawn from prior LVC Architecture Roadmap research and an assessment of current trends in software licensing:

a. Department of Defense (DoD) Wholly-owned and Centrally Distributed - A DoD organization owns the rights to the tool(s) and provides them to interested DoD organizations. This business model, also known as government-off-the-shelf (GOTS), is implemented by the organizations that support the Test and Training Enabling Architecture (TENA) and the Common Training Instrumentation Architecture (CTIA).
b. Laissez-faire - Each user organization or "buyer" decides what to adopt. Those adoption options can include purchasing commercial-off-the-shelf (COTS) software, adopting DoD wholly-owned tools, or adoption of an open source tool. Since DoD wholly-owned and open source are assessed as separate business models and described in subsequent subsections, the evaluation of the Laissez-faire business model focused on the purchase of COTS tools.
c. Open source - DoD fosters open source tools by contributing to their development and sustainment. This is the Open Technology Development approach recommended in the LVCAR Comparative Analysis of Business Models (Swenson, 2008).
d. Laissez-faire with Increased Visibility - This is essentially the same as Laissez-faire, but DoD puts an emphasis on making programs' choices, and more importantly, their experiences, more visible. The visibility mechanisms are addressed in the LVCAR Asset Reuse Mechanism subtasks (see section 5).
e. Standards-focused - In this approach, DoD does not take an active role to try to foster or force tool reuse but rather obtains the benefits of interoperability by focusing in on standards for tool data interchange. This is another variant on Laissez-faire, but tool compliance with the standards is used to "limit" the market.
f. Preferred Provider List - DoD publishes a list of preferred tools. Programs are "encouraged" to buy from this list or justify why not.
g. Central License Negotiation - DoD central purchasing organization receives tool requirements from users, makes selections on tools, and negotiates terms and licensing fee(s) for DoD users. Unlike the DoD wholly-owned approach, the individual organizations procure the tools with their own funds.
h. Software as a Service - Rather than purchasing licenses for installation, DoD negotiates with service providers. Delivery mechanisms vary across vendors. The software may be downloaded at run-time from the provider's server, may be provided via a services oriented architecture (SOA) interface, may be provided via a web client, or may be locally installed for a negotiated period of time.

In order to compare business models objectively, the study team identified a set of benefits and barriers by reviewing prior literature, as well as through the experience of the study team participating in previous LVC events. Based on the key findings of this analysis, the study team developed both short- and long-term recommendations for implementation.

4.3 Short-Term Recommendations

The short-term recommendations are intended to provide risk reduction before making more broadly sweeping long-term changes. They consist of pilots and initiatives that will determine feasibility and provide lessons learned, as follows:

- Execute a set of pilots to attempt to move some tool categories (especially DoD-owned) to business models with higher benefit to DoD.
- Explore the barriers to central license negotiation to see if any can be ameliorated.
- Conduct a pilot that transitions a currently DoD-owned tool to open source, while basing the effort on open standards.
- In addition to the open source pilot effort, foster the establishment of open standards.
- Gather information from industry to 1) inform industry that DoD is interested in the software as a service business model, and 2) determine if there are industry providers who would be interested in offering software as services.
- Regardless of the business model selected for a tool category, take actions to increase visibility of tools in use, and gather user feedback. Improved visibility across the board will enable decision-makers under all business models to make more informed decisions, particularly using feedback from other users' experiences with tools under consideration. This recommendation is supported by the results of the LVCAR Implementation Asset Reuse task.

4.4 Common Data Storage Formats

To achieve the second sub-objective, the study team:

- Identified classes and specific instances of data storage formats currently in use;
- Identified Global Information Grid (GIG) Communities of Interest (COI) with which to coordinate on classes of formats;
- Developed a set of criteria for assessing the difficulty of achieving a reduced set of formats in each class;
- Solicited priorities from the community;
- Held two workshops to solicit both broad and detailed input to the class identification and prioritization; and
- Assessed each category against the difficulty criteria and community priorities, and provided recommended actions to achieve community consensus on reduced set of data formats in each class.

The detailed process and interim products were previously reported in (Morse, 2010b).

For each of the nine (9) format categories identified by the team, a list of applicable formats was compiled and characterized in terms of currency, openness, maturity, and applicability as a source (producer), interchange (mediation) and executable (consumer) data format. This information was used to assess the difficulty of rationalizing formats within each category.

In addition, the team developed a strategy for each of the nine categories by evaluating the feasibility of moving to a state of greater reuse via a combination of: (1) reduction in the number of formats used in each category; (2) standardization of formats in each category if no standards exist; (3) increased adoption of mediation formats to reduce translation errors; and (4) creation or engagement with category-specific communities of interest (COIs). Using this prioritization approach, the team developed the recommendations for each category in Table 3.

Table 3. Common Data Storage Formats Recommendations

Category	Strategy
Manmade features (Priority 1)	Engage with ongoing efforts to ensure they include LVC-specific requirements: • Determine M&S-specific set of requirements for three dimensional (3D) manmade features representation. • Work with existing standards bodies to ensure requirements not yet met by their specifications are incorporated in the next iteration (Khronos Group - COLLADA[2], Open Geospatial Consortium (OGC) – CityGML, Web3D - X3D).
Event results (Priority 1)	Monitor until sufficient meaningful direction emerges: • Observe ongoing development in the Joint Digital Collection, Analysis, and Review System (JDCARS) and One Semi-Automated Forces (OneSAF) logging/After Action Report (AAR) efforts with the goal of discovering commonalities in the development event results data models. • Coordinate with subject matter experts (SMEs) who regularly utilize event results data to generate AAR reports to gather their input requirements.

[2] A COLLAborative Design Activity for establishing an open standard Digital Asset schema for interactive 3D applications – a standard of the Khronos Group.

Category	Strategy
Geospatial (Priority 2)	Establish forum/process for mediating between dissenting communities; management/cooperation changes: • M&S Technical Working Group (TWG) petitions for voting status in the GWG. • Establishment of an M&S Geospatial Task Force. This task force would be tasked with coordinating with the Command and Control (C2) community to establish broad format requirements. • Development of a standards strategy, including the potential for convergence on a common set of mediation formats and identification of the Standards Development Organizations (SDOs) responsible for managing and extending those formats.
UOB/force structure (Priority 3)	Engage with ongoing efforts to ensure they include LVC-specific requirements: • Ensure that government-owned proprietary standards are exposed to the commercial community in the form of recognized open standards. • Deconflict Coalition Battle Management Language (C-BML) with related standards. • Utilize Joint Land Component Constructive Training Capability (JLCCTC) as a reference implementation for wider LVCAR applicability.
Plans/ scenarios (Priority 3)	Engage with ongoing efforts to ensure they include LVC-specific requirements; initiate activity to bring key stakeholders together to develop format where no clear viable solution currently exists: • Move towards standardization and rationalization of data storage formats by delineating the relationship, scope and fundamental limitations of Joint Consultation, Command, and Control Information Exchange Model (J3CIEDM), Military Scenario Definition Language (MSDL) and C-BML. • Ensure that semantic as well as syntactic issues are addressed as existing mediation formats for plans and scenarios evolve. • Explore the reconciliation of plans and scenario representations in multi-resolution federations.
Platform /weapons performance (Priority 4)	Initiate activity to bring key stakeholders together to develop format where no clear viable solution currently exists: • Determine the Air Force and Navy's desire/need to establish authoritative data sources and formats analogous to those produced by Army Materiel Systems Analysis Activity (AMSAA).
Behavior (Priority 4)	Monitor until sufficient meaningful direction emerges: • SISO has established a Human, Social, Cultural, Behavioral (HSCB) study group to determine if any standards are feasible in this area. Participate in this activity. • The Office of the Secretary of Defense (OSD) / Office of Naval Research (ONR) HSCB program funds several key model developers, but they are indifferent or antagonistic to standards at this point. Continue to engage with this effort and attempt to improve understanding and acceptance of common data storage formats.
EOB/ network (Priority 5)	Engage with ongoing efforts to ensure they include LVC-specific requirements; initiate activity to bring key stakeholders together to develop format where no clear viable solution currently exists: • Extend recognized government standards (JC3IEDM, C-BML, MSDL) into a published open standard that is also reflected in the DISR baseline. • Establish an appropriately focused Simulation Interoperability Standards Organization (SISO) study group consisting of the relevant stakeholders from government and private industry. • Explore a pilot project aligning Commercial-Off-The-Shelf (COTS) and Government Off-the-Shelf (GOTS) tools with an updated Lightweight Directory Access Protocol (LDAP) Interchange Format (LDIF).
Logistics (Priority 5)	Accelerate promising, but slow, ongoing efforts: • Explore a pilot project that extends JC3IEDM to enable the direct interchange of logistics data into JLCTCC Entity Resolution Federation components • Extend initial JLCTCC pilot effort to support aggregate level constructive simulations and interaction with live systems through Logistics C2 systems.

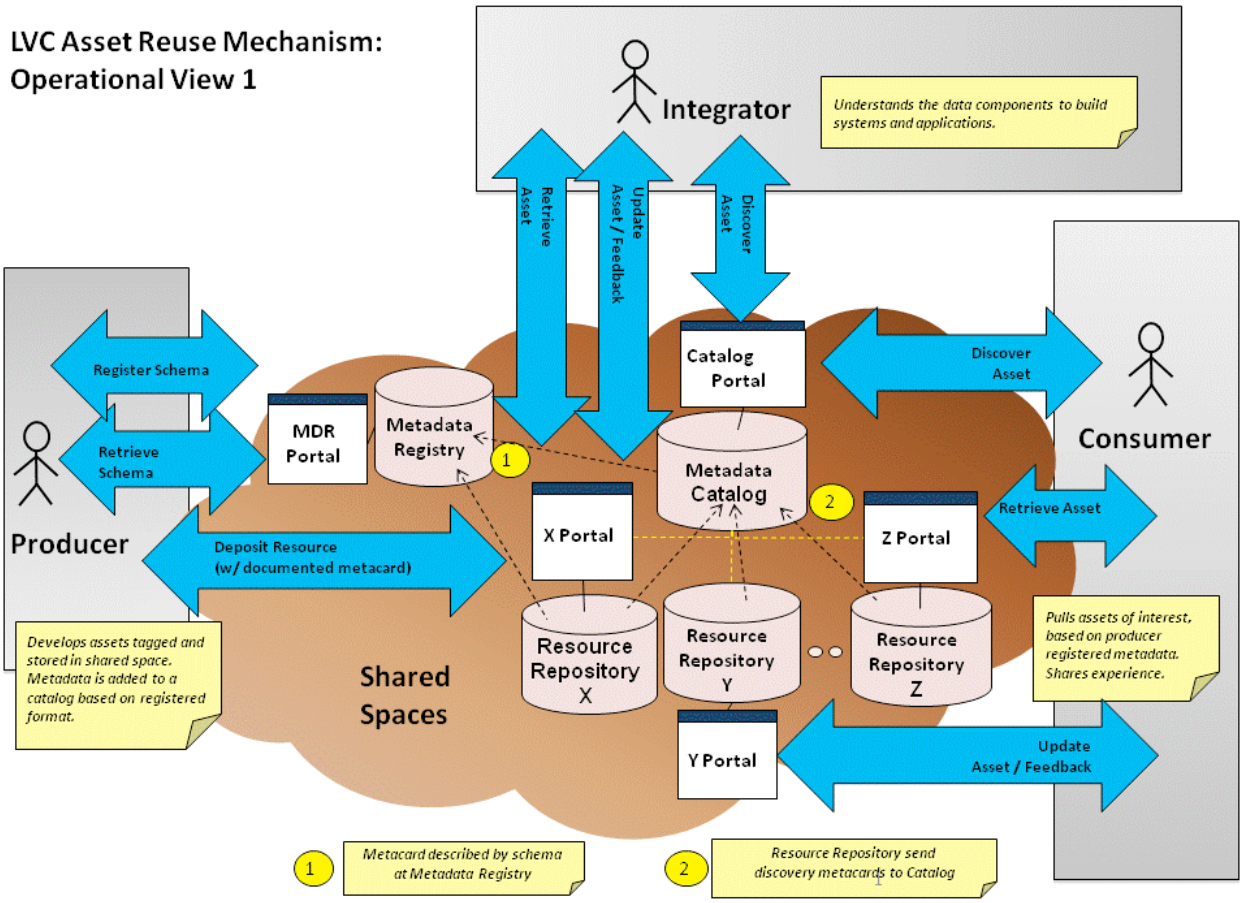

Figure 4. LVC Asset Reuse Concept

5 ASSET REUSE

The objective of this subtask was to examine existing infrastructure capabilities for M&S reuse, compare these capabilities to the required mechanisms for sharing and reuse described in the LVC Architecture Roadmap, and develop an implementation plan to ensure the appropriate discovery and distribution mechanisms are available in the future.

In the past, the reuse of software, data, and other assets in Department of Defense (DoD) Modeling and Simulation (M&S) development has neither been as frequent nor as effective as it could be; as a consequence, the potential benefits of reuse to the DoD M&S enterprise have yet to be fully realized. Improvements in the enterprise culture and processes supporting reuse are needed to increase the frequency of reuse. This subtask focused on barriers to reuse associated with these mechanisms, and how infrastructure, processes, and incentives for reuse could be improved to address these barriers.

As defined in this study, DoD M&S asset reuse mechanisms include repositories, registries and catalogs, with the following applicable definitions: (1) a Catalog is a system that accepts, stores, and provides access to discovery metadata for assets; (2) 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; (3) 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. Additional information on the definitions used as part of this effort and the methodology employed to develop a reuse lexicon has been reported in (Petty, 2010).

An assessment of multiple existing asset reuse mechanisms was conducted using a carefully developed set of M&S-oriented evaluation criteria to identify where enhancements are needed. The Asset Reuse 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 their applicability to LVC asset reuse.

Figure 4 depicts a conceptual overview of the model of LVC Asset Reuse mechanisms developed as part of this effort. This model was further detailed in the form of UML activity diagrams consisting of twenty-two (22) use cases. This model was linked to the DoD Net-Centric Data Strategy and commercial standards for repository evaluation. Stakeholder information and feedback from the various communities enabled by M&S was solicited in the form of questionnaires, workshop discussions, and interaction in the government-industry profession. A detailed description of the use cases and criteria developed as part of this effort has been reported in (Riggs, 2010)

Three complementary approaches to improve LVC Asset Reuse mechanisms were defined and evaluated: (1) a Transactional Approach that addresses the utilization of store-and-forward mechanisms and associated discovery processes to foster reuse of LVC M&S assets; (2) a Social Marketing Approach that emphasizes cultural barriers to LVC M&S reuse and the means to overcome those barriers; and (3) a Process-based Approach that addresses 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 advantage of 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. A repository or catalog seeks to protect the M&S resources by limiting only those authorized to access it. A repository, registry, or catalog that allows 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.

The Social Marketing Approach focuses on the long-term improvement of behaviors that promote reuse of M&S assets. This 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 in social networks. It should be noted that Social Marketing is distinct from social networks that are a cultural phenomena that can be exploited to perform social marketing.

The Process-Based Approach is based on enhancing existing standard systems and software development process models, or defining and implementing these models for M&S development so as to emphasize opportunities, methods, and advantages for reuse. Overarching enterprise wide process improvements aimed at increasing reuse are needed, not simply incremental program-by-program practices. While a straightforward enterprise-wide mandate may be attractive to some decision makers, history has shown that DoD mandates (e.g., Ada) have not been as effective as hoped. Instead, it may be more effective to encourage and enable reuse by including it within the M&S community's best practices for development.

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.

These three approaches were evaluated in terms of desirability, achievability, and affordability, as well as the likely barriers to their success. 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.

CONCLUSIONS

The LVC Common Capabilities team has taken the next step in the evolution of the LVCAR, translating the recommendations in the LVCAR into detailed, actionable implementation plans. The team is now engaged in the execution of these implementation plans for the purpose of delivering useable and useful products to the LVC community.

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