Live Virtual Constructive Architecture Roadmap (LVCAR) Comparative Analysis of Standards Management

Margaret Loper (GTRI)

Dannie Cutts (AEgis)

September, 2008

Cleared for public release (Distribution A) by the DoD Office of Security Review (Case No. 09-S-2414) / M&S CO Project No. 06OC-TR-001

List of Acronyms

AMG	Architecture Management Group
AMT	Architecture Management Team
API	Application Programmers Interface
CONOPS	Concept of Operations
CTIA	Common Training Instrumentation Architecture
DIS	Distributed Interactive Simulation
DOD	Department of Defense
DODAF	Department of Defense Architecture Framework
FEDEP	Federation Development and Execution Process
FOM	Federation Object Models
HLA	High Level Architecture
IDL	Interface Description Language
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IPR	Intellectual Property Rights
ISO	International Organization for Standardization
JNTC	Joint National Training Capability
JTEM	Joint Test and Evaluation Methodology
LVC	Live Virtual Constructive
LVCAR	Live Virtual Constructive Architecture Roadmap
MOU	Memorandum of Understanding
M & S	Modeling and Simulation
NATO	North Atlantic Treaty Organization
OM	Object Model
OMG	Object Management Group
PFP	Partnership for Peace
SEDRIS	Synthetic Environment Data Representation and Interchange Specification
SDO	Standards Developing Organizations
SISO	Simulation Interoperability Standards Organization
SOA	Service Oriented Architecture
SSO	Standards Setting Organizations
TDL	TENA Definition Language
TENA	Test and Training Enabling Architecture
UML	Unified Modeling Language
W3C	World Wide Web Consortium
XML	Extensible Markup Language

Table of Contents

List of Figures

List of Tables

Executive Summary

A number of distributed simulation architectures are commonly used today. Each was developed by specific user communities and each owes much of its success to well defined standards. Unfortunately, live, virtual, and constructive (LVC) federates that choose different architectures can't natively interoperate. The overarching LVC study is defining a proposed “way ahead” for improved interoperability across the major distributed simulation architectures and protocols. This component of the study deals with standards development, including the associated standards organizations and standards development processes that will best meet the needs of the broader LVC distributed simulation community. This appendix provides a comparative analysis of those findings.

The methodology applied in the standards study took the existing LVC standards, characterized their current state, and defined an “idealized” model against which they could be compared. The standards study began by examining the various types of standards (de jure, de facto, proprietary, and open), the organizations responsible for those standards (standards developing, standards setting, and consortia), and process attributes (governing body, meeting organization, source of authority, and standards creation) used to develop, maintain and evolve standards.

The next step in the study was to characterize the current state of the existing LVC architectures in terms of their standards, organizations, and processes. A detailed comparison was done for DIS, HLA, and TENA. The study also examined organizations and processes outside the M&S domain to determine whether they were applicable to future LVC standards. One key distinction that emerged from this comparison was the view of “commercial vs. government” organizations. Commercial refers to standards created in open forums outside of government control; government refers to standards created in forums under government control.

Characteristics of an idealized future state were derived using the external vs. internal view points and several key process characteristics. This analysis resulted in four candidate courses of action (COAs) characterizing a potential solution space for LVC standards evolution and management:

- COA 1: Continue with the existing LVC organizations and processes already in place.
- COA 2: Focus the LVC community on using a government organization for developing standards.
- COA 3: Focus the LVC community on using a commercial organization for developing standards.
- COA 4: Focus the LVC community on using both government and commercial organizations for developing standards.

The remaining work for the standards study team will focus on defining the idealized future state based on the proposed characteristics, refining the COAs, considering them in the context of the architectural COAs, and vetting the future state and COAs through the larger workshop process. These tasks will then be used to propose a way forward for the desired LVC standards organization and process.

1 Introduction and Overview

Standardization involves the use of common products, processes, procedures, and policies to facilitate attainment of business objectives[1]. Standardization is about enabling interoperability, which is a fundamental objective of all stakeholders, be they policy-makers, industrial players or users. Numerous commercial initiatives in a variety of different economic sectors owe their success to a commitment of the stakeholders to join forces to agree on open specifications for interoperable systems. Since the earliest days of distributed simulation, standards have played a crucial role in achieving interoperability.

The LVC distributed simulation standards in place today are Distributed Interactive Simulation (DIS), High Level Architecture (HLA), Test and Training Enabling Architecture (TENA), and Common Training Instrumentation Architecture (CTIA). There are various means to establish standards, and the communities responsible for these LVC standards have chosen different approaches. The standards study team has been evaluating these approaches in order to make a recommendation regarding a standardization approach for future LVC architectures.

The goals of the standards study team include:

1. Compare and contrast each of the standards development and evolution processes for the four LVC architectures being examined (CTIA, DIS, HLA, and TENA).

2. Classify the types of LVC standards currently used by each community.

3. Identify certification and testing methodologies used by each of the five LVC architecture standards.

4. Identify other standardization approaches to be considered in arriving at the LVC Architecture Roadmap's (LVCAR) recommended approach.

2 Problem Definition

The process being used to analyze the potential Courses of Action (COAs) for future LVC standards evolution and management is shown in Figure 2.1. The M&S architectures we are considering include DIS[2], HLA[3], TENA[4], and CTIA[5]. Using these models, we assess the current state of LVC standards and management in terms of their standards and products, standards organizations, and standards processes. Information for this assessment was collected from literature reviews, workshops, surveys and from the Expert Team.

The vision state was developed from discussions with the Expert Team. Desirable attributes of future LVC standards development should include: an open standards approach; a process that is responsive to evolving requirements; an organizational structure that enable the DOD to put forward requirements for standardization, and international recognition.

The remainder of this report describes the information collected by the standards study team and how that information was analyzed to create a set of COAs for future LVC standards evolution and management.

[1] http://www.ieee.org/portal/cms_docs/iportals/education/setf/glossary.html
[2] http://www.sisostds.org/ and http://en.wikipedia.org/wiki/Distributed_Interactive_Simulation
[3] http://www.sisostds.org/ and http://en.wikipedia.org/wiki/High_level_architecture
[4] https://www.tena-sda.org/
[5] http://www.peostri.army.mil/PRODUCTS/CTIA/home.jsp

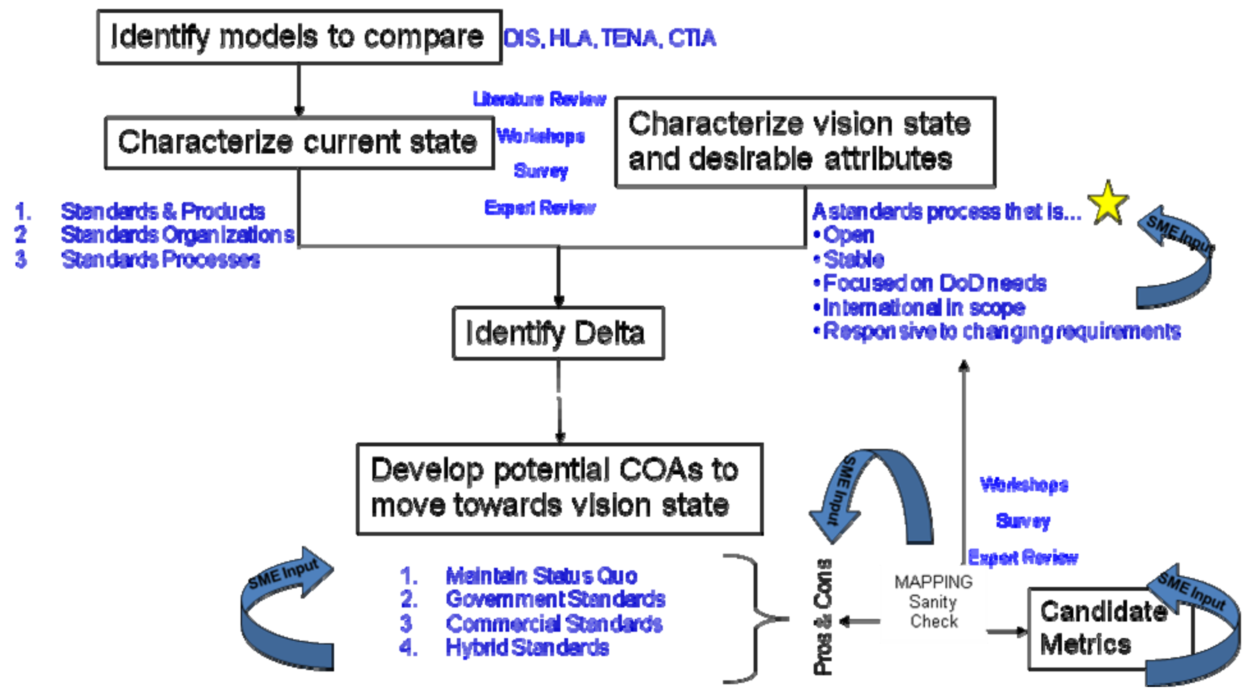

Figure 2.1 Analytic Framework for Standards Evolution and Management

3 Characterize the Current State

The current state attributes of interest are: 1) the types of LVC standards currently used by the community; 2) organizations involved in LVC standardization; and 3) LVC standards processes currently in use.

3.1 Standards and Products

During workshop #2, a list of information products were presented to workshop participants. The information product list was derived from reviewing the HLA systems engineering process model standard, the Federation Development and Execution Process (FEDEP). The list contained 24 individual products important for achieving interoperability among distributed simulations. Workshop participants reviewed the list and separated them into two parts: those products that were "in-scope" of this study and those products that, although important, were "out-of-scope" for this study. The information products deemed in-scope are shown in Table 3.1.

A goal of the information product exercise was to understand what de jure standards[6] have been created by each simulation community for these categories, and whether other de facto[7] or proprietary[8] standards have been used. For DIS, HLA, TENA, and CTIA this information is shown in Table 3.2. This table reflects the data gathered at Workshop #2 and via email exchange with CTIA project personnel. It should not be considered a complete characterization of all products developed by these architectures.

[6] De Jure standard: endorsed by a standards organization
[7] De Facto standard: widely used, but not endorsed by a standards organization
[8] Proprietary standard: belongs to an entity that exercises control over the standard

Table 3.1 LVC "In-scope" Information Products

Information Product
Object Model (Format)
Object Model (Content)
Service Specification
Architecture Specification and Rules
Security Requirements and Plan
Enumerations
Standard Algorithms
Data Logging / Collection Strategy
Federation Management (Systems Engineering Process)

As seen in Table 3.2, standards have been created in all categories except security requirements and data logging and collection. Significant amount of work has been accomplished in object model format, service specification, architecture specification and rules, and federation management.

In these categories, the standards DIS, HLA, TENA, and CTIA have created are de jure, being developed under the Institute of Electrical and Electronics Engineers (IEEE), Architecture Management Team (AMT), or CTIA Architecture Change Board (ACB) processes. The only exceptions are object model (OM) content, where many of the standards fall into the de facto or proprietary realm, and algorithms, where many are considered de facto.

The analysis also revealed that the LVC community uses a number of standards from other communities to help solve interoperability problems. These include Extensible Markup Language (XML), Unified Modeling Language (UML), Interface Description Language (IDL), Department of Defense Architecture Framework (DODAF), and Synthetic Environment Data Representation and Interchange Specification (SEDRIS). The SEDRIS[9] infrastructure technology program has a history similar to the distributed simulation programs being evaluated in this study. As such, we will also consider this family of standards when evaluating process and standards organizations.

3.2 M&S Standards Organizations

For the purposes of this report, we will classify M&S standards organizations into two types: government and commercial. Government refers to standards forums under US Government control. Examples of this are the HLA Architecture Management Group (AMG), TENA AMT and the CTIA ACB. These types of standards organizations are typically composed of systems engineers and technical leads of major DOD stakeholders of the architecture. They discuss requirements, design trade-offs and issues associated with the architecture. These standards organizations also have contractor support that is responsible for architecture design and prototyping. Simulation-related standards that have been created using this approach include TENA and CTIA.

Commercial refers to standards created in open forums outside of government control. Examples of this include the IEEE, Simulation Interoperability Standards Organization (SISO), International Organization for Standardization (ISO), and the Object Management Group (OMG). These types of organizations are composed of users, vendors, academics, and developers of the architecture. Like government forums, they discuss requirements, trade-offs, and other issues associated with the architecture. However, they do not have contractor support for architecture design and prototyping. Instead, these forums rely on members to develop prototypes and provide technical feedback on the architecture specifications.

[9] http://www.sedris.org/ and http://en.wikipedia.org/wiki/Sedris

Table 3.2 Information Products Standardized by the LVC Architectures

Information Product	DIS	HLA	TENA	CTIA
Object Model (Format)	Text, XML	IEEE 1516.2	TDL, UML with TENA profile	CORBA IDL – Wire Protocol OM API – Use of XML for CTIA OM
Object Model (Content)	PDUs, IEEE 1278.1	RPR, MATREX, JLVC, JMRM, Link16 BOM, JLCCTC/ MRF and ERF, NASMP, NTF	TENA Std OMs, JNTC OM	CTIA IDL, CTIA xml datamodel for CTIA Object Model
Service Specification	IEEE 1278.1	IEEE 1516.1	Metamodel + API Spec	Product Line Architecture Specification – LT2
Architecture Specification and Rules	IEEE 1278.1, DIS Vision document	IEEE 1516	ARD	Product Line Architecture Specification – LT2
Security Requirements and Plan				
Enumerations	SISO-REF-010-2006	RPR FOM, SISO-REF-010-2006	Object Model	CTIA IDL, CTIA XML CTIA OM
Standard Algorithms	Dead Reckoning, heart beat		Shared algorithms in OM	SEDRIS Coordinate Conversions
Data Logging / Collection Strategy				CTIA Database Schema - RDBMS
Federation Management (SE Process)	IEEE 1278.3	IEEE 1516.3	CONOPS, JTEM	LT2_Developers_Guide – L2 Portal

Commercial refers to standards created in open forums outside of government control. Examples of this include the Simulation Interoperability Standards Organization (SISO), Institute of Electrical and Electronics Engineers (IEEE), International Organization

Another model of standards development that has been successfully used for LVC architectures is a combination of government and commercial organizations. This was demonstrated with the first set of HLA standards. The AMG was responsible for developing and evolving the early versions of the HLA specifications. This enabled DOD stakeholders to include requirements and provide technical feedback resulting from their programs. Once they reached a point of maturity, the HLA specifications were transferred to SISO and went through the IEEE standardization process. The HLA standards were also taken to OMG to be standardized. Similarly, the SEDRIS standards were initially developed as government standards and then taken to ISO for standardization. Using IEEE, OMG, and ISO enabled the standards to receive a broader commercial review. Simulation-related standards that have been created using this approach include DIS, HLA and SEDRIS.

There are three main standards developing organizations in the LVC community today: the AMT, which develops TENA standards, the ACB, which develops CTIA standards, and SISO, which develops DIS and HLA standards. In addition to these standards organizations, the DOD services each have a group responsible for coordinating standards use, both from developing object model content (i.e., FOMs) as well as endorsing standards that meet the requirements of their programs. These groups have people that participate in the AMT, ACB or SISO, but they do not have formal representation nor formal requirements generation functions for these standards developing bodies.

There are also commercial standards organizations involved in developing specifications and standards for technologies related to LVC. For example, the Internet Engineering Task Force (IETF) develops communication standards, including security; the World Wide Web Consortium (W3C) develops web-related standards such as SOAP and XML; the OMG develops modeling standards such as UML; OASIS and the Open Group have developed specifications for the service oriented architecture (SOA); and ISO has standardized SEDRIS. Thus, we have a hybrid approach to standards, encompassing the best standards and technologies from all IT-related organizations.

3.3 Government and Commercial Processes

Standards processes, regardless of whether they belong to government or commercial organizations can be described using a common set of attributes. A list of general attributes was developed from reviewing the processes of major commercial standards organizations, including IEEE, W3C, IETF, and the OMG. The attributes fall into four general categories: governing body, meeting organization, source of authority, and creation and evolution process.

- Governing body/Organizational Structure describes how an organization is related to other standards organizations, how it is governed, how the community of practice is represented and how membership is established and maintained.
- Meeting organization describes how meetings of the organization are conducted.
- Source of authority deals with the authority of the organization to develop, endorse and enforce the types of standards within the user community.
- Creation and evolution process addresses the process by which the organization creates, maintains and evolves standards.

A comparison of the two main standards developing organizations in the LVC community, SISO and AMT, are shown in Table 3.3[10]. Since SISO develops both IEEE and SISO standards, these processes have been separated to show the distinction between the two processes.

In the governing body and organizational structure category, the main differences are relationship to other standards organizations and membership entities. Membership in SISO is based on individuals where AMT membership is based on programs and DOD stakeholders. In a general sense, there are no differences in the meeting organization and source of authority categories.

Table 3.3 Comparison of Industry (SISO) and Government (AMT) Standards Processes

CATEGORY	ATTRIBUTE	SISO/IEEE	SISO	AMT
Governing Body / Organizational Structure				
	Relationships to other standards organizations	Strong ties to ISO and IEEE	Strong ties to ISO and IEEE	None
	Governing Board	BOD, Advisory and Architectural Committee	BOD, Advisory and Architectural Committee	Advisory and Architectural Committee
	Representation on Board	Elected from members	Elected from members	Equal representation by stakeholders
	On-line Presence	Yes	Yes	Yes
	Membership Entities	Individuals	Individuals	Stakeholders and organizations
Meeting Organization				

10 This comparison is based on an email exchange with Katherine Morse (SISO) and Ed Powell (TENA) and also includes information from expert team meetings.

	Attendance	Open	Open	Open
	Frequency / Regularity	Fixed	Fixed	Fixed
	Meeting Location	Varies	Varies	Varies
Source of Authority				
	Types of Standards	De Jure	De Jure, De Facto	De Jure, De Facto
	Compliance Definition	Syntax and Semantics	Syntax and Semantics	Syntax and Semantics
Standards Creation and Evolution Process				
	Introduction and Prioritization of requirements	Individuals	Individuals	Stakeholders and organizations
	Transparency of Process	Discussions, minutes, membership, votes	Discussions, minutes, membership, votes	Discussions, minutes, membership
	Committee Membership	IEEE members	SISO members	TENA Stakeholders
	What is standardized	Architecture, process	Domain, algorithms, process	Domain, architecture, algorithms, middleware, process
	Voting Eligibility	Open to all IEEE members	Open to all SISO members	Closed; stakeholders only
	Voting Fairness	Balancing eqn; Ballot resolution req't, Threshhold req't	Balancing eqn; Ballot resolution req't, Threshhold req't	No balancing, threshhold or formal resolution process
	Update Frequency	Periodic per IEEE	As needed	As needed
	Cost of Standards	Fee	Free	Free
	Approval Process	IEEE members, committee and BOD review	SISO members, committee and BOD review	Committee
	Adjudication Process	Committee and BOD	Committee and BOD	Committee

The major differences appear in the standards creation and evolution process. For SISO, these attributes are governed by formal policies and procedures which have been approved by the IEEE. It is based on being open, fair, and structured so there are no ambiguities in the process such as, the approval process, how comments are resolved, and how voting is balanced. Since the AMT is a government standards organization, they have tailored a process to support their individual requirements for standards development. This process is focused on the stakeholders needs. In this process, the architectural committee makes decisions on when the standards are updated, how voting is handled, and what is approved to go into the standards.

It is important to recognize that this is merely a comparison of two processes and should not be interpreted as making a judgment on which process is better. These processes are designed to meet different needs and requirements of the M&S community.

4 Characterize Vision State

When considering a desired vision state for LVC standards evolution and management, several questions must be addressed. First is whether to use a commercial or a government standards approach. Second is how to create a process that balances the need for stable standards with the need for responsiveness of the standards process to enable timely evolution. Lastly, we must decide whether the desired vision state is to design a single overarching standards process or whether it is to consider coexisting multiple standards processes.

4.1 Issues for Selecting an LVC standards approach

In a meeting with expert team members[11], it was recommended that the list of attributes of a standards process (Table 3.3) be simplified to include a small number of key attributes deemed important for future LVC standards evolution and management. The attributes included:

- Open Standards approach
- Commercial or Government organization
- Responsive Standards approach
- Cost or Free standards

4.1.1 Open Standards

An Open Standard is more than just a specification; the *principles* behind the standard and the *practice* of offering and operating the standard are what make the standard "open." The term "open standard" may be seen from perspectives of its stakeholders[12]:

- Organizations representing the standards creators consider a standard to be open if the creation of the standard follows the tenets of open meeting, consensus and due process.
- An implementer of a standard would call the standard open when it serves the market they wish, is without cost to them, does not preclude further innovation (by them), does not obsolete their prior implementations, and does not favor a competitor.
- The user of an implementation of the standard would call a standard open when multiple implementations of the standard from different sources are available, when the implementation functions in all locations needed, when the implementation is supported over the user-planned service life, and when new implementations desired by the user are backward compatible to previous implementations.

There are numerous definitions of an open standard by national standards bodies[13]. The definition by Ken Krechmer lists ten requirements that enable open standards:

1. Open Meeting: all may participate in the standards development process.
2. Consensus: all interests are discussed and agreement found, no domination.
3. Due Process: balloting and an appeals process may be used to find resolution.
4. Open IPR: how holders of Intellectual Property Rights (IPR) related to the standard make available their IPR.
5. One World: same standard for the same capability, world-wide.
6. Open Change: all changes are presented and agreed in a forum supporting the five requirements above.
7. Open Documents: committee drafts and completed standards documents are easily available for implementation and use.
8. Open Interface: supports proprietary advantage (implementation); each interface is not hidden or controlled (implementation); each interface of the implementation supports migration (use).
9. Open Access: objective conformance mechanisms for implementation testing and user evaluation.

[11] See expert team meeting minutes in Appendix J-6.

[12] "Open Standards Requirements", Ken Krechmer, http://www.csrstds.com/openstds.pdf.

[13] http://en.wikipedia.org/wiki/Open_standard

10. On-going Support: standards are supported until user interest ceases rather than when implementer interest declines.

A desirable process would create an open standards process for LVC. Discussions to date between members of the study team, the expert team and workshop participants have all been favorable toward an open standards process for future LVC architectures.

4.1.2 Commercial or Government Organization

A commercial process is characterized by a level of formal structure and open review. It could have wide (international) visibility, and garner a high-level of vetting. Advantages of using a commercial organization include accreditation by an international or world standards body, maintaining compatibility with international partners, technical contributions from non-US participants, and cost sharing of the standards effort. Disadvantages of using a commercial organization include lack of control by US stakeholders as well as additional complexity and length of the standards evolution process due to a formal process and external review.

Another approach is to pursue a government standards process. This approach could be a relatively informal process with limited review. Advantages include responsive approach to establishing and evolving standards. Disadvantages include limited review and limited visibility beyond the immediate community developing the standard.

Factors that influence this decision include whether an international (or world) accreditation is needed for LVC interoperability standards. The DOD does have a policy to adopt non-government standards[14] but that does not necessarily push the LVC community towards creating international standards. An important consideration, however, is whether collaboration with NATO and PfP partners and other non-DOD partners necessitates use of international standards and whether partners would be able to use government-developed standards.

Other issues with using a commercial or government organization include: whether the DOD needs to be in charge of standards that affect them, who determines the priority for the requirements that are addressed by the standards, and whether commercial companies and individuals should have a voice in what is standardized. When choosing an external organization, wider participation and review is an integral part of the process, thus the standards developed will reflect ideas outside of DOD requirements. An internal process can be designed to address only DOD needs and thus reflect only the views of its developers.

A last consideration for whether to use a commercial or government organization has to do with who "owns" the standards that are developed, including their maintenance, copyright issues, and availability. In a commercial process, the organization owns the IPR associated with the standard, and has policies and procedures that govern maintenance, copyright, and availability. In a government process, the organization has more flexibility to specify how these factors are handled, and will often tailor them to meet the needs of the user community.

A desirable process would accrue the benefits of a commercial standards organization with international recognition and would also address DOD and government requirements. This might be accomplished through a bicameral organization, where membership and voting on standards included both individual and organizational representation.

4.1.3 Responsive Process

The responsiveness of the process to allow updates and modifications to the standards is another factor to consider when choosing a path for LVC standards. Due to evolving needs and data content, it is desirable to have a process that is flexible and agile such that new requirements can be addressed and included, yet maintain stable and constant standards that are not constantly in a state of flux.

---

[14] United States Standards Strategy, 9 May 2006, http://www.dsp.dla.mil/APP_UIL/content/policy/docs/USDATL-endorses-USSS.pdf.

Most commercial standards organizations implement a periodic approach to updating standards. A typical requirement for ISO and IEEE is to renew the standard every five years (maximum period between updates) or choose to retire it. A disadvantage of mandatory periodic updates occurs if the process to update the standard is so rigid that it takes five years to complete. However, from an end-user perspective, there is a natural tension between flexibility and standards. Having a stable standard over a period of years protects the development investment in a product. Examples of standards that use a periodic approach for updates include DIS, HLA, and SEDRIS.

A continuous update approach can be easily accommodated with government processes, since the frequency of updates can be determined by the participants' needs. For example, the AMT releases updates of the TENA standards every six months. Other standards that use a continuous update strategy include CTIA. However, being too flexible and changing the standard too frequently can have a negative impact on users, in that standards are constantly in a state of flux.

There are several approaches for dealing with the tension between flexibility and stability. Some commercial standards processes accommodate a certain degree of continuous updates using repositories and registries. For example, SEDRIS was standardized by ISO and uses a registry[15] to capture updates to the standards. ISO then releases formal versions of the standards, including any changes in the registry, every five years. In addition to the registry approach, sometimes evolving needs can be included in the software implementation without changing the actual standard. This approach can provide a quick turnaround for users as long as the change required does not violate the actual standard.

Standards must evolve to be viable; a standard that doesn't evolve runs the risk of being irrelevant. Factors that influence how LVC standards change include understanding which standards require long-term stability, which standards require frequent updates, and how frequently changing standards may eventually turn into stable standards.

A desirable process would be flexible and agile as well as rigorous and stable. This could be accomplished with a process that enables ideas to be standardized at a preliminary state (e.g., version controlled document) with a well-specified growth path for achieving formal standardization (e.g., IEEE) and other levels in-between. Such an approach might allow for different types of standards (e.g., trial, working drafts, fast-track, formal) such that flexibility can be accommodated with trial and working drafts or registries, and stability can be accomplished with fast-track and formal standards.

4.1.4 Cost or Free Standards

The cost of acquiring completed standards is an issue that concerns many people in the LVC community. A large majority believe that standards should be available to anyone via an online repository. Some commercial standards organizations, such as ISO and IEEE, charge a fee to obtain copies of its published standards. The fees are commonly in the hundreds of dollars for a single copy. As mentioned earlier, ISO does allow for online access to standards through its registry process, but charges a fee to receive the standards on CD.

In contrast government organizations such as the AMT do not charge fees for obtaining their standards. Additionally, some commercial standards organizations like the W3C, the OMG, and SISO have download sites where current and previous versions of the standards or specifications can be obtained. It is worth noting that even though some organizations provide copies of standards and specifications online; their availability is paid by someone. This service is typically paid for through sponsors (e.g., TENA, SISO) or membership fees (e.g., OMG, W3C).

A desirable process should provide freely available standards to the community.

4.2 Desirable Attributes for LVC Standards

Using the issues identified above, the attributes which are deemed most desirable for future LVC standards evolution and management are shown in Table 4.1.

---

[15] ISO/IEC 9973 Items Register http://jitc.fhu.disa.mil/nitf/graph_reg/welcome.html

Table 4.1 Desirable Attributes of Future LVC Standards Process

Attribute	Desirable
Commercial	X
Government	X
Continuous	X
Periodic	X
Cost	
Free	X
Open	X
International	X

.

Obviously, some of the desirable characteristics of the process may be in tension or conflict with each other.

- Commercial vs. Government – The benefits of a commercial organization such as broader technical contributions; involvement of non-US participants and broader cost sharing must be balanced against the needs of the US DoD for control.
- Continuous vs. Periodic Updates – The benefits of stable standards to protect investments must be weighed against the need for flexible standards that can be modified to meet emerging user needs. Approaches such as trial standards might support both flexibility and stability.
- Cost vs. Free – There are multiple perspectives to this issue. We are addressing the issue from the perspective of a consumer of the standards… not developers of standards. The strong opinion of most participants in the study is that standards should be free to users of those standards.
- Open Standards Process – Virtually all participants in the study felt that having an open standards process (producing open standards) was very desirable. Open processes would involve stakeholders in the development process and would better ensure that the standards truly meet the needs of the end user.
- International Standards Process – As with an open process, nearly all participants felt that international involvement would enhance the process and the resulting standards. This is particularly important for those DOD programs that anticipate working with coalition partners. Further, the HLA standards are the subject of the NATO draft standardization agreement (STANAG 4603) for modeling and simulation. Thus continuing an international process is important for continuing the established NATO relationship.

5 Comparison of Current and Vision State

The next step in the standards management and evolution analysis is to compare the current state with the desired future state. This will be accomplished by comparing the desirable attributes developed in Figure 4.1 and comparing that to the existing organizations and processes used today. This analysis will help identify the gaps that need to be addressed in modifying an existing organization to meet the needs of LVC standards. This comparison is shown in Table 5.1.

Table 5.1 Comparison of Current LVC Standards Approaches and Desired Attributes

Attribute	Desirable	SISO	SISO/IEEE	AMT	CTIA	SEDRIS	OMG
Commercial	X	X	X			X	X
Government	X	X		X	X		
Continuous	X	X		X	X	X	
Periodic	X		X			X	X
Cost			X			X	
Free	X	X		X	X	X	X
Open	X	X	X			X	X
International	X	X	X			X	X

The SISO process already includes many of the desired state attributes. An approach for including government requirements and feedback is needed, as is an approach for providing continuous updates to standards[16] and distributing these free[17]; although many SISO standards are already distributed free of charge. The AMT and CTIA are similar processes. Thus to meet the desired attributes, they require significant changes to meet the future state including international visibility and recognition, an open standards approach, and integration into a commercial organization. The SEDRIS process is the approach closest to the desired future state attributes. However, it does not have the user community level of involvement that SISO enjoys.

6 Courses of Action

Based on the attributes discussed in Section 4 and the comparison discussed in Section 5, a set of courses of action have been developed to characterize a potential solution space for LVC standards evolution and management. Note: these COAs only pertain to in-scope standards; they do not attempt to characterize how the LVC community would standardize all possible products in the interoperability space.

6.1 COA 1: Maintain Status Quo

This COA continues with the existing LVC organizations and processes already in place. The LVC standards community currently uses an uncoordinated, hybrid approach to managing standards. This approach uses both government and commercial standards organizations for developing architecture-related standards. The government standards organizations, processes, and groups include: TENA AMT, CTIA architecture control board, DOD Service Groups (AFAMS, AMSO, NMSO), other DOD organizations (DISA GIG, DISR), the M&S Coordination Office (MSCO) and the NATO M&S Groups (MSGs). The commercial standards organizations and processes include: SISO, IEEE, OMG, ISO, IETF, and W3C.

This COA is characterized by little coordination across standards organizations. Coordination is accomplished by individuals and/or companies that work across architectures. Discussions during Workshop #3 indicate the DOD services are establishing better coordination among themselves. No group has charter to work across boundaries and therefore this type of coordination is typically done in an

16 SISO is adopting a trial-standards program for non-IEEE standards that might satisfy the issue with continuous updates.
17 Some SISO standards are free (e.g., BOM, RPR FOM, DIS Enumerations), only those specifications approved by IEEE must be purchased by users.

ad hoc manner. Further, there is no central repository, website, or group that has the status of all activities. Thus trying to identify LVC activities is a challenge.

In terms of Table 5.1, this approach does cover the desired attributes for future LVC standards by relying on different organizations and processes. However, it is accomplished in a disorganized and uncoordinated way.

6.2 COA 2: Government Standards

This COA would focus the LVC community on using a government organization for developing all architecture-related standards. This approach would use a government organization (new or existing) to develop the standards. Existing government organizations that could be used or expanded to provide this service include: TENA AMT, CTIA architecture control board, DOD Service Groups (AFAMS, AMSO, NMSO), or MSCO. Another possibility is to shift the direction of SISO to remove their interaction with IEEE and ISO. For this to happen, SISO would have to first buy back the DIS and HLA standards from IEEE to own the IPR. SISO could then make the standards available for free and change the process for review and updating the standards.

Using a government standards organization for all LVC standards may mean taking on activities once handled by commercial standards groups, adding complexity to a new organization. Further, a decision would need to be made regarding the multiple, separate processes in use today (SISO, AMT, CTIA, DOD Services). Possible directions would include providing better coordination among the separate processes or converging the processes into a single unified process. This could be accomplished using an advisory group to help coordinate or converge the different organizations. Another issue with pursuing this approach is that the HLA standards are the subject of the NATO draft standardization agreement (STANAG 4603) for modeling and simulation. Thus using a government organization to create future LVC standards could break trust in our existing relationships with NATO and PfP partners to use a commercial, international process.

In terms of Table 5.1, this approach doesn't cover the desired attributes for future LVC standards. The biggest impediments to achieving the desired future state are the commercial, open and international attributes. Further, this COA could be considered in conflict with OMB Circular No. A-119 (Voluntary, Consensus Bodies), in that the Government should not be developing its own standards and should instead rely on the private sector.

6.3 COA 3: Commercial Standards

This COA would focus the LVC community on using a commercial organization for developing standards. This could be accomplished by enhancing what SISO has already created, creating a new standards organization, or going to another commercial organization (e.g., OMG). This approach could leverage existing relationships with the IEEE and ISO to create a broad commercial standards organization for LVC standards. Using a commercial standards organization for all LVC standards may mean changing existing interactions and relationships with government standards organizations. This could include the LVC community giving up activities that don't have wide commercial appeal. Further, this approach dilutes the interaction and requirements of government organizations in the standards process, since the relationship would be based solely on voting.

A consideration for choosing the commercial organization includes whether all "in-scope" information products are candidates for standardization[18]. Since all "in-scope" standards would be standardized through this commercial organization, convergence of existing processes (SISO, AMT, CTIA, DOD Services) into a single unified process would be needed. As an example, consider voting on standards. In IEEE anyone can vote that joins IEEE Standards Association; in ISO countries vote requiring a country position; in SISO individuals vote; and in AMT, CTIA, and DOD services, stakeholders vote. Determining how these separate voting processes work together or how they can be merged into a single unified process would need to be determined. Other attributes that require consideration include availability of standards and reference implementations.

---

[18] Some organizations are strict about the type of content that can be standardized using their process.

In terms of Table 5.1, this approach covers more of the desired attributes than COA 2. However, this would mean changes for how the DOD interacts with a standards organization in order to have requirements included in standards. Also some requirements may not be well suited for a commercial organization and thus those requirements may not get addressed. Depending on the commercial organization, responsiveness of the process to continuous update standards could be an issue.

6.4 COA 4: Hybrid Standards

This COA would focus the LVC community on using both government and commercial organizations for developing standards. This could be accomplished by enhancing an existing commercial organization such as SISO, using an existing organization such as the OMG, or creating a new organization. Existing government organizations could be used as-is or expanded to provide needed services. This approach could leverage existing relationships with the IEEE and ISO for LVC information products needing international accreditation (e.g., rules, architecture, services, process), and use a government organization for LVC information products that are more domain focused (e.g., enumeration, object model content, standard algorithms). This decision would be based on which organizations best fit the information products being standardized.

A hybrid approach could be accomplished in several ways. Most desirable would be a single organization that could create both types of standards. The organization would need to be internationally recognized for producing commercial standards and also provide mechanisms for interacting with government organizations for requirements generation and standards development. International recognition could be at the IEEE or ISO level, but could also be accomplished with an organization like the OMG or SISO. In fact, SISO has been gaining recognition in recent years as the international M&S standards organization. With their ties to IEEE and ISO, SISO is a desirable organization to create the hybrid approach.

Another possibility is to use multiple organizations for the different types of standards needed by the LVC community. For example, government standards could be developed by organizations such as the AMT or ACB and commercial standards developed by an organization like SISO. This approach requires little change to existing organizational structures, but would require sufficient coordination among the organizations to ensure consistency among the in-scope information products. A disadvantage of this approach is that it does not provide a well-defined growth path for standards evolution from preliminary idea stage (possible generated in a government organization) to a more formal international specification.

A third approach for creating a hybrid organization would be for DOD to use a government approach to come to consensus, and then work with a commercial organization (e.g., SISO or OMG) to publish the standards. This was the approach for HLA standards. The specifications were developed by the HLA AMG and were then submitted to SISO for IEEE standardization. As in the second approach described above, this also requires little change to existing organizational structures. However, it does require sufficient coordination to ensure the commercial organization is willing to accept and standardize the specification. It also necessitates continued participation and involvement by the government organization through the commercial standardization process.

From a process point of view (as described in section 3.3), convergence of existing processes (SISO, AMT, CTIA, DOD Services) into a single unified process would be desirable, but unlikely. A single process would have to be the formal process required by a commercial organization, which may not be as responsive. Instead, a hybrid process that enabled both government and commercial aspects is more realistic. This could provide improved participation through bicameral membership and voting. It could also provide better responsiveness by creating a growth path from government to commercial standardization using categories of standards (e.g., trial, working drafts, fast-track, formal).

In terms of Table 5.1, this approach covers the desired attributes for future LVC standards. It is best accomplished by providing better coordination among the separate processes using an advisory group to help coordinate or converge the different government and commercial processes. A central repository, website, or group that can provide status of all activities would be beneficial.

7 Pros and Cons of COAs

During Workshop #3, participants were asked to generate a list of pros and cons associated with each COA. These are shown in the figures below.

COA 1: Maintain status Quo had a number of Pros and Cons. Several of the positive comments revolved around the fact that people are often reluctant to change something that works and that they are familiar with, whether it works well or not. Another observation was that the processes currently in place are generally responsive to the needs of the community. In the CONS column, the participants made a number of observations including the need for an all-encompassing department level solution. They also noted that integration and interoperability was often expensive and painful due to the differences in the processes.

Figure 7.1 Pros and Cons for COA 1: Maintain Status Quo

PROS	CONS
Seems to be working	Not a dept–level soln
Comfortable with their specific process	More expensive in the long-term
Cheaper in short-term	Painful to integrate
Communities control it so it's responsive to them	No common set of requirements
No one has to do anything different (familiar)	Duplication of effort
	Not doing everything we want
	Not addressing the hard problems

COA 2: Government control of the standards process also had a number of pros and cons. On the positive side, Government control of the M&S standards process certainly allowed a stronger focus on problems facing the US DOD. However, the limit on participation outside the DOD made coalition participation questionable and limited both the peer review process and the potential marketplace. Given that international participation and participation outside the US DOD seemed to outweigh the PROS.

Figure 7.2 Pros and Cons for COA 2: Government Standards

PROS	CONS
Total control over stds	Defy DoD defn of interoperability (open stds)
Proof new ideas while technology is maturing	Works against coalition exercise/interoperability
Can address specific hard problems (e.g., MLS)	More expensive
Flexible environment	Limit the people that can participate
	Force “cottage industries” to emerge to support standard
	Limits peer review
	Limits market place

COA 3: In recent years, the DOD has increasingly relied on commercial standards. Commercial control of the standards process was seen as a way to get wider involvement and a more competitive environment resulting in a wider adoption. CONS included a concern that there would be a loss of control by the DOD and the perception that a commercial approach to standards was slower than a government controlled process.

Figure 7.3 Pros and Cons for COA 3: Commercial Standards

PROS	CONS
Interoperability	Slow to change
Cheaper in short-term	If formal slow to get standard adopted
More competitive environment	Culture issues
If de facto quick to implement	Limited ability to influence the standard
Need broader peer review and knowledge of other technologies	Limited control
Anti-trust protection	Promotes folks developing point solutions
Buy-in from wider community (all cons of COA 2)	

COA 4: A hybrid approach resembles COA 1 in some respects. The hybrid approach would allow multiple standards processes to exist and standards would be evolved using the process that was most applicable to what was being standardized. Although this process seemed to appeal to the participants, several serious CONs were raised including the need to manage interoperability across standards bodies and organizations with no guarantee that the groups would cooperate. A successful COA 4 approach would require management and oversight across all the applicable standards bodies. The observation was made that without good vision and strong management, COA 4 could devolve back to COA 1.

Figure 7.4 Pros and Cons for COA 4: Hybrid Standards

PROS	CONS
Cover span of M&S LVC	Harder to manage
Flexible, shopping cart approach	Feature interaction
Same as pros for COA 1?	Could fall back to COA 1 if not actively managed with good vision
Best of both worlds	Must maintain presence with all standards bodies
Reduce duplication	Worst of both worlds
	No guarantee commercial standards groups would play

8 Compliance to Standards

The overarching purpose of compliance certification to a standard is to ensure that products adhere to that particular standard. A number of approaches to compliance certification are discussed below. This section outlines the compliance certification process in use today for the most commonly employed distributed simulation architectures, and puts forth a recommendation for future LVC Architecture standards compliance certification. Operational certification is most often associated with Verification and Validation (V&V) however; this section addresses only certification of compliance to a defined standard.

8.1 Definitions

Compliance certification may be defined as the act or process of determining compliance to a defined standard. The primary reasons for standards compliance are; a greater probability of interoperability between simulation assets and a greater probability for reuse of those assets in different configurations.

8.2 Compliance & Certification Processes today

A number of processes are in use today with existing distributed simulation architectures and protocols. Each is discussed below:

8.2.1 DIS Compliance Certification

In the early days of DIS, an extensive test suite was developed to check compliance of sent Protocol Data Units (PDUs) to the DIS standard format for those PDUs. Since DIS uses no middleware, the only test was for the format of the data units. The test is rarely if ever used any more. First created for the 1992 I/ITSEC interoperability demonstration in San Antonio, TX, the tests consisted of five levels:

- Level 1 - Network Level Tests
    - Focus on verifying the ability to transmit and receive data packets using UDP/IP/Ethernet.
- Level 2 - PDU Tests
    - Verify the bi-directional exchange of Application Level Messages (PDUs) generated or interpreted by the System Under Test (SUT).
- Level 3 - Terrain Orientation Comparison Tests

    - Verify correlation between the Terrain Database (TDB) used by the SUT and a reference TDB.
- Level 4 - Appearance Tests
    - Verify proper generation and interpretation of location, orientation, and velocity information.
- Level 5 - Interactivity Tests
    - Verify that the SUT interacts appropriately with the rest of the simulation by generating events appropriately or by responding properly to externally generated events.

8.2.2 TENA Compliance Certification

TENA enforces a higher level of compliance through the use of a compiled object model. The use of the compiled code enforces adherence to the agreed upon object model and offers type safety. TENA has three levels of compliance none of which have formal compliance tests.

- Level 1 – Minimal Compliance
    - Applications must use the standard API when interacting with other TENA applications via the TENA middleware. *There is an implicit compliance test resulting from the compiled object model code which compiles to only the standard API calls. There is no non-standard API call to the TENA middleware.*
    - Logical ranges must have a Logical Range Object Model (LROM) defined. *There is a "built in" compliance test in that interoperating applications must use the same compiled middleware code which was generated from a common LROM*.
    - All objects in the LROM must conform to the TENA meta-model. *Once again, this is enforced by the object model compiler which will not compile an object model that does not conform to the TENA meta-model.*
    - *Although no formal certification process exists, the minimal compliance level is implicitly enforced by the use of a TENA LROM and the TENA TDL middleware compiler.*
- Level 2 – Extended Compliance
    - All execution-time communication between applications must be via the TENA Middleware.
    - Application designers must describe the data their applications produce and consume
    - All applications must implement time properly
    - All applications must describe the mechanism and accuracy of their time measurements
    - *None of the level 2 compliance requirements have formal compliance certification tests.*
- Level 3 – Full Compliance
    - All applications must publish an Application Management Object
    - Applications may not use object definitions that conflict with the standard TENA Object Model
    - Applications must use the Logical Range Data Archive for all data storage

   - *The third level of compliance is unattainable at this time due to the fact that the Logical Range Data Archive has not yet been implemented. The first two components could be formally tested.*

8.2.3 HLA Compliance Certification

There are four types of HLA Compliance testing that may be considered:

- The HLA Runtime Infrastructure (RTI) middleware can be subjected to an extensive test suite to verify API and service functionality testing against the HLA Interface Specification. Only RTI developers wishing to have their RTI middleware certified would undergo this level of testing.
- HLA Object Models can be compliance tested against formal schemas. HLA 1.3 object models are tested against a defined OMT Schema while the HLA 1516 object models are tested against a formal XML schema. OMT Compliance Testing is built into the commercially available Object Model development tools (OMDT). Object models (both FOMs and SOMs) are tested for structural and syntactic correctness, and several simple relationships are also tested. The HLA Compliance test suite administered by the Department of Defense uses the commercial OMDT tools.
- Individual HLA Federates may choose to undergo Federate Compliance Testing using Federate Test Suite. This test provides minimal testing against the service APIs for syntax and semantics of the RTI services. The test does not (and can not) test for correct internal implementation of the RTI service. The federate is also tested against a subset of a submitted object model.
- There is no formal test suite for Federation Compliance Testing. Federations use the Federation Rules documented in the HLA Rules document and may use a Federation Checklist document to check various aspects of interoperability. In addition, a systems engineering process for HLA is defined in the Federation Development and Execution Process (IEEE document 1516.3) which is transitioning into the Distributed Simulation Engineering and Execution Process (DSEEP) which is intended to better encompass the various distributed simulation architectures.

8.2.4 CTIA Compliance Certification

CTIA compliance is based on compliance to the Product Line Architecture Specification (PLAS) and the Product Line Architecture Framework (PLAF) elements, such as the CTIA Frameworks, and the Graphical User Interface (GUI) Framework. Compliance is defined at the component and product levels. CTIA-based systems are comprised of components. Components are the fundamental element of reuse in the context of CTIA and the Live Training Transformation (LT2) Product Line. Four levels of component compliance are defined that have increasing levels of reuse and associated benefits across the product line. Each is highlighted below. Table TBD summarizes the four levels of CTIA Compliance.

- Non-CTIA Compliant Components – It is impractical to assume that all components will be developed as CTIA-Compliant. In order for a non-CTIA-compliant component to interface with the rest of the software and systems on the range, the range will often employ some sort of gateway component. A gateway component presents two interfaces. On one side of the gateway, it will present the interface that is required for the non-CTIA-compliant component, such as High Level Architecture (HLA), Distributed Interactive Simulation (DIS) or some other interface. On the other side of the gateway, it will present a CTIA-compliant interface, which in effect would make the gateway component CTIA Level 1 Compliant (at a minimum). It is important to note here that the gateway component would be the component that is assessed as CTIA-compliant, not the system or software that is being encapsulated by the gateway component.
- **Component Level 1: Unique Component -** Components that are Level 1, Unique Component, compliant:

- Can exchange data with the rest of the CTIA-based system through the interfaces defined by the PLAS. This includes use of CTIA Services for data distribution and may include implementation of the instrumentation or processor interfaces
    - Does not have a CTIA Component Contract/Agreement.
    - These components do not need to carry the reuse overhead associated with components that are to be reused across the product Line.

- **Component Level 2: Integrated Component** – A component that is Level 2, Integrated Component, compliant:
    - Can exchange data with the rest of the CTIA-based system through the interfaces defined by the PLAS. This includes use of CTIA Services for data distribution and will include implementation of the instrumentation or processor interfaces,
    - Has a CTIA Component Contract/Agreement,
    - Has its conformance validated through the CTIA Component Handover Process Checklist Document

- **Component Level 3: Systematic Component –** This is the minimum level of compliance required for the development of new common components. Common components have the potential of being reused across the full LT2 Product Line and help optimize systematic reuse. A Component that is Level 3, Systematic Component Compliant:
    - Can exchange data with the rest of the CTIA-based system through the interfaces defined by the PLAS. This includes use of CTIA Services for data distribution and will include implementation of the instrumentation or processor interfaces.
    - Has a CTIA Component Contract/Agreement,
    - Has its conformance validated through the CTIA Component Handover Process Checklist Document
    - If the component has a User Interface (UI), then that UI conforms to the LT2 GUI Style Guide.

- **Component Level 4: Optimized Component** – Level 4, Optimized Component, realizes the greatest degree of systematic reuse. This additional reuse is achieved by utilizing the frameworks that are a part of CTIA PLAF and the LT2 GUI Framework. These frameworks help enforce consistency across the LT2 Product Line. A Component that is Level 4, Optimized Component, Compliant:
    - Can exchange data with the rest of the CTIA-based system through the interfaces defined by the PLAS. This includes use of CTIA Services for data distribution and will include implementation of the instrumentation or processor interfaces.
    - Has a CTIA Component Contract/Agreement,
    - Has its conformance validated through the CTIA Component Handover Process Checklist Document
    - If the component has a User Interface (UI), then that UI conforms to the LT2 GUI Style Guide.
    - Uses the CTIA Framework(s).

- **Summary** - Component compliance levels build on each other with level 1 being the lowest level of compliance and level 4 the highest. Level 2 is the minimum level for interfacing an element or subsystem to a CTIA-based product. Level 3 is the minimum level to assure reuse across the LT2 Product Line. It should be noted that a level 2 compliant component that does not have a user interface would be considered level 3 compliant. Finally, level 4 assures the highest level of reuse by employing the frameworks that are provided by CTIA. Components may be promoted from lower levels of compliance to higher levels of compliance by meeting the additional requirements for compliance.

Table 8.1 CTIA Component Compliance Definitions

Level	Name	Criteria	Examples
N/A	Non-CTIA Compliant	- Data is not exchanged using interfaces defined in the PLAF - Is not developed by LT2 Product Line	• Legacy Instrumentation • HLA/DIS Simulation • Test Software • Joint Training System • TENA Application
1	Unique Component	- Data exchanged using interfaces defined in the PLAF - Does NOT have a Component Agreement/Contract	• Legacy Instrumentation System Gateway • OOS Live Native Adapter • Communications Infrastructure
2	Integrated Component	- Data exchanged using interfaces defined in the PLAF - Has a Component Agreement/Contract with PLAS interfaces - Validated through CTIA Component Handover process - Does not use CTIA Frameworks	• Gateway Component that provides it's own user interface (not compliant with LT2 GUI Style Guide)
3	Systematic Component	- Data exchanged using interfaces defined in the PLAF - Has a Component Agreement/Contract with PLAS interfaces - Validated through CTIA Component Handover process - If GUIs, they meet the LT2 GUI Style Guide - Does not use CTIA Frameworks	• Player Unit (TESS/Tracker) that does not use CTIA Framework • Gateway Component that provides a User Interface compliant with LT2 Style Guide
4	Optimized Component	- Data exchanged using interfaces defined in the PLAF - Has a Component Agreement/Contract with the PLAS interfaces - Validated through CTIA Component Handover process - If GUIs, they meet the CTIA GUI Style Guide and use the GUI Framework - Uses CTIA Frameworks	• Info-centric Tool Suite (ICTS) • System External Gateway (SEGW) • Pairing Processor

9 Conclusions and Recommendations

Based on the analysis and subsequent pruning of the possible strategies for the standards dimension, the Standards Study Team believes that COA 4: Hybrid Standards is the best standardization approach for future LVC architectures. The strategies that will be used to build the standards aspects of the LVC Roadmap include:

- Use an open standards process
- Investigate bicameral membership and voting organizational policies

- Develop evolutionary growth path for LVC standards (from government to commercial)
- Make standards (including IEEE) more accessible to LVC community
- Better coordinate participation in diverse standards groups and activities related to LVC

In the final report, these strategies will take on the form of recommendations for LVC standards evolution and management. The final report will also will develop standards recommendations for each of Architecture Activities based on these strategies.