Comparative Analysis of Standards Management for LVCAR

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ABSTRACT

A number of distributed simulation architectures are commonly used today. Each architecture was developed by a specific user community, 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 LVC Architecture Roadmap (LVCAR) study proposed a "way ahead" for improved interoperability across the major distributed simulation architectures and protocols. One component of the study dealt 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.

The methodology applied in the LVCAR standards study took the existing LVC distributed simulation architecture standards, characterized their current state, and defined an "idealized" model against which they could be compared. The study then characterized the vision state of future LVC standards evolution and management. This resulted in a set of desirable attributes for future LVC standards.

Based on the vision state characterization and an analysis to identify gaps in existing organizations and processes, a set of courses of action (COA) were developed to characterize a potential solution space for LVC standards evolution and management. The pros and cons of each COA will be presented, followed by recommendations about future LVC standards development organizations, standards processes, and compliance certification.

ABOUT THE AUTHORS

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INTRODUCTION AND OVERVIEW

Standardization involves the use of common products, processes, procedures, and policies to facilitate attainment of business objectives [IEEE 2010]. 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 Architecture Roadmap (LVCAR) Phase I Study considered three important dimensions of simulation interoperability: technical architecture, business models, and the standards evolution and management process. Study teams were established to consider each of these dimensions. This paper focuses on the activities of the Standards Study team [Loper 2008].

The live, virtual, and/or constructive distributed simulation architecture standards (or LVC 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 evaluated these approaches in order to make a recommendation regarding a standardization approach for future LVC architectures.

The goals of the standards study team included:

1. Compare and contrast each of the standards development and evolution processes for the four LVC architectures being examined (DIS, HLA, TENA, and CTIA).
2. Classify the types of LVC standards currently used by each community.
3. Identify certification and testing methodologies used by each of the four LVC architecture standards.
4. Identify other standardization approaches to be considered in arriving at the LVC Architecture Roadmap's (LVCAR) recommended approach.

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 1. The Modeling & Simulation (M&S) architectures considered include DIS, HLA, TENA, and CTIA. Using these models, the current state of LVC standards and management were assessed in terms of their standards and products, standards organizations, standards processes, and compliance certification. Information for this assessment was collected from literature reviews, workshops, surveys, and from community experts.

The vision state was developed from discussions with a set of community experts assigned to work with the LVCAR study team. This included creating a set of desirable attributes of future LVC standards development. The remainder of this paper 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.

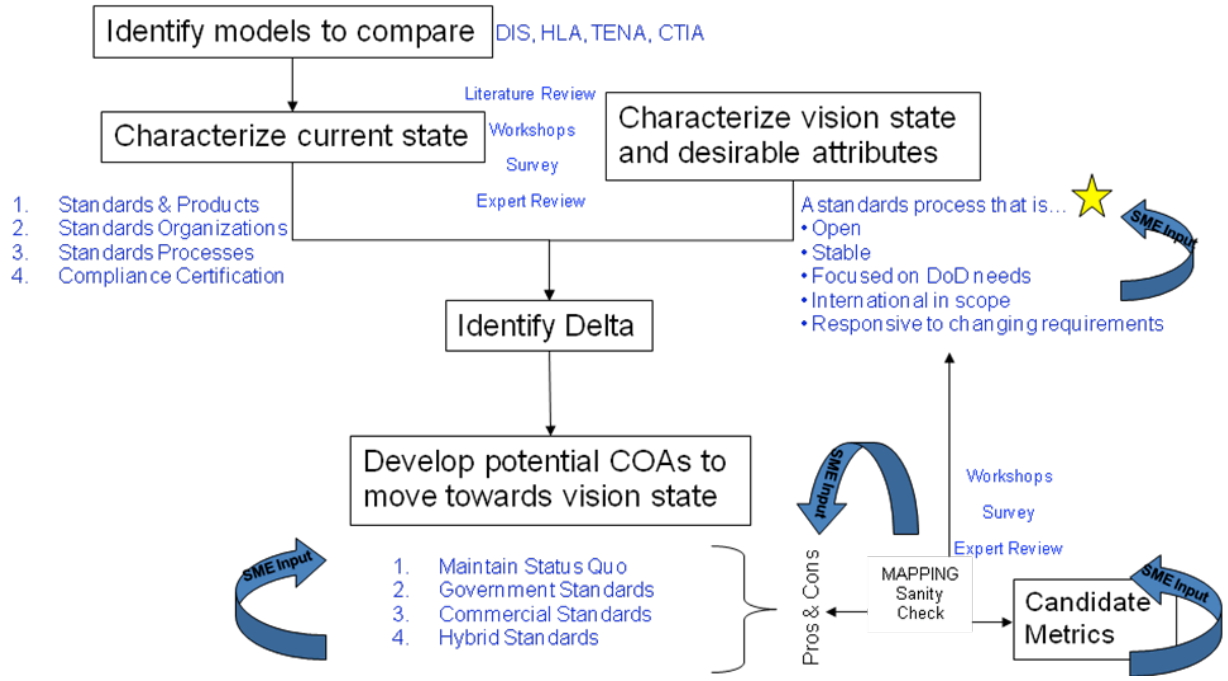

Figure 1: Analytic Framework for Standards Evolution and Management

CHARACTERIZE THE CURRENT STATE

The current state of LVC standards management approaches can be characterized using four attributes: 1) the types of LVC standards and products currently used by the community; 2) organizations involved in LVC standardization; 3) LVC standards processes currently in use; and 4) compliance certification. Each attribute is discussed in the following sections.

Standards and Products

The LVCAR study included a set of workshops open to the community where information about the study was both gathered and disseminated. At one of these workshops, a list of information products was presented to 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 1.

Table 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)

A goal of the information product exercise was to understand what de jure standards have been created by each simulation community for these categories, and whether other de facto or proprietary standards have been used.

The analysis revealed that the LVC community has created de jure standards under several organizations: the Institute of Electrical and Electronics Engineers (IEEE), the Simulation Interoperability Standards Organization (SISO), the TENA Architecture Management Team (AMT), or the CTIA Architecture Change Board (ACB) processes. Exceptions to the de jure standards 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 LVC community also 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 infrastructure technology program has a history similar to the distributed simulation programs being evaluated in this study. As such, this family of standards will also be considered when evaluating process and standards organizations.

M&S Standards Organizations

For the purposes of this report, M&S standards organizations were classified into two types: government and commercial. Government refers to standards forums under U.S. Government control. Examples of this are the (now defunct) HLA Architecture Management Group (AMG), the TENA AMT and the CTIA ACB. 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 IEEE, SISO, International Organization for Standardization (ISO), and Object Management Group (OMG).

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.

There are currently three main standards-developing organizations in the LVC community: the AMT, which develops TENA standards, the Architecture Control Board (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 participate in the AMT, ACB or SISO, but they do not have formal representation or 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, e.g., Internet Engineering Task Force (IETF), World Wide Web Consortium (W3C), Object Management Group (OMG), International Standards Organization (ISO). However, there is little, if any, coordination in the LVC community to participate in these standards development activities. This results in commercial standards that may not fully address LVC requirements.

Standards 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, organization meetings, 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.
- "Organization Meetings" 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 2. Since SISO develops both IEEE and SISO standards, these processes have been separated to show the distinction between the two.

In the governing body and organizational structure category, the main differences are relationships to other standards organizations and membership entities. Membership in SISO is based on individuals, whereas AMT membership is based on programs and DOD stakeholders. In a general sense, there are no

differences in the organization meetings and source of authority categories.

The major differences appear in the standards creation and evolution process. For SISO and SISO/IEEE, these attributes are governed by formal policies and procedures that have been approved by the IEEE. Since the AMT is a government standards organization, they have tailored a process to support the TENA stakeholder's requirements for standards development. 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 requirements of the M&S communities they serve.

Compliance Certification

The overarching purpose of compliance certification to a standard is to ensure that products adhere to that particular standard.

The primary reasons for standards compliance in the M&S LVC domain are a greater probability of interoperability between simulation assets, and a greater probability for reuse of those assets in different configurations. A number of processes are in use today with existing LVC standards. Those processes range from very informal approaches, such as checklists, to formal compliance tests. Operational certification is most often associated with Verification and Validation however; this section addresses only certification of compliance to a defined standard.

Of the four LVC Standards, only HLA has a formal compliance certification for Runtime Infrastructure implementations, object models, and federates. TENA has a tool that measures compliance of an application with a specific version of the middleware and a specific TENA object model. CTIA compliance is based on compliance to the Product Line Architecture Specification (PLAS) and Product Line Architecture Framework (PLAF) elements.

CHARACTERIZE VISION STATE

When considering a desired vision state for LVC standards evolution and management, several questions must be addressed:

- Should the M&S industry use a commercial or a government standards approach?
- How does the process balance the need for stable standards with the need for timely evolution?
- How should the M&S industry decide between a single standards process and multiple coexisting standards processes?

In order to create a vision state response to these questions, the issues associated with selecting an LVC standards approach must first be explored. From these issues, a set of desirable attributes for future LVC standards evolution and management can be identified. This list of desirable attributes can then be compared to the current state to identify gaps that need to be addressed.

Issues for Selecting an LVC standards approach

In a meeting with Expert Team members, it was recommended that the list of attributes of a standards process (Table 2) be simplified to include a small number of key attributes deemed important for future LVC standards evolution and management. The attributes included:

- Open or Military Standards approach
- Commercial or Government organization
- Responsiveness and Predictability
- Cost or Free standards

Open or Military 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 [Krechmer 2006]:

- Organizations representing the *standard 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.

An alternative to the open standards approach is to develop military standards (MIL-STD). Military standards evolved from the need to ensure proper performance of military equipment. By 1990 nearly

Table 2. Comparison of Industry (SISO) and Government (AMT) Standards Processes

CATEGORY	ATTRIBUTE	SISO/IEEE	SISO	AMT
Governing Body / Organizational Structure				
	Relationships to other standards organizations	None	Strong ties to ISO and IEEE	None
	Governing Board	BOD (SAC)	BOD (EXCOM) and Architectural Committee (SAC)	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
Organization 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	SISO members	SISO members	TENA stakeholders
	What is standardized	Architecture, Process	Domain, Algorithms, Process	Domain, Architecture, Algorithms, Middleware, Process
	Voting Eligibility	Open to all IEEE standards association members	Open to all SISO members	Closed; stakeholders only
	Voting Fairness	Balancing equation; Ballot resolution req't, Threshhold req't	Balancing equation; Ballot resolution req't, Threshhold req't	No Balancing, Threshhold or Ballot resolution process
	Update Frequency	Periodic per IEEE	Periodic - specified in the Product Nomination	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

30,000 MIL-STDs had been developed and it was argued that the large number of MIL-STDs imposed unnecessary restrictions, increased cost to contractors, and impeded the incorporation of the latest technology. As a result, Secretary of Defense William Perry issued a memorandum that prohibited the use of most defense standards without a waiver [Perry 1994]. Even though a new memorandum was issued in 2005 eliminating the requirement for a waiver [Kratz 2005], the DOD is still encouraged to use industry standards and not develop its own [OMB 1998].

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.

Commercial or Government Organization

A commercial process, such as IEEE or SISO, 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 standards development organization (SDO) include accreditation by an international or world-standards body, maintaining compatibility with international partners, technical contributions from non-U.S. participants, and cost sharing of the standards effort. Disadvantages of using a commercial SDO include lack of control by U.S. 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 or not an international (or world) accreditation is needed for LVC standards. The DOD does have a policy to adopt non-government standards [OMB 1998] but that does not necessarily push the LVC community towards creating international standards. However, collaboration with NATO, PFP partners and other non-DOD partners promotes the need for international standards, as these partners may not be able to use U.S. government-developed standards.

Other issues regarding commercial or government organizations for standards development include who is "in charge" of the standards and who "owns" the standards.

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.

Responsiveness and Predictability

Standards must evolve to be viable. A standard that doesn't evolve in response to emergent user needs will fall into disuse and become irrelevant. Users will adopt another standard or pursue a non-standard course, which will have a negative impact on interoperability and reuse.

There is an obvious tension between responsiveness and predictability. Responsiveness involves the elapsed time required to update a standard to meet changing user needs, while predictability involves a formal update interval. A standard that is not responsive to user needs will not be widely adopted; however, a frequently changing (responsive) standard adds a burden to users in that they are frequently required to adopt and implement an updated standard. Predictability ensures users of a standard that their investment in the standard will be stable for a period of time.

A desirable process would be both responsive to user needs and have a predictable update interval. 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, and formal) such that responsiveness can be accommodated with trial and working drafts or registries, and predictability can be accomplished with fast-track and formal standards. Further, it is crucial that the process have active volunteers participating in the process.

Cost or Free Standards

The cost of acquiring completed standards is an issue that concerns many people in the LVC community. A large majority believes that the requirement to purchase standards is a barrier to entry for many individuals, including small companies and academic researchers. Thus, standards should be available to anyone in the LVC community at little or no cost. 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 range for a single copy.

In contrast, government organizations such as the TENA AMT do not charge fees for obtaining their standards. Additionally, some commercial standards organizations like W3C, 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; someone pays for their availability. 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. This should include a plan for existing DIS and HLA IEEE standards, as well as any new LVC standards created in the future.

Desirable Attributes for LVC Standards

Using the issues identified above, the attributes that are deemed most desirable for future LVC standards evolution and management are shown in the first column of Table 3. Some of the desirable characteristics of the process are in tension or conflict with each other.

Approaches such as trial standards might support both responsiveness and predictability.

- Costs vs. Free – There are multiple perspectives to this issue. For the study, the issue was addressed from the perspective of a consumer of the standards, not developers of standards. The strong opinion of most participants in the LVCAR 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 involving stakeholders in the development process was very desirable 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 LVC standards. Further, international standards are necessary if our international partners are going to use the same standards as the U.S. DOD. HLA standards are the subject of the NATO standardization agreement (STANAG 4603) for M&S, ratified in 2006 by eight nations including the U.S. Thus, continuing an international process is important for continuing the established NATO relationship.

Table 3. Comparison of Current LVC Standards Approaches and Desired Attributes

Attribute	Desirable	SISO	SISO/IEEE	AMT	CTIA	SEDRIS
Commercial	X	X	X			X
Government Influence	X			X	X	
Responsiveness	X			X	X	X
Predictability	X	X	X			X
Cost			X			X
Free	X	X		X	X	X
Open	X	X	X			X
International	X	X	X			X

- Commercial vs. Government – The benefits of a commercial organization such as broader technical contributions, involvement of non-U.S. participants and broader cost sharing must be balanced against the needs of the DOD for effective LVC standards.
- Responsiveness and Predictability – The benefits of stable standards to protect investments must be weighed against the need for responsive standards that can be modified to meet emerging user needs.

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 is accomplished by comparing the desirable attributes developed in Table 2 with 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 3.

The SISO process already includes many of the desired state attributes. A more effective way to communicate and advocate government requirements is needed, as is an approach for providing responsive updates to standards. The SISO/IEEE process also lacks government influence and responsiveness, and has the added disadvantage of charging for standards. 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 lacks needed government influence and does not have the user-community level of involvement, nor M&S recognition that SISO enjoys.

COURSES OF ACTION

Based on the attributes and comparison discussed in the previous sections, a set of courses of action (COA) was 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.

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 including both government and commercial standards organizations for developing architecture-related standards.

This COA is characterized by little coordination across standards organizations. Coordination is accomplished by the 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 a charter to work across boundaries, and therefore, this type of coordination is typically done in an ad hoc manner.

In terms of Table 3, the desired attributes are covered in a stovepipe approach to standards development. Currently, each attribute exists but in a different organization or process. This results in a disorganized and uncoordinated approach to standards management.

COA 2: Government Standards Management Approach

This COA would focus the LVC community on using a government SDO for developing all architecture-related standards. Existing government organizations that could be used or expanded to provide this service include: TENA AMT, CTIA ACB, DOD Service Groups (AFAMS, AMSO, NMSO), or MSCO.

Using a government standards organization for all LVC standards may mean taking on activities once handled by commercial standards groups, which would add 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). Another issue with pursuing this approach is that the HLA standards are the subject of the NATO standardization agreement (STANAG 4603) for modeling and simulation. Thus using a government organization to create future LVC standards could break trust in existing relationships with NATO and PFP partners to use a commercial, international process.

Currently two of the architectures (TENA and CTIA) rely on government organizations to develop and evolve the standards.

In relation to Table 3, this COA 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.

COA 3: Commercial Standards Management Approach

This COA would focus the LVC community on using a commercial SDO for developing standards. This could be accomplished in several ways: enhancing what SISO has already created, creating a new standards organization, or going to another commercial organization (e.g., OMG). Using a commercial standards organization for all LVC standards would mean changing existing interactions and relationships with government standards organizations. This could include the LVC community not supporting activities that don't have wide commercial appeal. Further, this approach dilutes the interaction and requirements of government organizations in the standards process.

Two of the LVC M&S architectures (HLA and DIS) use commercial organizations for standards development and evolution, but neither relies on

commercial organizations for compliance testing. HLA uses a government organization to administer compliance testing and certification for both the middleware and simulations.

One approach for dealing with the different processes 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 initial approach for HLA standards. The specifications were developed by the HLA AMG and were then submitted to SISO for IEEE standardization. However, this would 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.

In relation to Table 3, this approach covers more of the desired attributes than COA 2. However, this would mean changes for how the DOD interacts with SISO, and whether a process should be put in-place to ensure all SISO-developed standards are traceable to requirements (i.e., enforce a basic systems engineering concept). Also some requirements may not be well-suited for a commercial organization or may be restricted for security reasons (e.g., multilevel security). Thus, not all requirements may get addressed using this approach. Depending on the commercial organization, responsiveness of the process to continuous update standards could be an issue.

COA 4: Hybrid Standards Management Approach

This COA would focus the LVC community on using both government and commercial SDOs in a coordinated fashion for developing standards. This could be accomplished by using an existing SDO (e.g., SISO, OMG) or creating a new one. Existing government organizations could be used as-is or expanded to provide needed services. This approach could leverage existing relationships with IEEE and ISO for LVC standards needing international accreditation (e.g., rules, architecture, services, process), and use a government SDO for LVC standards 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. Key to the approach is selecting the primary organization responsible for commercial LVC standards. As discussed previously, many commercial SDOs exist which produce standards relevant to LVC interoperability. However, SISO is the most desirable organization upon which to base this approach due to their growing recognition as the international SDO for M&S. This recognition has been shown through their interactions with NATO [TCA 2007], as well as their established relationships with IEEE to create M&S standards and their liaison with ISO. Existing government SDOs, such as the TENA AMT or CTIA ACB, would coordinate with commercial organizations to ensure consistency among the standards being developed.

From a process point of view, a hybrid process that enables both government and commercial aspects would need to be implemented. Three examples of process attributes that should be studied include membership, voting, and standards evolution. Membership and voting are core principles in a standards organization. Approaches for including both individual and organizational membership would be beneficial for the LVC community, as it would increase participation and create a more unified LVC culture. Also, a growth path should be developed which encourages the nurturing of good ideas in environments where users can implement and experiment (e.g., government organizations) before bringing the idea into a formal standards process (e.g., SISO). This may necessitate the development of a broader set of deliverables (e.g., trial, working drafts, fast-track, and formal) to better classify the variety of LVC information products needed for interoperability.

A coordinated hybrid policy for compliance certification would allow a more flexible approach tailored to the needs of the particular LVC product. A coordinated approach would also encourage a greater level of consistency in the processes and would likely result in improved interoperability across LVC products. SISO could serve as an overarching organization for coordinating compliance certification processes. The standards development group for each product would be best suited for establishing the certification requirements for that product.

In terms of Table 3, this approach covers all of the desired attributes for future LVC standards. It is best accomplished by providing better coordination among the separate processes. A central website that can provide status of all activities would also be beneficial.

PROS AND CONS OF COAS

During LVCAR Workshop #3, participants were asked to generate a list of pros and cons associated with each

COA. For COA 1: Maintain status Quo, 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 were often expensive and painful due to the differences in the processes.

On the positive side for COA 2: Government standards management approach, Government control of the M&S standards process certainly allowed a stronger focus on problems facing the U.S. 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 U.S. DOD seemed to outweigh the PROS.

In recent years, the DOD has increasingly relied on commercial standards. Therefore, for COA 3: Commercial standards management approach, 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.

The last approach considered was COA 4: Hybrid standards management approach. 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. Without good vision and management, COA 4 could devolve back to COA 1.

STANDARDS MANAGEMENT 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 Management Approach is the best standardization approach for future LVC architectures. In order to realize this COA, the following recommendations have been developed to address the standards management and evolution aspects of the LVC Roadmap.

Engage SISO and the broader LVC standards community. SISO is the primary target for LVC standards development. Their existing infrastructure and established presence as an M&S standards development organization uniquely position them to take the lead in future LVC standards evolution and management. However, SISO is currently perceived as an organization that is focused primarily on HLA. In order to create a unified LVC community, the government standards organizations (e.g., AMT, CTIA, DOD Service M&S groups, DOD programs) must be encouraged to take a role in participating in SISO, as well as developing and vetting interoperability standards.

Make IEEE standards more accessible to LVC community. The cost of acquiring IEEE standards (DIS and HLA) is an issue that concerns many people in the LVC community. The requirement to purchase the standards is a barrier to entry for many individuals, including small companies and academic researchers. There is a considerable degree of consensus in the LVC community that these standards should be available to anyone in the LVC community without charge. The three options to accomplish this (buy back the rights from IEEE, buy copies in bulk for open distribution by MSCO, or implement a creative commons license) should be analyzed to determine the best approach to make these standards more accessible.

Coordinate activities and fund participation in commercial standards development groups. While SISO is the primary target for LVC standards development, the spectrum of standards needed by the LVC community is much broader than SISO. Emerging work on the Service Oriented Architecture, Global Information Grid, Information Security, Web Services, and Modeling, are but a few of the standards poised to heavily impact LVC systems. However, the LVC community develops none of these standards. In order to understand what other standards communities are doing and how their work will impact LVC interoperability, there must be a more active role in participating in these processes and making contributions based on LVC requirements.

Increase sphere of influence in SISO. Membership and voting are how decisions are made about standards. There are different approaches for implementing voting

and membership policies, and there is concern in the LVC community regarding the policies adopted by SISO. SISO uses a model similar to IEEE where membership and voting is based on individual representation. The concern is that any person, even those individuals who have no expertise in the technology being standardized, can vote on a standard and affect its outcome. A hybrid approach to membership that embraces all members (individuals, organizations, and stakeholders) is an important part of bringing together the LVC standards community. It is a missing piece in the culture that needs to exist.

Develop an evolutionary growth path for LVC standards. The types of standards needed by the LVC community are varied, and they include integration standards, data exchange standards, best practices, and threshold standards. Additionally, standard data sources, data sets, and object models are also critical for achieving interoperability among LVC simulations. Good ideas can emerge in a variety of places, (government working groups or DOD programs) and these ideas will be at varying levels of maturity. Some ideas may need considerable time to gain consensus, while others may be ready to be "fast-tracked" into the standards process. A growth path should be developed which encourages the nurturing of good ideas in environments where users can implement and experiment before bringing the idea into a formal standards process. A unified process that provides a path for government standards to enter SISO and go through a commercial standards development process is needed.

Develop a hybrid compliance certification process. If the LVC community moves toward a hybrid standards approach, it suggests that the compliance certification process will likely be a hybrid also. As standards for LVC products (e.g., middleware, support tools, documentation, and systems engineering processes) are defined, a compliance certification process for each product should be identified or defined. The certification process should include:

- Identification of appropriate certification agent. This includes determining who will be responsible for conducting certification tests, and whether the testing is external or internal to the user.
- The need for compliance to a particular standard. This includes why a product should be certified as compliant (i.e., the value), whether the certification is mandatory or voluntary, and the risks associated with the use of non-certified products.
- The basis for compliance certification for each standard. This includes the types of tests needed (e.g., formal and checklist), and the compelling evidence that support a claim of compliance.
- The cost associated with certification. This includes who bears the cost of compliance testing.

If SISO becomes the primary SDO for LVC standards, it should be the responsibility of each product development group within SISO to determine the compliance certification process for the particular standard it is responsible for developing / adopting. Some products such as middleware will, by its potential usage, require a more rigorous compliance certification process while other products such as documentation may not require the same level of testing.

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