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The Standards Landscape - SISO Standards for Operations, Systems and Ontologies

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***ABSTRACT**: SISO standards support a great number of domains including applications of services/middleware, simulation systems and operational activities. Horizontally the scope includes synthetic environments, protocols (DIS, HLA, etc), and data models such as the base object model (BOM), SEDRIS, and the Military Scenario Definition Language. Emerging needs are focusing SISO in new directions including service oriented architectures (SOA), battle management language, and format independent Ontologies. There is a critical need to align and integrate SISO development efforts horizontally and vertically. The day of perceiving standards as independent or competitive is giving way to a new era of collaboration and seamless integration. SISO and our stakeholders can begin to build upon the successes of the past to integrate systems into systems of systems level simulation environments. To prepare for these changes this paper outlines potential strategies for SISO by ensuring standards (1) support one another, (2) integrate vertically and horizontally, (3) support management and control across operational simulation environments and (4) integrate services dynamically in support of Live-Virtual-Constructive (LVC) environments. This paper applies concepts of systems engineering, lifecycles, and architectural best practices to provide a road map or blueprint for SISO's standards landscape.*

1. Introduction

The Simulation Interoperability Standards Organization (SISO) is remaking itself, evolving approaches and standards focus to answer the needs of our changing Modeling and Simulation (M&S) community of interest.

The number of standards and applications of standards is growing horizontally and vertically to include human social culture behavior (HSCB) modeling, battle management decision support systems, medical fields, manufacturing applications, and others.

This growth in the scope and variety of disciplines creates real challenges and problems for standardization. This is evidenced by the veritable explosion of study groups and product development groups in recent years. There are currently 15 study groups, 5 standing study groups, 14 product development groups, and 7 product support groups in various levels of activity. One begins to wonder if we are fracturing an already over-stretched community of M&S professionals by trying to address the many areas of concern without an over-arching perspective on the field. SISO needs a capability to conceptually organize and publish standards across the broadening scope of disciplines while reducing the complexity of understanding and appreciating the proper application of these standards.

How can SISO help make standards relevant across a growing base and scale of disciplines with the objective of expanding standards usage, sponsorship, and SISO membership?

This paper explores this question to help define broad concepts or boundary conditions of interoperability. Specifically, this paper examines how standards integrate (1) horizontally across disciplines and functional areas, (2) vertically from the top-down, and (3) vertically from the bottom-up.

These perspectives will then be integrated to provide a conceptual framework view that enables SISO to begin answering this question.

1.1 Levels of Interoperability

Standards exist for the sake of interoperability and reuse. Standards enable applications to interoperate at the level of models, systems, and systems of systems. Before we can address the need for standards organization across varying disciplines, we need to better define the term interoperability to provide a stronger context for the discussion.

Joint Publication (JP) 1-02 defines Interoperability as:

"The ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces, and to use the services so exchanged to enable them to operate effectively together.” [1]

From Wikipedia [2]: "Interoperability is a property referring to the ability of diverse systems and organizations to work together (inter-operate)."

In [3], the authors describe several levels of conceptual interoperability. Each level is necessary, but not sufficient for the next higher level of interoperability:

- Level 0, No Interoperability: Stand-alone systems have no interaction with other systems.
- Level 1, Technical Interoperability: A communication infrastructure is established allowing the exchange of bits and bytes. An example is Transmission Control Protocol/Internet Protocol (TCP/IP) on a network.
- Level 2, Syntactic Interoperability: A common structure for the exchange of data is used. An example is a data file encoded in Extensible Markup Language (XML).
- Level 3, Semantic Interoperability: A common information exchange reference model is used, allowing the meaning of the data to be shared. An example is application of the Joint Consultation Command and Control Information Exchange Data Model (JC3IEDM) as a common reference model for information exchange across command and control systems.
- Level 4, Pragmatic Interoperability: The systems are aware of the methods and procedures each is employing to process the information. An example is Service-Oriented Architectures employing Web services.
- Level 5, Dynamic Interoperability: The systems automatically adapt to changes that occur in assumptions and constraints each is making over time.
- Level 6: Conceptual Interoperability: The systems are fully aligned, sharing common understanding of both data (purposeful abstraction of reality) and processing.

Interoperability is a planned capability that functions differently depending on the architectural layer/level or view being considered. Another view / perspective on interoperability is captured in Figure 1**Error! Reference source not found.** which depicts a layered conceptual view of interoperability. This conceptual view of interoperability layers and aligns standards vertically from the bottom-up for data, systems, and operations.

Horizontally, layers consist of roles (components, capabilities, and types), rules and relationships conceptually providing for activities, functions, and data standards. Levels consist of a layer of standards (blue)

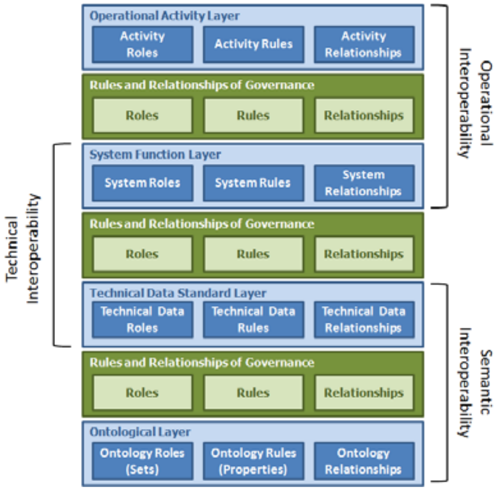

Figure 1: Layered Conceptual Interoperability

combined with a layer governing those standards (green). These components are conceptual in nature, meaning there are multiple items in each layer with corresponding sets of rules and inter-relationships governing those items. The intent is show to that (1) standards and interoperability occur at all levels and (2) the nature of the standards and the interoperability they provide varies by level. A consequence of this is that standards can apply across levels of interoperability. This can be disruptive because the more layers over which one standard has influence the more likely other standards could be precluded from participating. For example, if Distributed Interactive Simulation (DIS) Simulation Management (SIMAN) is used to manage and control systems at the operational level, High Level Architecture (HLA) systems would be largely precluded from participating at the systems level.

When properly aligned, vertically and horizontally, each layer builds upon simple concepts in the lower layer without affecting the items, rules and relationships in the lower layer. The vertical progression of layers on top of other layers is not disruptive. When aligned the layers below interoperate and integrate their capabilities/resources into the activities being performed above. For example, in a mixed protocol environment gateways are used to translate enumerations, etc. This can be disruptive if one federate dictates the translations to the other federates. But if we borrow from concepts of fair fight, a gateway could be used to translate all enumerations to and from a common ontology enabling each federate to specify how enumerations are translated. When one federate “shoots” an enumeration at another federate, the receiving federate can assess the “damage” done by specifying the translated enumeration it will receive. This is an example the *fair interoperability* that can be provided by good governance. In this context T. Gruber describes ontology as "An ontology is an explicit specification of a conceptualization. The term is borrowed from philosophy, where an ontology is a systematic account of Existence. For knowledge-based systems, what "exists" is exactly that which can be represented." [4]

Disruption is avoided by the green "Governance" layers that integrate aspects of interoperability in a lower layer with other aspects of interoperability in the higher layers.

Governance layers and the Roles, Rules, and Relationships in those layers are answers/solutions SISO needs to provide. However, exploration of the problem itself can reveal significant insights into the possible set of solutions. The integration between layers emerges as three levels of interoperability from the top down. For purposes of discussion and common vocabulary these levels of interoperability are defined as:

- Operational Interoperability - Operational interoperability integrates system functions within roles (actors) of operations (use cases) within or across an organization. The roles are actors/elements of organizations which relate to other actors/elements through rules of operations/use cases.
- Technical Interoperability - Technical interoperability integrates technical data standards within capabilities or across systems. The roles are equivalent to standards which relate to other standards by business rules.
- Semantic Interoperability - Semantic interoperability integrates common ontology sets within or across technical data standards. The roles are equivalent to ontological sets, which relate to other ontological sets through rules.

Conceptually operations are the activities organization perform or operate with. Those operations occur through systems, which function through standards, which deliver changes to the simulated world (locations, damage, etc.) that is the ontology of the simulated environment.

1.2 Semantic Interoperability

Semantic interoperability ensures a common interpretation and understanding of data/information. This concept of semantic interoperability is defined by Wikipedia as follows:

"Beyond the ability of two or more computer systems to exchange information, semantic interoperability is the ability to automatically interpret the information exchanged meaningfully and accurately in order to produce useful results as defined by the end users of both systems. To achieve semantic interoperability, both sides must refer to a common information exchange reference model. The content of the information exchange requests are unambiguously defined: what is sent is the same as what is understood." [2]

1.3 Technical Interoperability

Technical interoperability is a more common mainstream view of interoperability. This view generally involves the linking up of computer systems and services. In modeling and simulation technical interoperability applies to many standard protocols to include DIS, HLA, Link 16, and TENA. Technical interoperability is generally viewed as singular standard protocols.

1.4 Operational Interoperability

Operational interoperability is the ability of organizations/groups to provide services to and accept services from other organizations/groups and to use the services so exchanged to enable them to operate effectively together. [5]

Operational interoperability involves the mixing of standards. The challenge of operational interoperability is in retaining the underlying technical and semantic interoperability across systems, groups, and organizations.

2. Real World Examples

Standards exist for interoperability and reuse, but the benefits of standards do not end there. Interoperability and the reuse interoperability provides enable implementations to compete for utilization. Standards enable the value or return on investment (ROI) to be objectively measured because they enable standardized methods for comparing offerings. The objective measures of ROI inform decisions on how to initiate constructive change. Governance of standards is conceptually very similar to the governance of commerce and the economy. This section of the paper will examine two examples (also see [6]): (1) transportation systems and the history of the railroad; and (2) bookstores and the evolution of the industry brought on by technological changes to the marketplace.

2.1 Transportation Systems

The history of transportation systems in the United States provides an interesting perspective on standards and governance. Horse-drawn carriages were long the norm for travel until the railway system was created. The Central Pacific Railroad and the Union Pacific Railroad companies had to agree on standards of railroad construction. While today the railroad has been largely replaced with roadway infrastructure, airfreight, and seaports, this replacement was not necessarily a predictable outcome. Railroad companies created monopolistic empires growing out of the great depression. The US Government regulated railroad companies to provide for fair competition. This governance enabled roadway transport and air transport to flourish and compete with the railroad.

Today these systems compete to deliver goods/people by giving companies and people choices. In other words, these systems compete for contracts through which they are provided the opportunity to transport goods and people. But there is more involved than simple competition. These same systems also interoperate and cooperate to transport goods and people. For example an ocean liner delivers cars from Japan to the United States, cars are then distributed via railroad and roadway to distribution centers and car lots where customers purchase the vehicles. In this example, the systems work together (as a meta-system or system-of-systems) in the delivery of goods and people to new locations. What is also interesting is how these systems integrate and interoperate. An ocean liner delivers goods to a sea port, which includes roadway distribution centers for semi-trucks, and railroad infrastructure. Railroads then integrate with roadway systems at railroad stations. These are like gateways or bridges between standards. What is interesting is that we generally agree seaports, airports, and railroad stations are necessary, but are they efficient? Any traveler has stories of problems encountered from lost luggage, to cancelled trips/flights. Even in transportation, the interoperability of gateways has its issues. [7]

2.2 Bookstores

Bookstores have experienced tremendous change over the last 10 to 15 years, primarily as a result of technological innovations such as the internet. The advent of the internet has forced bookstores to adapt by developing new standards for electronic commerce. The companies that adapted to the new technologies, such as Amazon.com, were able to grow and expanded as a result of the new opportunities for e-commerce. This in turn enabled a new standard for books; electronic books gained in popularity. Other companies like Borders did not adapt to the new e-book standards and thus, are now closing their doors.

Still other companies like Barnes and Noble realized the market was splitting between paper-based books and e-books. By offering both formats they were able to retain their market share. What is interesting here is that again people had choices; they could choose to purchase e-books or paper books. Borders, which held fast and chose to compete paper against electronic books is now going out of business. Their mistake was to compete books of the paper standard against other book standards as a business model. Borders held fast to a purist, one-size-fits-all approach to business. In contrast, Barnes and Noble provides their customers with the freedom to compete the standards by offering both paper and e-books. Barnes and Nobel used these standards cooperatively to retain market share.

3. The Need for Governance

Governance is a two-sided coin, one side being inter-standards governance, and the other side being intra-standard governance. SISO already practices intra-standard governance through the Standards Activity Council (SAC), Product Development Groups (PDGs), and Product Support Groups (PSGs). These groups ensure openness of the standards development process, establish standards needed by the M&S community, and provide the community support in the interpretation and extensions to standards.

But how do SISO standards inter-relate? Consider SISO is an "interoperability" standards organization vs. an "intra-operability" standards organization. Shouldn't SISO (1) ensure the integration and sharing (collaboration) of rules and relationships between standards and (2) ensure groups are exploring these rules and relationships rather than creating standards "independently" of each other? There are so many moving parts, so many activities, that one half of SISO's standards efforts is not sure what the other half is doing.

3.1 A Sports Analogy

Let us revisit the concepts of cooperation and competition from a sports analogy.

Yaneer Bar-Yam describes the separation of competition and cooperation by levels in his book "Making Things Work, Solving Complex Problems in a Complex World" (pp. 79 - 85) [8].

From the bottom up, players compete (try out) to be on teams. Players then cooperate to compete against other teams. Teams cooperate to promote their sport. Sports compete for fans and money.

Figure 2: Coooperation and Competition in Sports

Rules in sports govern not only team play but also govern the relationships between sports and teams, and teams and players.

Comment [c1]: Doesn't make sense as written. Do you mean "by developing new standards for electronic commerce" or "by developing in accordance with new standards for electronic commerce"?

"The basic point here is this: the interplay between competition and cooperation can only be understood by using a multilevel perspective. Competition and cooperation will tend to support each other when they occur at different levels of organization, but they will generally be in conflict if they occur at the same level." [8]

At each level a healthy balance between competition and cooperation is desired. Each contributes to the governance that brings balance. Cooperation includes inter-activity governance. Competition includes intra-activity governance.

Cooperation of standards might seem ideal. Would it not be easier if everyone used HLA for simulations, for example? But this is not realistic. The problem is that the ability of the community to adapt to new environments would be irrevocably damaged. As is indicated by the real world examples of the transportation systems and bookstores, new standards will always emerge to answer the needs of an evolving world. It is important for SISO to understand that competition of standards does not belong within SISO, but is the responsibility of SISO's stakeholders; the customers and users of SISO standards.

3.2 Alignment of Standards

The alignment of SISO standards with governance will enable growth across the M&S community. The role of governance will vary vertically through the levels of interoperability as well as horizontally across roles of each level.

The governance of fair interoperability ensures standards compete fairly on a level playing field. In the previous section we discussed levels of governance at the organizational, team/group, and individual levels. How do these insights help SISO make standards relevant across a growing base of diverse stakeholders?

The layering of standards by levels of interoperability can enable SISO to:

- More clearly define the role of standards in specific contexts of data, systems, and operations.
- Simplify a stakeholder's understanding of best practices in the application of mixed standards.

Figure 1 takes on new meaning when we view it from a competition and cooperation perspective. The blue (contextual) layers represent an intra-view of SISO standards and the rules/relationships that govern each standard individually. The green (governance) layers represent the inter-view of SISO standards and the rules/relationships that govern standards collectively.

3.3 Vertical Alignment of Standards

It is interplay between competition and cooperation across levels of interoperability that enables the growth, adaptation and evolution of SISO as an organization. Governance of standards will increase SISO's relevance to operational decision makers. Just as the governance the United States provides for world trade and commerce brings investment money to the United States, SISO governance can bring with it investments from those who have a stake in standards for modeling and simulation. The United States is a champion of fair trade. SISO can become the champion of fair interoperability across standards, enabling our stakeholders to adapt and evolve to their changing environments.

Consider the bookstore analogy. Technical data standards of paper and electronic formats for books were made available to readers. Systems for e-commerce of books (brick store front vs. web store front) became common place. Further, the operational capabilities/technologies for e-books emerged in the form of hand-held devices, including Amazon's Kindle, smart phones with Kindle apps, etc. Without governance of fair trade, paper books might still be the only alternative.

3.4 Horizontal Alignment of Standards

The horizontal alignment of standards occurs at each level. This alignment is role-based. Consider the operational layer. SISO provides standards that align well here. Some examples include:

- Scenario Development - Military Scenario Definition Language (MSDL) provides for the role of Scenario Development.
- After Action Review - The emerging Distributed Debrief and Control Architecture (DDCA) will enable AAR systems to interoperate.
- Simulation - DIS and HLA enable simulations and simulators to interoperate.
- Stimulation - Link 11, Coalition Battle Management Language (C-BML), and Tactical Digital Information Link (TADIL) Technical Advice and Lexicon for Enabling Simulation (TALES) enable simulations to stimulate operational devices such as the Global Command and Control System (GCCS).

Vertical alignment focuses the capabilities of components in lower layers on roles of the higher layers. Horizontal and vertical alignment are inter-dependent. One element of a horizontal layer will compete standards for application to its role in the layer's activities. When those activities are employed or executed those standards previously selected are used in a cooperative manner and participate in the execution of the horizontal layer's activities.

4. Conclusions

SISO standards are each effective when considered alone, but not always when combined. SISO standards do integrate well in some areas such as HLA. In other areas, integration has been ad-hoc and opportunistic, rather than being deliberate and planned.

The opportunity for SISO now is to change approaches to mixed standards interoperability and begin active alignment of standards through inter-standards governance.

SISO standards governance needs to evolve to ensure standards (1) support one another, (2) integrate vertically and horizontally, and (3) support fair interoperability across operational and mixed simulation environments.

Through standards governance and alignment, SISO can make its standards relevant across a growing base and scale of disciplines to achieve the necessary expansion of standards usage, sponsorship, and SISO membership.

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Author Biographies

JEFF B ABBOTT holds a masters degree in engineering from the University of Central Florida. Mr. Abbott has worked in the area of modeling and simulation for 22 years. Much of that time has been spent working issues of interoperability related to simulation based training. Mr. Abbott works on standards development with SISO in support of interoperability between battle command and modeling and simulation technologies. Complexity theory focuses on evolving systems engineering techniques for application to Department of Defense programs and policy.

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DANNIE CUTTS is a Senior Computer Scientist with AEgis Technologies Group Inc. supporting the USJFCOM Joint Advanced Training Technologies Laboratory (JATTL) in Suffolk, VA as well as the Missile Defense Agency. He has over 20 years experience in Modeling and Simulation for NASA and the DOD and has been involved with the High Level Architecture (HLA) since 1995, serving on the Interface Specification and Time Management Working Groups. He has provided HLA Training and Cadre support for DMSO, and currently serves on the IEEE Drafting Group for the HLA IEEE 1516 standard. Mr. Cutts is a Certified Modeling and Simulation Professional (CMSP). At USJFCOM he is involved in efforts to improve interoperability between Live, Virtual and Constructive assets for Joint Training. He serves on the Standards Activity Committee (SAC) for SISO.