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

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James E. Coolahan, Ph.D.
Johns Hopkins University
Applied Physics Laboratory
11100 Johns Hopkins Road
Laurel, MD 20723-6099
240-228-5155
James.Coolahan@jhuapl.edu

Gary W. Allen, Ph.D.
Joint Training Integration and Evaluation Center
12000 Research Parkway, Suite 300
Orlando, FL 32826
407-208-5607
gary.allen@us.army.mil
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

| Standards Development | Core Task | Affiliated Task | Supporting Task |
|-----------------------|-----------|-----------------|-----------------|
| Systems Engineering Process | | | |
| Federation Agreement Templates | | | |
| Reusable Development Tools | | | |
| Asset Reuse Mechanisms | | | |

| Software Development | Core Task | Affiliated Task | Supporting Task |
|-----------------------|-----------|-----------------|-----------------|
| Common Gateways & Bridges | | Joint Composable Object Model | |
| Architecture Convergence | | | |

| Studies | Core Task | Affiliated Task | Supporting Task |
|---------|-----------|-----------------|-----------------|
| Management – Product Transition Strategy | | Management Organizations and Processes | SOA Concepts |
| | | | LVC Futures |

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

*Note: Issues indicated in parentheses.*
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
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

- **Laissez-faire (COTS)**: Retain where open source not feasible; Large markets (third preference)
- **DoD Owned (GOTS)**: Consider shift
- **Open Source**: New development
- **Preferred Provider List**: Retain where existing
- **Central License**: Consider option (second preference)
- **Software as a Service**: For all models:
  - Increase visibility
  - Promote standards
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

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
An Envisioned Converged Architecture
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

**“Cave Dive”**
Intervention into civil war that soon may spill over border into allied country.

**“Sequoia Ring”**
Humanitarian Aid, Stability in response to natural disaster.

**“Relay Exchange”**
Continued long-term COIN / Stability operation in fragile state.

**“Urgent Extreme”**
Conventional small war to restore overthrown democracy.

**“Electronic Egret”**
Cyber attack by near-peer nation against joint effort with allied nation.

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**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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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
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- “LVCAR Enhancements for Selecting Gateways,” 2011 Spring SIW
- “LVCAR Enhancements for Using Gateways,” 2011 Spring SIW
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- “Future Technologies and Processes and their Impact in the Domain of Live-Virtual-Constructive Architectures,” 2011 Spring SIW
Questions and Feedback