Improving the Systems Engineering of Live- Virtual-Constructive (LVC) Simulations

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Presentation Outline

- Background
- Overview of the LVCAR Implementation Effort
- Prototyping LVC Simulation Standards
- Advancing the Reuse of LVC Simulation Assets
- Increasing the Commonality of Data Storage Formats
- Improving the Use of Gateways and Bridges for LVC Simulations
- LVC Architecture Convergence – Perhaps a Bridge Too Far
- Investigating the Application of Additional Technologies to LVC Simulations
- The Way Ahead
- Acknowledgments
- References

Background

- The Live-Virtual-Constructive Architecture Roadmap (LVCAR) study effort was completed in 2008
  - Purpose: “Develop a future vision and supporting strategy for achieving significant interoperability improvements in LVC simulation environments.”
- The principal aims of LVCAR Implementation (LVCAR-I) are to explore organizational and structural (e.g., use of standards) options to better:
  - manage LVC architecture interoperability;
  - create reference models to focus data and service reuse efforts;
  - reduce LVC architecture divergence and tool proliferation; and
  - explore emerging technology issues related to future LVC architecture performance and requirements.

Background: Overview of LVCAR-I Efforts

	Core Task	Affiliated Task	Supporting Task
Standards Development	Systems Engineering Process		
	Federation Agreement Templates		
	Reusable Development Tools		
	Asset Reuse Mechanisms		
Software Development	Common Gateways & Bridges	Joint Composable Object Model	
	Architecture Convergence		
Studies	Management – Product Transition Strategy	Management Organizations and Processes	SOA Concepts
			LVC Futures
Outreach	Core Task Workshops	Management Workshops	M&S Forums Presentations
			Working Group Presentations
			Web-based Information

Addressed in this presentation

Overview of the LVCAR Implementation Effort

- LVCAR-I efforts are grouped into four major technical areas:
  - LVC Common Capabilities
  - LVC Gateways and Bridges
  - LVC Architecture Convergence
  - LVC Future-Oriented Efforts
- From a functional perspective, these technical areas can be reformulated into six major objectives:
  - Prototyping LVC Simulation Standards
  - Advancing the Reuse of LVC Simulation Assets
  - Increasing the Commonality of Data Storage Formats
  - Improving the Use of Gateways and Bridges for LVC Simulations
  - Investigating LVC Architecture Convergence
  - Investigating the Application of Additional Technologies to LVC Simulations

Prototyping LVC Simulation Standards: The DSEEP Multi-Architecture Overlay (DMAO)

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 (1 issue)
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 issue)**

Prototyping LVC Simulation Standards: The Federation Engineering Agreements Template

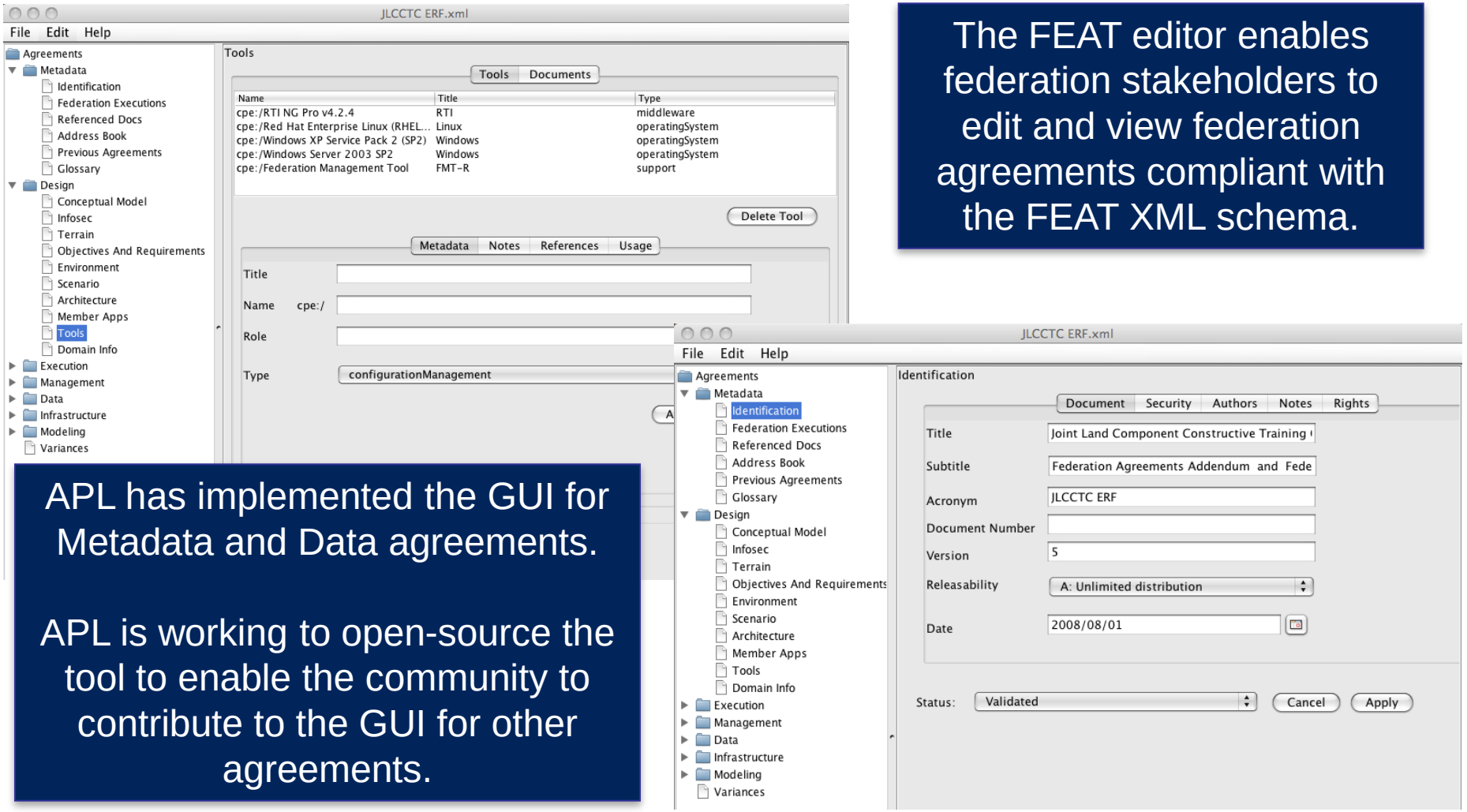
Schemas Leveraged

- Modeling and Simulation (M&S) Community of Interest—Discovery Metadata Specification (MSC-DMS)
- XML Linking Language (XLink)
- XML Metadata Interchange (XMI)
- Common Platform Enumeration (CPE)
- Intelligence Community Information Security Marking (IC-ISM)
- eXtensible Configuration Checklist Description Format (XCCDF)
- Geography Markup Language (GML)

Federation Agreement Categories

- 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
- Management—Systems/software engineering and project management
- Data—Agreements about structure, values, and semantics of data to be exchanged
- Infrastructure—Technical agreements about hardware, software, network protocols, and processes for implementing infrastructure
- 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

FEAT Editor Tool

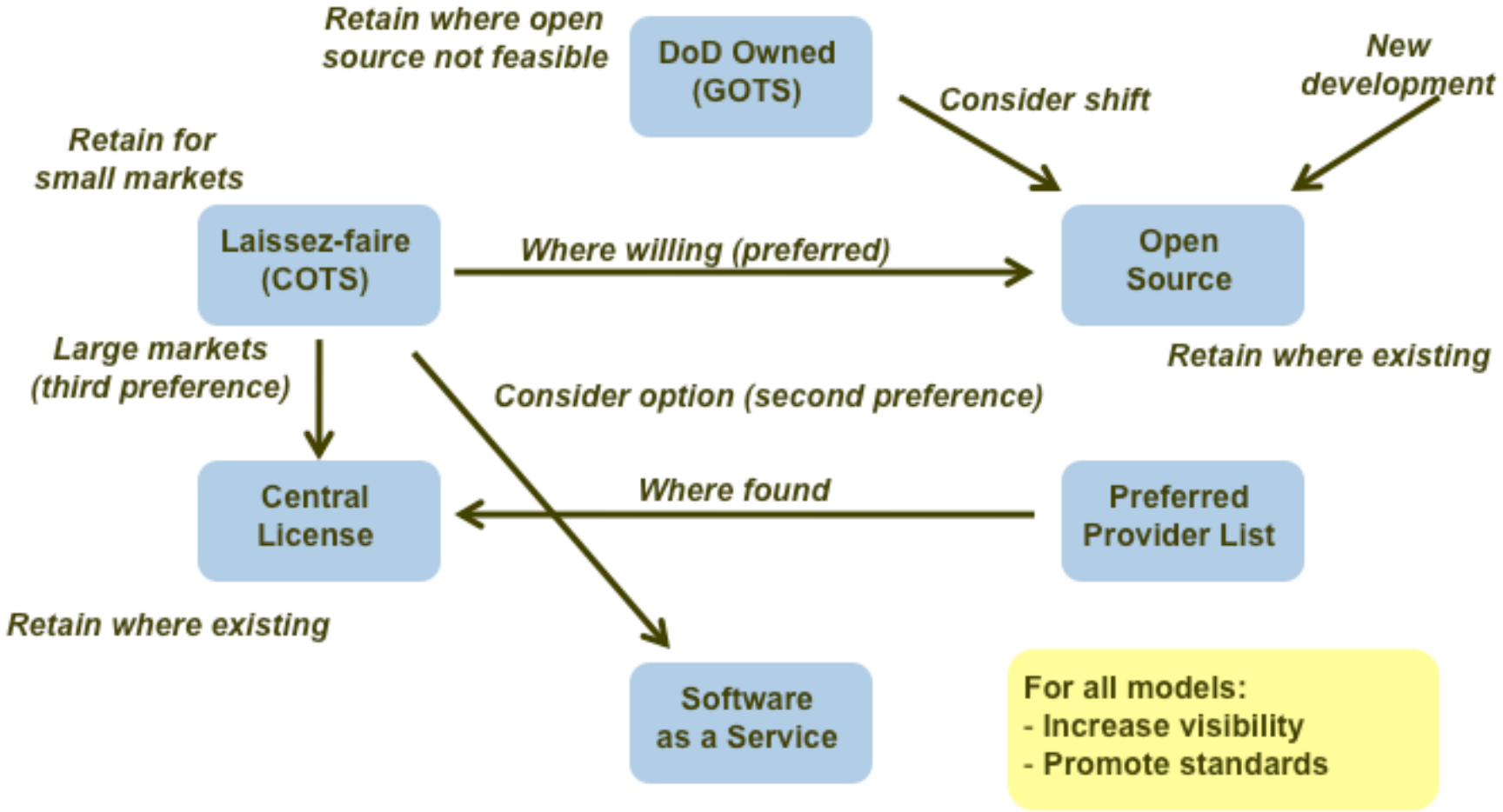


The FEAT editor enables federation stakeholders to edit and view federation agreements compliant with the FEAT XML schema.

APL has implemented the GUI for Metadata and Data agreements.

APL is working to open-source the tool to enable the community to contribute to the GUI for other agreements.

Advancing the Reuse of LVC Simulation Assets: Investigation of Alternative Business Models

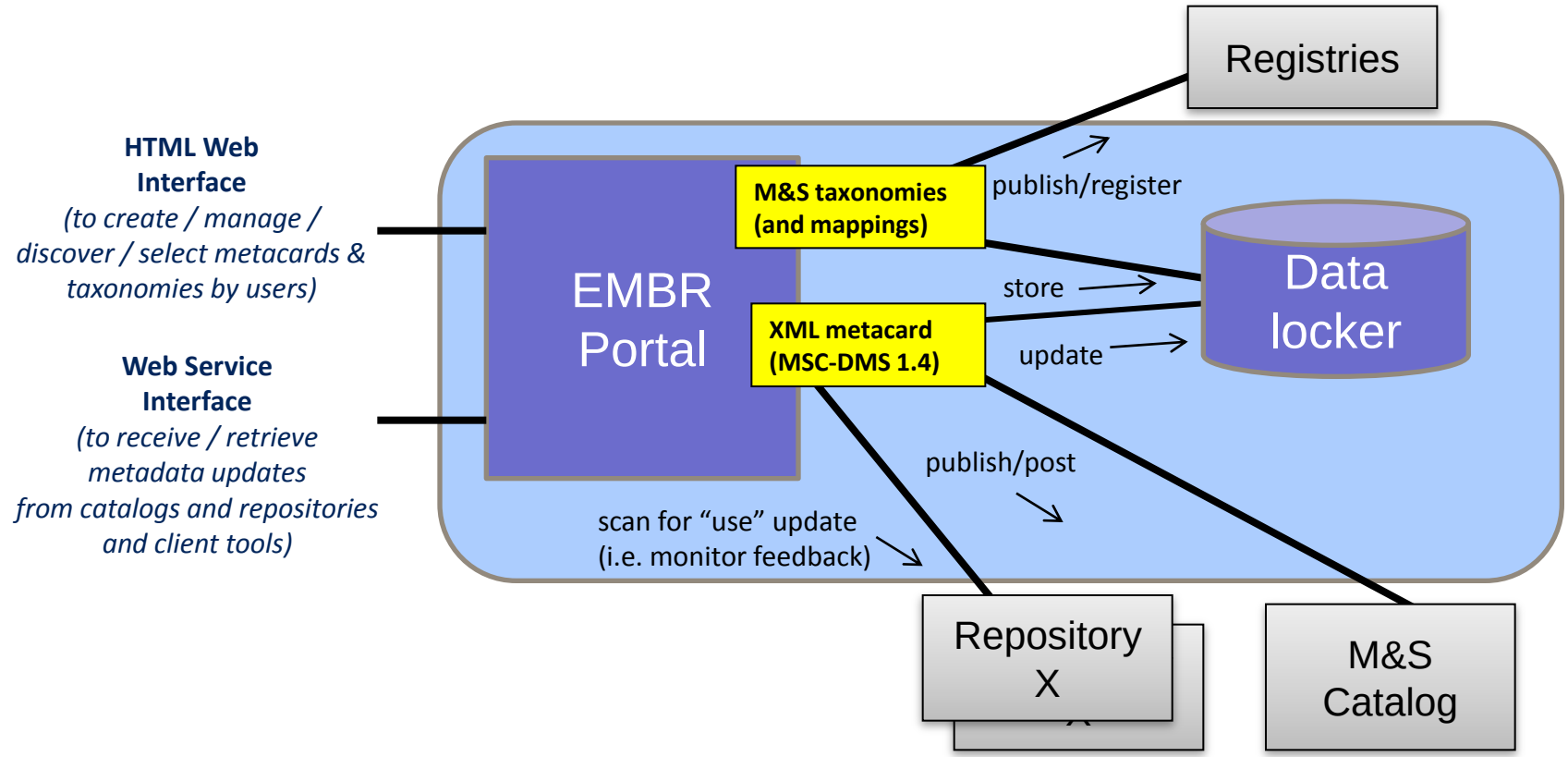


Advancing the Reuse of LVC Simulation Assets: LVC Simulation Asset Reuse Mechanisms

Alternative Approaches that Influence Reuse

- **Transactional Mechanisms**
  - Integration of distributed M&S catalogs, registries and repositories that makes assets available and discoverable
- **Social Marketing Mechanisms**
  - Utilization of social networking and collaboration mechanisms that help affect reuse behavior
- **Process-Based Mechanisms**
  - Application of standard process models that help influence interoperability and contribute to effective reuse

Advancing the Reuse of LVC Simulation Assets: The Enterprise Metacard Builder Resource (EMBR)



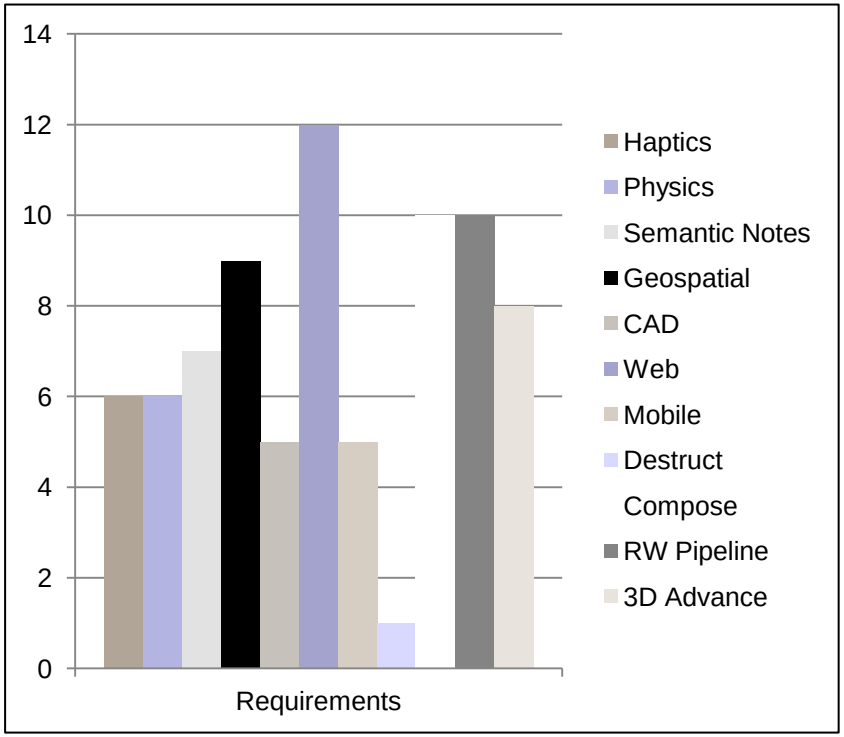
The EMBR Portal supplements M&S Catalog capabilities, providing a means for M&S producers and consumers to collaborate on metadata content and to exchange information and feedback on M&S usage.

Increasing the Commonality of Data Storage Formats: Technical Approach

- **Identified nine categories of data storage formats**
  - **Geospatial data (including METOC and air/space)**
  - **Manmade environmental features (e.g., 3D models)**
  - **Unit order of battle/force structure (including manning and readiness)**
  - **Electronic order of battle/network**
  - **Platform/weapons performance and/or characteristics**
  - **Plans/scenarios (including TPFDD)**
  - **Behavior (including organizational and individual)**
  - **Logistics**
  - **Event (testing, training, analysis, etc.) results**
- **Prioritized continuing work as follows:**
  - **Priority 1: Manmade features and event results**
  - **Priority 2: Geospatial**
  - **Priority 3: Unit Order of Battle (UOB) and Plans / scenarios**
  - **Priority 4: Platform/weapons performance and behavior**
  - **Priority 5: Electronic Order of Battle (EOB)/network and logistics**

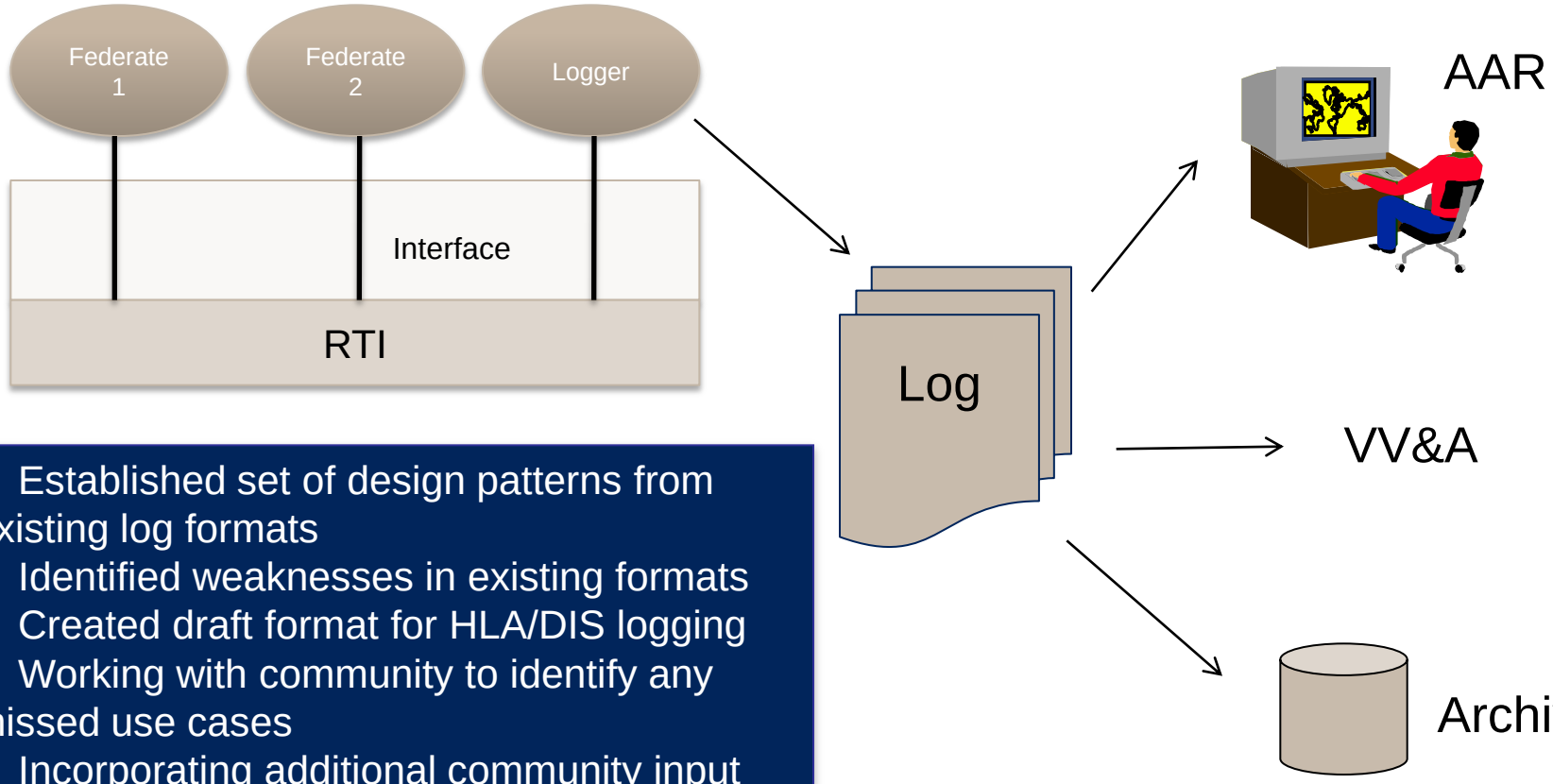
3D Manmade Features

- Identified requirements based on previous research/workshops
- Matched requirements to capabilities in the formats previously identified



- Identified conforming format (X3D)
- Identified needed extensions
- Working with COI to implement and integrate extensions within standard
- Publishing study results

Event Logging

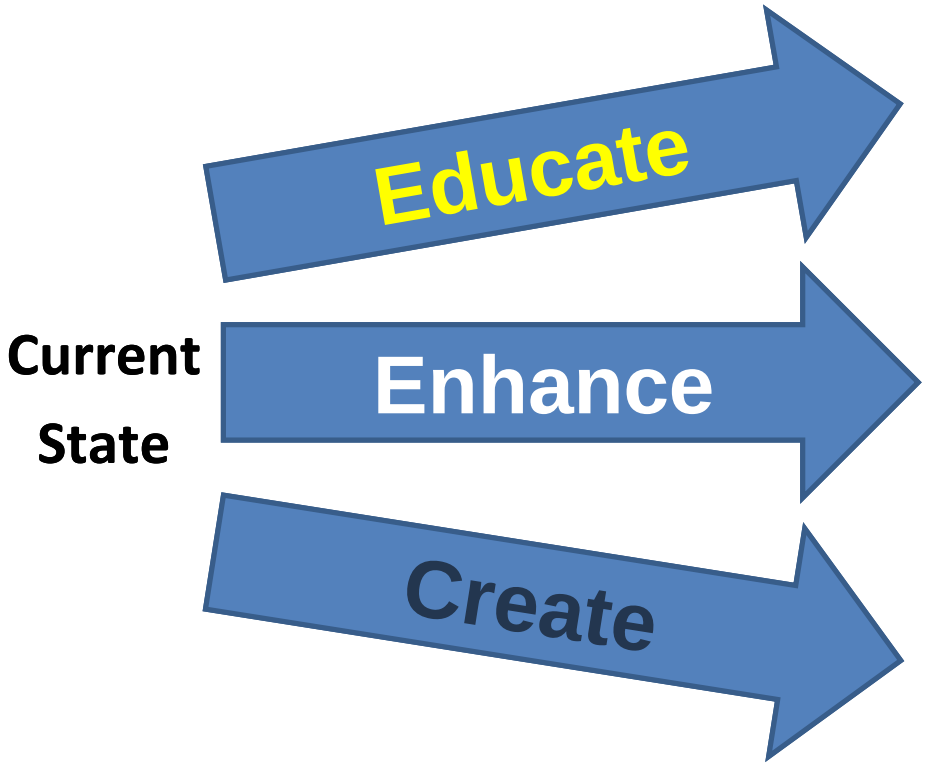


- Established set of design patterns from existing log formats
- Identified weaknesses in existing formats
- Created draft format for HLA/DIS logging
- Working with community to identify any missed use cases
- Incorporating additional community input

Improving the Use of Gateways and Bridges: Gateway Challenges

- Gateways provide the most widely used means of addressing interoperability concerns in multi-architecture LVC environments
- Despite the many documented success stories associated with the use of gateways to facilitate LVC interoperability, there are also some significant issues that impact technical, schedule, and cost risk
- Examples of known gateway issues include:
  - No central "marketplace" of gateways
  - Gateways built for specific needs
  - Broad proliferation of gateways
  - Developer or integrator lock-in

Improving the Use of Gateways and Bridges: Strategy Dimensions



- Tutorials
- Classes
- Help Desk

- Machine-readable gateway languages
- Architecture-neutral SDEM representation
- Performance Benchmarks

- Fund existing & enhance
- Fund new
- New business models

Looking for the "sweet spot" that addresses the issues in a timely fashion, for reasonable cost, enacts positive change that is long-lasting, and has a credible business model

Selected the "Enhance" Strategy, along with an element of the "Educate" Strategy

LVCAR-I Gateways Effort: Completed Product Development Activities

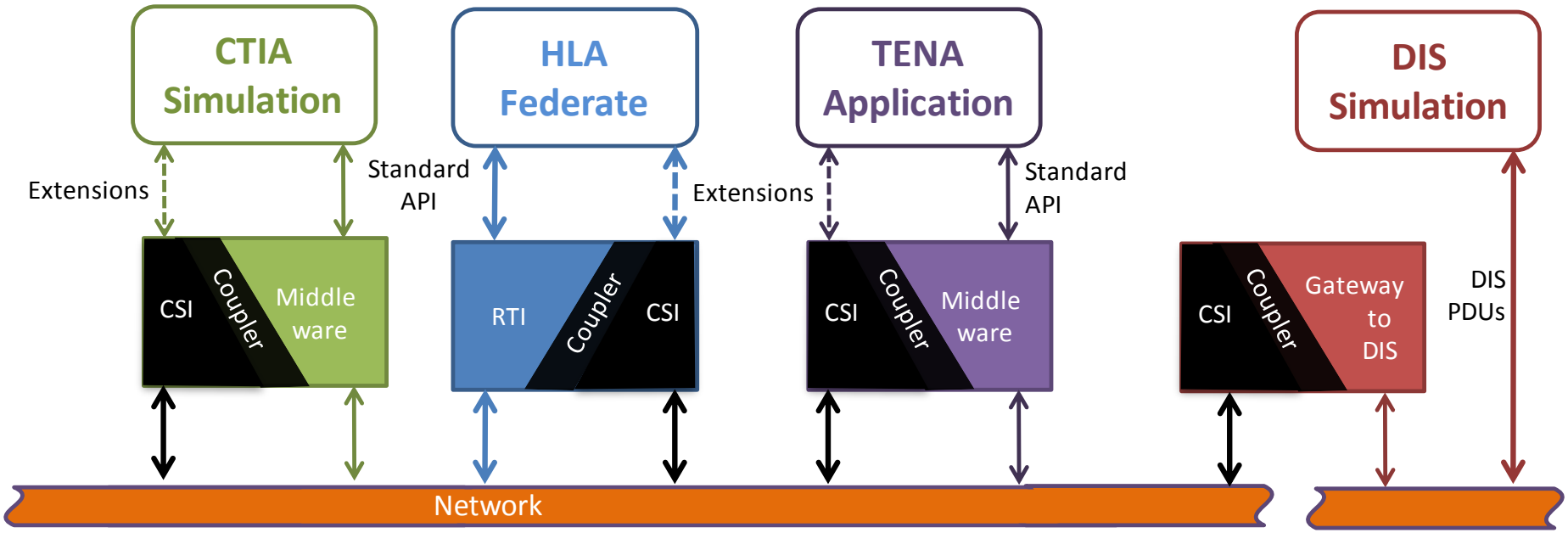
- Developed a ***Gateway Configuration Model*** that identifies an explicit set of gateway requirements, and discusses how the emerging gateway products and processes will address those requirements
- Developed a ***Gateways Capability Description*** document, which formally delineates the various capabilities that individual gateways can offer to user programs, along with specific levels of implementation for each unique capability
- Assessed the *Architecture-Neutral Data Exchange Model* (ANDEM), originally developed by the Joint Composable Object Model (JCOM) Program, to support Simulation Data Exchange Model (SDEM) mapping and/or translation in gateways
- Developed a set of ***Gateway Performance Benchmarks*** (GPBs) to identify specific gateway performance measures, along with use cases that describe how and where these measures should be applied

LVCAR-I Gateways Effort: FY11-Funded Product Development Activities

- Development of a common ***Gateway Description Language*** (GDL), in a machine-readable format/syntax, for describing both user gateway requirements and the capabilities that individual gateways can offer
  - Supports user discovery of needed gateway capabilities
- Development of a common ***SDEM Mapping Language*** (SML) to formalize format and syntax of mappings between different SDEMs
  - Reduces number of required mappings, and supports reuse of mapping data
- Development of a repository for GDL-based gateway descriptions. Incorporate applicable search and requirements-to-capabilities matching algorithms
- Development of tools for GDL and SML file creation/editing
- Development of SML Translators for selected gateways
  - JBUS, GWB are likely choices
- Socialization of draft GPBs with gateway developer organizations, incorporation of feedback, and preparation of formal specification
- Development of a Gateways tutorial

LVC Architecture Convergence – Perhaps a Bridge Too Far

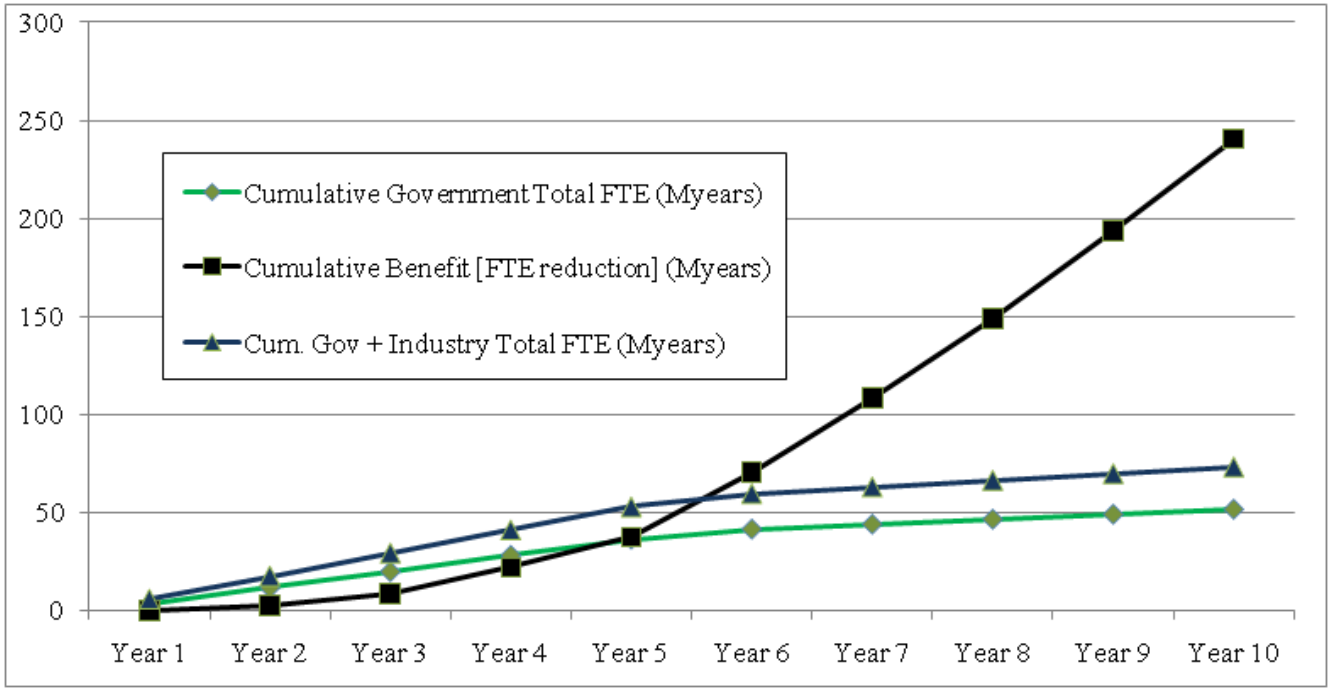
An Envisioned Converged Architecture



LVC Architecture Convergence – Perhaps a Bridge Too Far

Return on Investment (ROI) Estimate

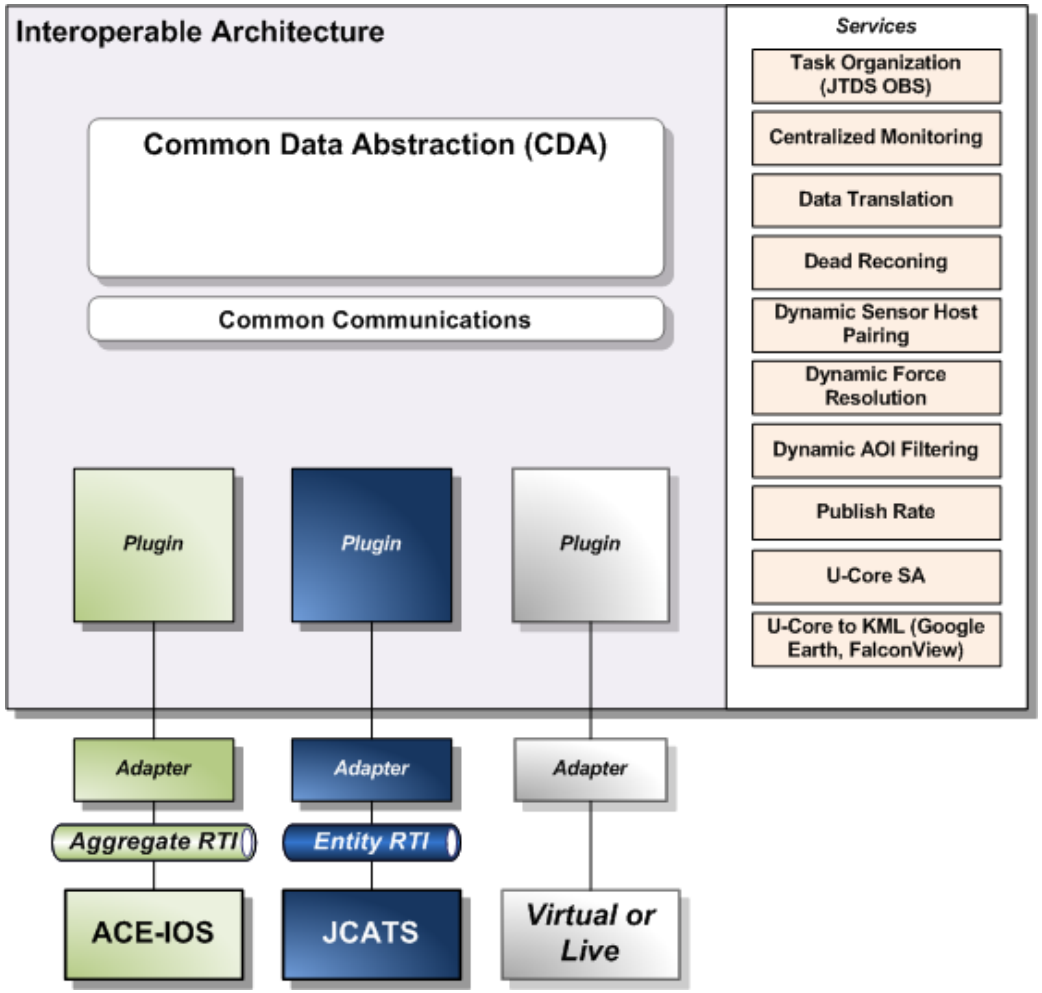
Better ROI is provided through a slower, multi-year development process that gradually builds confidence in the new approach.



Investigating the Use of Service-Oriented Architectures (SOAs) in LVC Simulations

- **Benefits of Employing SOA in LVC Distributed Simulations**
  - Positive aspects to leveraging multiple contributors to the LVC simulation
  - Addresses a systemic need for agility in deployment and execution
  - Aids implementation through use of well-defined encapsulation
  - Designed for composability and reuse of distributed simulation components
  - Allows use of more business models, such as Software-as-a-Service (SaaS)
- **Barriers to Employing SOA in LVC Distributed Simulations**
  - Uncooperative competing factions can stall governance agreements
  - Budget, time, and scope constraints on project
  - Actual or perceived lack of need for deployment and execution flexibility
  - Actual or perceived performance requirements
  - Existing LVC simulation infrastructure is extremely brittle, limiting upgrade
  - Difficulty in acceptance within M&S community

Applying SOAs in LVC Simulations: SOA Pilot Effort (MITRE)



Investigating "LVC Futures" – Five Scenario Vignettes and Nine Technology Categories

Implementation

- Mobile computing and augmented reality
- Ubiquitous surveillance and automated reasoning
- Event-model driven architectures
- Self-healing / self-managing systems
- M&S social graph

Socialization and adaptation

- Crowd-sourcing
- Mashup software and FIST (Fast, Inexpensive, Simple, Tiny)
- Cloud encapsulation
- Everything is a game

The Way Ahead

- Standards
  - The DMAO is expected to become an IEEE standard
  - The FEAT is expected to become a SISO standard
  - The FEAT tool to aid users in implementing the FEAT is expected to become a complete open-source product
- Lessons learned in the exploration of alternative business models will be documented
- Common data storage format advances will be solidified in several areas, including 3D data formats and event logging
- Gateways
  - Users will have automated tools at their disposal to aid in discovering appropriate gateways for specific uses
  - Common components for SDEM translation will be completed
  - Building on the EMBR portal, an LVC asset reuse repository will be available to support LVC gateway discovery and reuse

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- Mikel Petty (UAH)
- Wes Milks (LMCO)
- Bob Murray (Boeing)
- Ed Powell (SAIC)

Other Organizations with Representatives at LVCAR-I Workshops (selected):

- DISA
- SPAWAR
- USJFCOM
- PEO STRI
- M&S CO
- NMSO
- AMSO
- UK MOD
- Army RDECOM
- IDA
- CNA
- MSIAC
- CAE USA
- Saab
- CACI
- Northrop Grumman
- Raytheon

References

- "Live-Virtual-Constructive (LVC) Architecture Roadmap Implementation Workshop," *2010 Spring SIW*
- "Live Virtual Constructive (LVC) Common Capabilities," *2010 I/ITSEC*
- "Emerging Solutions for LVC Asset Reuse," *2011 Spring SIW*
- "LVC Common Gateways and Bridges," *2010 I/ITSEC*
- "Gateway Concepts for Enhanced LVC Interoperability," *2011 Spring SIW*
- "LVCAR Enhancements for Selecting Gateways," *2011 Spring SIW*
- "LVCAR Enhancements for Using Gateways," *2011 Spring SIW*
- "Live Virtual Constructive Architecture Roadmap (LVCAR) Convergence Approaches," *2010 I/ITSEC*
- "Future Technologies and Processes and their Impact in the Domain of Live-Virtual-Constructive Architectures," *2011 Spring SIW*

Questions and Feedback