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Extensible Modeling and Simulation Framework (XMSF) Opportunities for Web-Based Modeling and Simulation

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TECHNICAL OPPORTUNITIES WORKSHOP WHITEPAPER, 14 JUNE 2002

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TABLE OF CONTENTS

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1 Introduction

1.1 Purpose

As the Department of Defense (DoD) is engaged in both warfighting and institutional transformation for the new millennium, DoD Modeling & Simulation (M&S) also needs to identify and adopt transformational technologies which provide direct tactical relevance to warfighters. Because the only software systems that composably scale to worldwide scope utilize the World Wide Web, it is evident that an extensible Web-based framework shows great promise to scale up the capabilities of M&S systems to meet the needs of training, analysis, acquisition, and the operational warfighter. By embracing commercial web technologies as a shared-communications platform and a ubiquitous-delivery framework, DoD M&S can fully leverage mainstream practices for enterprise-wide software development.

1.2 Scope

Web-based technologies have the capability to support interoperability of the spectrum of DoD models and simulations including constructive, virtual, and live as well as integrating legacy simulation frameworks and the increasingly important distance-learning technologies. This white paper describes the basis and initial requirements for such transformational interoperability through development of the Extensible Modeling and Simulation Framework (XMSF). The precepts of XMSF are:

- Web-based technologies applied within an extensible framework will enable a new generation of modeling & simulation applications to emerge, develop and interoperate.
- Support for operational tactical systems is a missing but essential requirement for such modeling and simulation applications frameworks.
- An extensible XML-based framework can provide a bridge between forthcoming M&S requirements and open/commercial Web standards.
- Compatible and complementary technical approaches are now possible for model definition, simulation execution, network-based education and training, network scalability and 2D/3D graphics.
- Web approach for technology, software tools, content production and broad use provides best business cases from an enterprise-wide perspective.

1.3 Current Shortcomings

Unfortunately a number of severe gating problems are evident in the current generation of defense-related modeling and simulation systems. Hundreds of active legacy applications have limited commonality, mixed levels of support and stove-piped interoperability. Despite the best efforts of numerous programs, the difficulties inherent in current M&S strategies have thwarted the deployment of tactically useful systems into the hands of warfighters. Interoperable software, networking and message semantics are needed at all levels of activity. This need for scalable interoperability is growing faster than ever before, as nearly all operations become coordinated joint/coalition efforts, and diverse new agencies for homeland defense and peacekeeping operations become critical partners.

- Leveraging successful commercial software imperatives is essential for feasibility, life-cycle supportability, fundability and product flexibility.
- Modeling and simulation is not a significant asset for U.S. operating forces.
- A spectrum of operational goals can be met: direct warfighting, homeland defense and coalition peacekeeping operations. Tactical needs are broad, immediate and interrelated, thus approaches must be scalable and take a global scope.
- Technical limitations are evident in current software. New capabilities are needed that still work correctly in small scale but can also grow/aggregate into much larger scales.
- Current DoD strategies are not leveraging the investments of the commercial sector in interoperable Web technology.
- Distance-learning technologies for audio/video/whiteboard/documents/ADL/SCORM are not compatibly augmenting or utilizing simulation technology

2 Postulates, Issues, and Challenges

XMSF has several high-level requirements derived from years of experience with M&S frameworks, and the challenges of their effective deployment across diverse networks and systems. It must enable simulations to interact directly and scalably over a highly distributed network through compatibility with the web framework and technologies. XMSF must be equally usable by human and software agents. Clearly it must support composable, reusable model components. For this reason, the Extensible Markup Language (XML) is the technology of choice for root data structure representations, with Resource Description Framework (RDF) and ontology-tagset support for semantics. XML also enables equivalent model representations to be autogenerated in a variety of human and programming languages. The following are key challenges for XMSF:

- Utilize Web-based technologies for more powerful and cost-effective government-wide networking, serving, client-side rendering and user interaction.
- Provide open, affordable, extensible modeling and simulation capabilities for tactical scenarios of direct use to participants engaged in conflict and peace operations.
- Employ mainstream practices of enterprise-wide software development.
- Improve ease of use for developers and users, fueling rapid growth of interoperable simulations.
- Provide support for all types and domains of M&S: constructive, live, virtual, and analytical.
- Models of interest reflect reality. Simulations and tactical engagements are each the behavior of models over time. Models and simulations need to match tactical requirements for <u>rehearsal</u>, <u>reality</u> and <u>replay</u> to meet operational needs.

3 <u>Web and XML Considerations</u>

XMSF will have a modular framework with kernel plug-ins to support extensions and modifications to framework layers as low as the network layer. The increasing focus on security means that XMSF must be underpinned by the strongest and most current web security technologies. To support real-world military secure communications systems XMSF must be compatible with currently fielded wireless, radio and wire military technologies to include SINGARS, UHF/VHF radios and Digital Subscriber Network (DSN). The ambitiousness of these requirements requires aggressive reliance on commercial technologies and active engagement with their standards development groups such as IETF, ISO, W3C, IEEE, and Web3D. All this means that adaptive, cross-platform capabilities will be a given. A particular strength of the XMSF approach is that many of the most difficult interoperability challenges are already being solved in due course by the development of tightly interdependent and highly complementary Web standards. This strategy can provide the most technically robust solutions, with the most reliable future-growth processes, and the best-case enterprise-wide business practices (i.e. DoD-wide and coalition-wide).

To meet these requirements, XMSF will employ object-oriented programs and validatable structured data in a language-independent and object-system-independent manner. Design patterns will unambiguously define language bindings by mapping representations and component models from root XML schemas to multiple programming languages and application programming interface (API) bindings, including the Interface Description Language (IDL). Software component functionality and interactions will be further documented using the Unified Modeling Language (UML).

3.1 Functional Requirements

Many of the functional requirements described below overlap, complement or build on one another. The crux of these requirements is that they are considered the key properties that a framework should have in order for it to be platform-independent, flexible, extensible, secure, distributed and dynamically reconfigurable.

3.1.1 Data Representation

Data is defined as any information of interest that is to be exchanged between two systems. The XMSF will need to be able to represent data in a language-independent manner. This means it's readable both by humans and by a complete variety of computer languages.

For clarification, computer language in this case refers to both computer programming language (e.g. C++, Java, Prolog) and platform (operating system) native machine language. This is typically addressed by using text-based standards.

A further requirement is that the data representation not only be suitable for machine processing, but also amenable to being read by humans. The logical implication of data being machine readable is that the data representation will need to be structured and self-defining.

For posterity, the data representation needs to allow for the facile extension of the represented data.

Finally, given the verbosity of text-based representations, the framework will need to support compression if such a representation is chosen. But compression should apply to both documents and streams equally. Further, it would be desirable that standard compression facilities be offered by the framework (probably as a code component).

The current state of standards evolution already accounts well for this. XML is an example (and currently the preferred standard) of a platform independent representation that also accommodates a human language independent representation of that data. Further, it is both machine readable and human readable, and extensible.

3.1.2 Service Description

A (web) service is defined as a logically coherent set of functions offered for invocation by a code component. A code component may expose more than one service.

As for data, the functionality offered by a code component will need to be represented in a computer language independent manner. This means that irrespective of the programming language (e.g. C++, Java, Fortran) used to develop the code component, and the platform on which it is deployed, the representation of the exposed functions and the parameters of those functions will need to be consistently represented.

The implication of the preceding paragraph is that the service description needs to be binding independent. The corollary of that implication is that the service description will need to define a binding specification.

If the underlying mechanism employed is the same as for data representation (e.g., XML), then many of the issues of platform independence will have been addressed already.

3.1.3 Graphical User Interface Description

A Graphical User Interface (GUI) is defined as a man-machine interface of a graphical (as opposed to a textual) nature. Typically these are things like windows, toolbars and dialogs, but 3D virtual environments are also encompassed.

In a similar manner to Service Descriptions, a GUI description will need to represent user interface elements in a computer-independent (language and platform) manner. Further, the GUI description will need to not only define the appearance of graphical elements, but also their behavior. In this case behaviour is the component's response to user stimulus.

The end aim of a GUI description is to define a consistent look and feel across operating systems.

3.1.4 State Transition Description

State transition is defined as the progression of a system through its logical states. In effect this will translate to the allowable sequences of messages.

Since we are now dealing with the logical domain rather than the physical domain, there are fewer issues of representation. If we consider the workflow representation to simply be data we wish to exchange between systems, then it suffices to use a computer-independent data representation to address platform independence issues. All that then remains is for a syntax to be developed for the workflow representation.

One key requirement is that even though a set of logical state transitions may be published, these should not reveal the internal logic (or internal state transitions) of the code component. What to publish should be at the discretion of the developing entity, and will very likely be a subset of the actual state transitions of the system.

3.1.5 Security Paradigm

Security is defined to encompass identification, authentication, authorization and encryption. Access restriction (permissioning) is considered to be the responsibility of the application.

It would be desirable that a framework such as the XMSF offer utilities (probably through a code component) that included one or more encryption paradigms. This would allow applications to interact in a standardized way if they did not need a specific encryption implementation.

The framework should also provide a standard for signing messages and documents. Note that the signature itself does not provide authentication, but rather associates an identity with data.

Following on from identification, the framework should define a standard for authentication. As for encryption, it would be preferable that a pre-existing mechanism (outside applications) be made available to provide authentication services. This could take the form of an authentication server.

A novel requirement that follows from the nature of dynamic reconfiguration is that there needs to be a mechanism for defining groups and group membership. Additionally, the membership of those groups needs to be dynamic. A further consideration is that the groups should be definable in such a way as to apply to either a single service, or span multiple services (as in the case of a distributed multi-application simulation).

3.1.6 Transactions

A transaction is defined as a logical set of changes that must be made as a single action, e.g. a funds transfer from one account to another must debit the source account and credit the destination account as a single action.

The usual paradigm that has been used for some time is that of the 2-phase commit. Unfortunately, this approach when applied to the Internet suffers from latency and heavy resource utilization.

An alternative approach that has been suggested recently is that of undo operations. The idea is that certain (simpler) actions can be reversed by another action, e.g. the request to be added to a mailing list can be undone by a request to be removed from the mailing list.

Nonetheless, a requirement of the framework is that a transaction standard (that may encompass more than one paradigm) needs to be defined and supported. The standard should allow for both simple situations that do not require the overhead of a 2-phase commit, but also for more complex situations where that do require a 2-phase commit paradigm.

3.1.7 Ontologies

An ontology is defined as a basis of meaning. This is a fundamentally difficult area, with much research in the last few years being devoted to the “semantic web”.

The first requirement in the area of ontologies is to define a taxonomy that can be applied across all domains within the XMSF. If nothing else this will allow for the consistent classification of data and services.

A subsequent requirement is that of consensual common meaning. It does not suffice for there to be agreed meaning within a group, but to be truly useful, there needs to be a mechanism for defining the equivalence of terms between groups. This will allow for both extensibility and for interoperability.

3.1.8 Repositories

A repository is defined as a logically related collection of information.

It should be relatively easy to see from the preceding sections that each level of "web service stack" will have one or more associated repositories. For the purposes of this whitepaper, the requirement for repositories will be assumed to be an implicit requirement of each of the preceding areas discussed.

One common requirement that will be necessary for effective use of the repositories is that a common interface be defined that allows consistent access to the contained information by search engines.

3.1.9 Search Engines

A search engine is defined as a code component that extracts information from one or more repositories that matches a specified set of criteria.

One of the great challenges of the Internet has been locating information. In order for the XMSF to not fall prey to the same shortcomings it will be necessary for the framework to provide a capable search engine.

The areas discussed in the preceding sections are a good starting point for the criteria by which to search the various repositories. Hence the search criteria should include, but not be limited to –

- Provider
- Type of Service
- Name
- QoS
- Security

3.2 Issues

- Identify standards for identification, authentication, authorization, and encryption.
- Recognizing XML's verbosity, how do we minimize impact on bandwidth? Consider compression standard(s).
- Identify standards for searching for types of services. Consider the implications for ontologies to establish commonalities between services. Identify areas where standards don't yet exist.
- Where are the schema/ontology repositories for common service representations?
    i. Generic Hub information-exchange data model
    ii. DARPA agent modeling language (DAML)
    iii. Resource Description Framework (RDF) ontologies
- Identify potential libraries of components which can be made public to support reusability, encourage interoperability, and reduce learning curves.

i. 3D models
ii. Portable computational models
iii. Software-agent templates with requested capabilities
iv. Stream-specific adaptors/components
v. Exercise simulation management
vi. Operational recording
vii. Order of battle

- Discuss push vs. pull architectural models.
- Discuss frameworks for agents: RDF, DAML, partnerships with other projects (e.g. ESG), etc.
- Discuss unambiguous autogeneration of behaviors in multiple languages.
- Given that many of the standards that are required are still nascent or not even defined, how do we minimize the impact of changing standards ?
- *Discuss XML-based wire protocols with a view to allowing run time extensibility.*[1]
- *Identify technology availability: immediate, near-term (1-2 years), likely (3-5 years), problematic.*

4 Networking, Streaming & Multimedia Considerations

Wire protocols will be defined unambiguously and flexibly in XML to allow rapid definition of application-specific data streaming formats that include run-time extensibility, portability and semantic interoperability, e.g. the NPS Dynamic Behavior Protocol. While the expectation is that users will have fast workstations (running any major operating system), XMSF will support a scaled list of capabilities to support users with a wide range of network bandwidths from modems through ADSL through gigabit networks.

4.1 Functional Requirements

4.1.1 End-to-end QoS

All parameters are measured end-to-end. This means they are measured between release by the sending application and availability to the receiving application, i.e. the host computer operating system is considered to be part of the network for these measurements. Delivery is defined as correct for reliable data if the data does not contain detectable errors, and for best-effort data if the specified loss rate and latency is not exceeded.

4.1.1.1 Average Data Throughput (Capacity)

The network meets a specified or negotiated standard, at specified or negotiated latency and jitter.

4.1.1.2 Peak (burst) Data Throughput

The network provides for a specified burst over average, for a specified or negotiated period, with a specified minimum inter-burst interval.

[1] Some issues were identified as spanning multiple topic areas. These issues are indicated by italics.

4.1.1.3 Average Latency

Within a specified or negotiated limit, typically 300 ms.

4.1.1.4 Average Jitter

Within a specified or negotiated limit, typically 10% of average latency.

4.1.1.5 Loss Rate

For best effort traffic, loss rate could be specified or it might be dynamically negotiated. In any case losses must be random, with a defined worst-case distribution.

4.1.1.6 Congestion Response

Observed network behavior that constitutes congestion should be specified, and the response of the end system to congestion should be specified or negotiated.

4.1.2 Many-to-many Multicast

4.1.2.1 Selectively Reliable (SR) Latest-value Multicast

Special case for distributed simulation: Traffic designated SR is delivered without detectable error or loss to all group members, subject to the limitation that when transmission is superseded by another before it is delivered, only the latest value need be delivered.

4.1.2.2 Reliable, Ordered Multicast (RM)

Traffic designated RM is delivered without detectable loss or error to all members of the group.

4.1.3 Streaming Multimedia

The network and middleware support streaming with configurable buffering period, as low as one RTT, in both unicast and multicast modes.

4.1.4 Network Monitoring

End systems are capable of reporting the end-to-end measurements to any legitimate participating host on a per-group basis when queried using a standard, message-based protocol.

4.1.5 Negotiation of QoS

A paradigm for the negotiation of the QoS needs to be developed. This must include default behaviour for the case when QoS is not explicitly negotiated, and the behaviour when the requested QoS cannot be fulfilled.

4.1.6 Object Request Broker

Network middleware, such as an implementation of the Common Object Request Broker Architecture (CORBA), should provide for seamless location of and access to software objects within a specified, internetted group of networks.

4.1.7 Group Coordination Middleware

Network middleware should support application group management functions such as simulation exercise initiation and floor control for education/conferencing. Minimum required functionality is the ability to have controlled exchange of a token that permits the holder to send multimedia and/or control traffic to the group. More sophisticated requirements are likely to emerge.

4.1.8 Session Coordination Middleware

Network middleware should support announcement of group activities with defined start and stop times and network resource/QoS requirements.

4.2 Issues

- Consider architectural trade offs for supporting QoS negotiations required to support computation, networking, rendering and physics as commodity items.
- Discuss establishment of 24 x 7 x 365 networked virtual worlds over DREN/Abilene/Web between NPS and GMU to show accessible/growing exemplars with network monitoring.
- Discuss server, push and streaming strategies for SEDRIS-compatible environmental data. What are the design patterns for weather servers?
- Discuss servers which make the full world visible/available as an expected resource, e.g.
    - i. Terrain
    - ii. Bathymetry
    - iii. Satellite imagery/sensors
    - iv. UAV/UUV imagery
- Discuss servers for high-resolution weapons-effect computations augmenting simpler client-side estimators, compatibly tied to corresponding servers for battle-damage assessment (BDA).
- Discuss servers for diverse physics interactions, e.g.
    - i. Radio/radar/sonar propagation
    - ii. Sensor prediction models
    - iii. Virtual sensors
- Discuss feasability of SNMP network monitoring support built in as first-class capability with automatic reporting and correlation available from cooperative centralized servers/analyzers.
- Discuss feasability of automatic setup, connection and tear-down of multicast streams corresponding to scenario needs using Area of Interest Management (AOIM) wizards.
- Identify design patterns and user-interaction paradigms for individual and collaborative scientific visualization and information visualization.
- How will XMSF address the general lack of availability of network multicast?
- How will XMSF address the general lack of QoS support available in production networks?
- *Discuss feasability of run time extensibility of wire protocols.*
- *Identify technology availability: immediate, near-term (1-2 years), likely (3-5 years), problematic.*

5 <u>Modeling & Simulation Considerations</u>

XMSF has a further critical requirement to integrate with tactical systems to augment the joint common operational picture. XMSF should be supported by a public library of useful reusable components and that provide rendering support and architectural hooks for visual simulations.

XMSF will incorporate time services for the support of discrete-event simulations, wide-area routing, and exercise/operations recording/playback. All XMSF services will be represented transparently as first-class objects in the framework, meaning that discovery mechanisms enable run-time extensibility even for future plug-in components.

5.1 Functional Requirements

5.1.1 Backward Compatibility

Backward compatibility with existing protocols such as DIS, ALSP, and HLA will enable XMSF to deliver existing M&S capabilities to new constituencies via the web.

5.1.2 Authoritative Representations

XMSF will provide mechanisms and formats for mapping existing authoritative representations between existing formats. The goal of this effort is not to develop authoritative representations, but rather to identify existing data formats and ensure the ability to map them.

5.1.3 Composability

XMSF must support multiple levels of model and component composability including enabling reasoning about the suitability of components for composition. This effort may initiate a longer term effort to develop ontologies for composability as the semantics of composition is outside the scope of XMSF itself.

5.1.4 Multi-resolution modeling

One of the challenges with model integration in general and composability in specific is identifying appropriate levels of model resolution for desired simulation. XMSF will need to provide mechanisms for labeling model resolution and reasoning about integration suitability based on these labels. This effort may initiate a longer term effort to develop ontologies for the labels as the semantics of these labels is outside the scope of XMSF itself.

5.1.5 Tactical System Integration

Sim-to-C4I integration is an ongoing issue of interest. XMSF will need to address this issue in addition to identifying other tactical systems whose integration with M&S will benefit the warfighter.

5.1.6 Simulation Support Services

5.1.6.1 Time Management

XMSF will support real time, scaled real time, time stepped discrete event, and event driven discrete event simulations. Doing so will require time management services which scale across a highly distributed, dynamic environment.

5.1.6.2 Logging and Playback

The highly distributed, dynamic nature of XMSF will exacerbate the already challenging problem of consistent, complete logging and playback in existing distributed simulation environments. Addressing this issue may entail defining an initial set of scenarios which drive logging and playback requirements.

5.2 Issues

- Discuss the shared goal of bringing working M&S applications matching real world problems into tactical use.
- Discuss approaches for backwards compatibility to HLA/RTI and DIS technologies which don't constrain emergence of new capabilities. Explore specific bridging approaches for HLA/RTI and DIS over web channels.
- Discuss compatibility with the Joint Technical Architecture (JTA), http://www-jta.itsi.disa.mil.
- Explore integration of C4I systems to augment joint common operational picture.
- Discuss approaches for playback capture.
- *Identify technology availability: immediate, near-term (1-2 years), likely (3-5 years), problematic.*

6 <u>Strategic Considerations</u>

In addition to specific technical considerations, XMSF's highly distributed and collaborative nature further requires addressing several logistic and business challenges.

6.1 Issues

- *Discuss establishment of 24 x 7 x 365 networked virtual worlds over DREN/Abilene/Web between NPS and GMU to show accessible/growing exemplars with network monitoring.*
- Identify approaches for gaining support of various service operational commanders plus OSD C4I and transformation agents as top-level sponsors.
- Discuss business model and logistics of open-source implementations.
- Identify models/scenarios for bottom-up demonstration of capabilities using scenarios of increasing sophistication and interoperability.
- List contrary technical attributes/conflicts which ought to be avoided.

7 Exemplar Demonstrations

Our choice of driving exemplars is very important. We want to demonstrate the ability to work on essential problems challenging U.S. and coalition defense forces. Diverse individual systems for communication, command and operations must support diverse organizational entities. Modeling and simulation capabilities must be demonstrated in the small (on a system-by-system basis) and in the large (within a scalable non-stove-piped framework). In some respects even individual systems can't be effectively modeled in isolation – they are deployed in concert on coordinated problems. Exemplar demonstrations tackling visionary defense scenarios must work across this range of scalable interoperability. Specific technical issues for scenario development follow.

Table 7-1. Vision Scenarios Provide Specific Technical Guidance for Development Requirements

- Develop simple, compelling, cross-cutting scenarios demonstrating the vision
    - i. Joint/coalition, overseas warfare, coalition peace keeping, amphibious raid for hostage rescue demonstrating diverse physics, perimeter defense
    - ii. Homeland defense against bio-terror: how to connect disparate inputs and provide a framework for successful cooperation despite systemic challenges
    - iii. Joint targeting problem, tracking with real-time updates in a dynamic conventional environment, include possible FCS and future Aviation (e.g., Multi-Mission Aircraft).
- Vignettes provide back story for exemplar software-capabilities demonstrations; when carefully chosen, these provide precise technical requirements for tactical capabilities
- Describe exemplar or validating scenarios showing goal capabilities 2-5 years
    - i. Command & control applications; decision support tools
    - ii. Need high flexibility due to diverse legacy mission-critical systems
    - iii. Ability to interoperate with commercial tools and databases
    - iv. Virtual worlds connect diverse models, datasets, data streams
    - v. Virtual environments for diverse interaction modes, palm-PC-Cave
    - vi. Vignette tasks drive technical needs for low latency, high throughput, ability to control sockets down to the network layer, etc.
    - vii. Don't look like a toy problem
    - viii. Don't look like "science fiction" since results have to look broadly achievable
    - ix. Keep message simple: connect existing technologies of immediate value to warfighter capabilities
- Show systems operating across 3-part spectrum: <u>rehearsal</u> using simulation, <u>real</u> for operations, <u>replay</u> for training/critique

7.1 Vision Vignettes: Defense Scenarios

- Coalition hostage rescue from terrorists holding one hundred ambassadors at a United Nations (UN) conference situated on a coastal city in the Middle East.
- Multiple U.S. agency bio-terror response to simultaneous epidemic outbreaks centered at Dulles and San Francisco International Airports.
- Conventional forces with complex real-time targeting problem, small scenario. Possible Future Combat System (FCS) scenario.

8 The Path Forward

For XMSF strategies to succeed, supported applications must succeed broadly and thus successful development must be enabled for many participants through a sustainable business model. The minimal framework will be a royalty-free open source implementation, but interoperable commercial implementations are equally important to sustainability. This business model engages successful business models for both military simulation and the Web, enabling more sponsors to participate and also enabling diverse simulations, models, and applications to survive despite intermittent funding profiles. The model also makes it possible for programmers and managers to develop transferable, career-building skills and reusable experience, reinforced despite any employer flip-flops, through the availability of open-source example implementations.

8.1 Partnerships

Where's the market for industrial partners? In many ways it is the same market we have today. There will still be a need for expert support, development of proprietary models and tools, consulting and integration, and maintenance. For DoD partners, the use of commercial and transportable technology is crucial. With shrinking budgets and expanding requirements, spending too much for unique, proprietary or perishable technology is no longer a sustainable option. DoD can benefit most by slipstreaming with Web-wide standards and industry best practices. T

The following table provides a simple overview summary of relationships necessary for broad success. These provide a basis for workshop invitations and will be elaborated in the group report.

Table 8-1. Liaison Relationships Needed for Utilizing and Influencing XMSF-related Standards

- Consortia and Standards Bodies
    i. World Wide Web Consortium
    ii. Web3D Consortium
    iii. OASIS
    iv. ISO
    v. IEEE
    vi. IETF
    vii. SISO
    viii. Others
- Service M&S Management Offices
    i. DMSO
    ii. NAVMSMO
    iii. AMSO
    iv. AFAMS
    v. MCMSMO
- SECDEF Initiatives
    i. NATO Generic Hub (Trilogy) C^4I Tagset Semantic Interoperability
    ii. Future: inevitable need to find web-based interoperability solutions
- Navy Initiatives
    i. Task Force Web
    ii. IT21, NMCI, portals
    iii. DON CIO XML Working Group
    iv. NUWC submarine/shipboard combat control systems
- Army Initiatives
    i. SMART
    ii. Army Data portal

  Initiatives in other services: seek out corresponding partnerships

8.2 Candidate Technologies

- XML technologies: XML schemas, stylesheets, validators, repositories. Guarantees interoperability, availability, clarity and best business practices for most (and probably hardest) architectural challenges
- Family of open-standard XML languages including

i. XHTML
ii. Scalable Vector Graphics (SVG) for 2D
iii. Extensible 3D (X3D) Graphics
iv. MathML
v. Synchronized Multimedia Integration Language (SMIL)
vi. Extensible Stylesheet Language for Transformations (XSLT)
vii. XML Schema Description Language
viii. Document Object Model (DOM)
ix. Others as appropriate

- Broad suite of open and commercial-grade tool support
- E-business, U.S. government, DoD and service: registries and repositories for XML
- Web Services – furious activity underway (SOAP, registries, etc.)
- Dynamic Behavior Protocol: XML-defined packet payloads providing extensible/discoverable/validatable protocols customized for diverse applications
- XML data interchange standards
- Network Time Protocol (NTP) and GPS plugins for globally networked time
- Virtual reality transfer protocol (vrtp) to provide integrated suite and URL accessibility for content-author use of these diverse network protocols
- ADL/SCORM for integration of instruction with simulation (and vice versa) for the purposes of training to employ simulations, interacting with story-engine and game-play simulations as instructional content, etc.
- Make deployment and duplication easily repeatable: Web-browser plugins, installers, updaters, server builders as extensible one-click/automatic utilities
- Real-time Transport Protocol (RTP) header mechanisms for diverse behavior-based streams to maximize WAN routability as unicast, multicast
- Making reliable multicast protocols available
- Lightweight Directory Access Protocol (LDAP) capabilities within a Web framework and possible suitability for broad and diverse shared-state-consistency support
- Session Announcement Protocol (SAP) and Lightweight Directory Access Protocol (LDAP) suitability for advertising arrival of entities and availability of services for large-scale widespread distributed simulations/operations
- Availability of multicast fabric despite long-standing delays in deployment, possible benefits for bandwidth-constrained tactical networks, and whether new approaches such as Java JXTA or Cisco routers provide new capabilities (or at least address long-standing barriers to deployment)
- Suitability of internationalization (i18n)/localization (l10n) via XML and other approaches

- Extreme programming: design patterns and team practices for effective cross-platform, cross-technology software integration and life-cycle sustainability
- NPS-directed SIGGRAPH 2001 Online project. http://cave.cs.nps.navy.mil/contents.html

9 Glossary

ADL	Advanced Distributed Learning
AMG	(HLA) Architecture Management Group
AMSAA	Army Materiel Systems Analysis Agency
AOIM	Area of Interest Management
API	Application Programming Interface
BDA	Battle Damage Assessment
CMM	Capability Maturity Model
CORBA	Common Object Request Broker Architecture
DAML	DARPA Agent Markup Language
DIS	Distributed Interactive Simulation
DOM	Document Object Model
DREN	Defense Research & Engineering Network
DSN	Digital Subscriber Network
ESG	Expeditionary Sensor Grid
FCS	Future Combat System
GCCS	Global Command and Control System
GMU	George Mason University
GPS	Global Positional System
HLA	High Level Architecture
IDL	Interface Description Language
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
I/ITSEC	Interservice/Industry Training, Simulation & Education Conference
ITEM	Integrated Theater Engagement Model
ISO	International Standards Organization
JTA	Joint Technical Architecture
JXTA	"Juxtapose" – Next Generation Jini
LDAP	Lightweight Directory Access Protocol
MAGTF	Marine Air-Ground Task Force
M&S	Modeling and Simulation
MEDAL	Mine-warfare Environmental Data Analysis Laboratory
MMA	Multi-Mission Aircraft
MOVES	Modeling, Virtual Environments, and Simulation
MTF	Message Text Format
MTWS	MAGTF Tactical Warfare Simulation
NEW	Network Education Ware
NGIC	U.S. Army's National Ground Intelligence Center
NMCI	Navy Marine Corps Internet
NIMA	National Imagery and Mapping Agency
NPS	Naval Postgraduate School
NPSNET	NPS Network
NSF	National Science Foundation

NSS	Naval Simulation System
NTP	Network Time Protocol
OASIS	Organization for the Advancement of Structured Information Standards
RDF	Resource Description Framework
RTI	(HLA) Run Time Infrastructure
RTP	Real-time Transport Protocol
SAF	Semi-Automated Forces
SAIC	Science Applications International Corporation
SAP	Session Announcement Protocol
SAVAGE	Scenario Authoring and Visualization for Advanced Graphics Environments
SCORM	Sharable Content Object Reference Model
SEDRIS	Synthetic Environment Data Representation Interchange Standard
SEI	Software Engineering Institute
SIGGRAPH	(Associate for Computing Machinery) Special Interest Group on Graphics
SISO	Simulation Interoperability Standards Organization
SIW	Simulation Interoperability Workshop
SMART	(Army) Simulation Modeling Acquisition Requirements & Training
SMIL	Synchronized Multimedia Integration Language
SNMP	Simple Network Management Protocol
SOAP	Simple Object Access Protocol
TRAC	(Army) Training & Doctrine Command Analysis Center
UAV	Unmanned Aerial Vehicle
UDDI	Universal Description, Discovery and Integration
UML	Unified Modeling Language
UUV	Unmanned Underwater Vehicle
W3C	World Wide Web Consortium
WSDL	Web Services Description Language
X3D	Extensible 3D Graphics
XHTML	Extensible HyperText Markup Language
Xj3D	Extensible Java 3D Graphics
XML	Extensible Markup Language
XMSF	Extensible Modeling and Simulation Framework
XSLT	Extensible Stylesheet Language for Transformations

10 References

To be provided by workshop participants.