Extending Capabilities of the Military Scenario Definition Language (MSDL) for Nontraditional Warfare Scenarios

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ABSTRACT: *The Military Scenario Definition Language (MSDL) version 1.0 was recently approved as a new international standard by the Simulation Interoperability Standards Organization (SISO). MSDL is intended to be used as a common data representation for storing scenario information for use in initializing a variety of simulation systems. In today's Joint Operational Environment, the Military component is only one of six complex dimensions that need to be simulated, the others being Political, Economic, Social, Infrastructure, and Information (making up the common PMESII acronym). Stability Operations have been elevated to have equal weight with combat operations, creating new emphasis on the other five dimensions in training and analysis simulations. Under the mandate for the military to support Stability, Security, Transition, and Reconstruction (SSTR) Operations, military decision makers are focusing on new areas of concern, including the fundamental mission of restoration of essential services. In order for MSDL to maintain its relevance, an enabling framework must be incorporated. The first step is to provide schema designs for essential services and how entities relate to each other from the social aspect. This paper provides a design that can be easily adapted to military supplies, relief supplies, and other similar concerns. In addition, a basic building block for description of social relations is proposed that represents one such theory.*

1. Introduction

DoD uses a variety of modeling and simulation systems for analysis, training, experimentation, acquisition, and mission planning and rehearsal. Often there is a requirement to represent the same operational situation in multiple systems to serve these various purposes or to examine a problem from different perspectives. For example, a scenario used in a training exercise may be needed to conduct analysis of future force structures, or vice versa. Or, a scenario used for conducting certain analyses may be employed in an operational experiment evaluating new Command and Control (C2) systems or new tactics, techniques, and procedures (TTPs). Many events now use a federation of M&S systems to represent battlespace entities and dynamics. Because of differences in design of the individual federates, common aspects of the scenario have to be expressed in different ways to be understandable to the individual software. The individual M&S system (or federate) representations are not easily interchangeable, even though they often represent very similar aspects of the situation, such as force structures, initial plans and orders, weather conditions, and terrain. It is not currently possible to use a single description of a scenario to initialize common aspects of the battlespace across all federates.

Version 1.0 of the Military Scenario Definition Language (MSDL) [1] was approved by the Simulation Interoperability Standards Organization (SISO) as an international standard in October 2008. The language specifies force structures, environment, and other information for initialization of simulation systems. The standard specifies an Extensible Markup Language (XML) schema to provide a common mechanism for validating and loading military scenarios, to promote sharing of scenario files across simulation and C2 systems, and to improve scenario consistency among federated simulations. Now that the standard has been approved, it is important for the community to understand the nature and scope of MSDL and to explore application of the standard across a variety of M&S contexts. While MSDL may benefit an individual system by providing a well-defined, well-organized expression of scenario information, its greatest benefit to the M&S community will be through broad adoption permitting multiple systems to share scenario descriptions.

In today's Joint Operational Environment, the Military component is only one of six complex dimensions that need to be simulated. Decision makers in today's Joint Operational Environment speak of taking Diplomatic, Information, Military, Economic, Financial, Intelligence, and Law Enforcement (DIME-FIL) *actions* to create desired Political, Military, Economic, Social, Infrastructure, and Information (PMESII) *effects*. Department of Defense Directive 3000.05 placed Stability Operations on equal footing with combat operations:

> "Stability Operations are a core U.S. military mission that the Department of Defense shall be prepared to conduct and support. They shall be given priority comparable to combat operations and be explicitly addressed and integrated across all DoD activities including doctrine, organizations, training, education, exercises, materiel, leadership, personnel, facilities, and planning." [2, p2]

The M&S community has long focused on the military dimension. Now, modeling requirements and development need to expand to determine appropriate representations of the other dimensions of the modern battlespace. The new Army Field Manual on Stability Operations, FM 3-07 [3], describes Stability Operations as follows:

> "Stability operations aim to stabilize the environment enough so the host nation can begin to resolve the root causes of conflict and state failure. These operations establish a safe, secure environment that facilitates reconciliation among local or regional adversaries. Stability operations aim to establish conditions that support the transition to legitimate host-nation governance, a functioning civil society, and a viable market economy." [3, p3-2]

FM 3-07 identifies the following categories and sub-categories of essential stability tasks ("those that the force must successfully execute to accomplish the specific mission"):

- Establish Civil Security
  - Enforce cessation of hostilities, peace agreements, and other arrangements
  - Determine disposition and constitution of national armed and intelligence services
  - Conduct disarmament, demobilization, and reintegration
  - Conduct border control, boundary security, and freedom of movement
  - Support identification
  - Protect key personnel and facilities
  - Clear explosive and CBRN [chemical, biological, radiological, and nuclear] hazards
- Establish Civil Control
  - Establish public order and safety
  - Establish interim criminal justice system
  - Support law enforcement and police reform
  - Support judicial reform
  - Support property dispute resolution processes
  - Support justice system reform
  - Support corrections reform
  - Support war crimes courts and tribunals
  - Support public outreach and community rebuilding programs
- Restore Essential Services
  - Provide essential civil services
  - Tasks related to civilian dislocation
  - Support famine prevention and emergence food relief programs
  - Support nonfood relief programs
  - Support humanitarian demining
  - Support human rights initiatives
  - Support public health programs
  - Support education programs
- Support to Governance
  - Support transitional administrations
  - Support development of local governance
  - Support anticorruption initiatives
  - Support elections
- Support to Economic and Infrastructure Development
  - Support economic generation and enterprise creation
  - Support monetary institutions and programs
  - Support national treasury operations
  - Support public sector investment programs
  - Support private sector development
  - Protect natural resources and environment
  - Restore transportation infrastructure
  - Restore telecommunications infrastructure
  - Support general infrastructure reconstruction programs

A brief perusal of these tasks indicates the extent of the new challenge to the M&S community. The scope of the current MSDL standard evolved from a focus on combat operations. Clearly, to remain relevant as we address the new challenges of Stability Operations, the community needs to examine possible extensions to MSDL for models relating to the kinds of tasks identified above.

As a start in this direction, this paper considers one of the essential tasks from FM 3-07, restoration of essential services (e.g., sewage, water, electricity, education, trash, medical, and safety). This involves devising schema designs for essential services and how entities relate to each other from the social aspect. This paper provides a design that can be easily adapted to military supplies, relief supplies, and other similar concerns. In addition, a basic building block for description of social relations in scenario data is proposed.

2. Overview of MSDL

The top-level structure of the MSDL XML schema is shown in Figure 1.[1] The following subparagraphs provide brief overviews of the MSDL data model. It is not possible to provide a complete description of MSDL in this paper. The reader is referred to the current MSDL specification and XML schemas for a full description of the language.

2.1 Primary Scenario Constructs in MSDL

MSDL describes locale, forces, intelligence, situation, and course of action for re-use across multiple C2 and M&S systems. The MSDL Specification [1] defines a military scenario as "a specific description of the situation and course of action at a moment in time for each element in the scenario." The scenario description largely reflects common Mission, Enemy, Terrain and weather, Troops and support available, Time available and Civil considerations (METT-TC) elements of a military situation. The purpose is to provide the M&S community with:

- A common mechanism for validating and loading military scenarios.
- The ability to create a military scenario that can be shared between simulations and C4I[2] devices.
- A way to improve scenario consistency between federated simulations.
- The ability to reuse military scenarios as scenario descriptions are standardized throughout the Army, Joint, and international communities and across simulation domains; e.g. training exercise, analysis, etc.

Scenario *elements* can be individual items of equipment, such as a tank or aircraft, or aggregates of troops and equipments, such as an infantry company. The *reality* of the situation reflects known or established content in the scenario, such as a certain force structure being employed to conduct an operation in the simulation or terrain and weather conditions set for the execution. These descriptions are exact and not the result of interpretation by the scenario elements. *Intelligence information* reflects knowledge of the battlespace that an entity or force may possess at the outset of the execution, such as knowledge of enemy force positions and activities. This information may be incorrect and incomplete, but represents what is known when the execution begins (and on which simulated entities may begin making decisions and taking action). Some simulations do not start with such information, but establish battlespace awareness through simulated detections as the entities and forces begin to interact in the simulation.

The MSDL description of the scenario is expressed as an XML file conforming to an XML schema described and provided in the SISO specification. The MSDL XML schema defines one global element, the *MilitaryScenario* root element. All other constructs in the language are defined as global types, either complex or simple types, to maximize reuse of the definitions in creation of other XML languages. MSDL also has extensibility provisions through the use of the XML Schema *any* construct. This permits an MSDL XML document to contain XML structures defined elsewhere.

We can examine the content of an MSDL description by examining the structure of the language defined in the XML schema. The root element of the XML file is called *MilitaryScenario* and contains the following child elements (the descriptions here are illustrative, not exhaustive):

- *ScenarioID* (mandatory) – provides identification of the scenario and its purpose.
- *Options* (mandatory) – provides global parameters about the scenario and its content.
- *Environment* (optional) – describes the simulated physical environment in which the execution is to occur (e.g., area of interest, weather, time).
- *ForceSides* (mandatory) – describes the structure of the forces and sides involved in the execution.
- *Organizations* (optional) – describes the structure of the units and equipment involved in the execution.
- *Overlays* (optional) – describes the logical overlays used to group the intelligence elements/instances in the scenario. Ownership of a specific overlay is determined through the intelligence elements/instances contained in that overlay.
- *Installations* (optional) – describes the detected installations as determined by the intelligence gathering process of each force, side, or unit individually.
- *TacticalGraphics* (optional) – describes the tactical information as known by a particular force, side, or unit individually.
- *MOOTWGraphics* (optional) – describes the detected MOOTWGraphics[3] instances as determined by the intelligence gathering process by each force, side, or unit individually.

[1] The *msdl:* prefix in element and type names in the MSDL XML schema refers to the MSDL namespace "urn:sisostds:scenario:military:data:draft:msdl:1". Solid boxes in the figure denote required elements; dashed boxes indicate optional elements.

[2] C4I: Command, Control, Communications, Computers and Intelligence

[3] MOOTW: Military Operations Other Than War. Current terminology is Stability, Security, Transition, and Reconstruction (SSTR) Operations (see [2]).

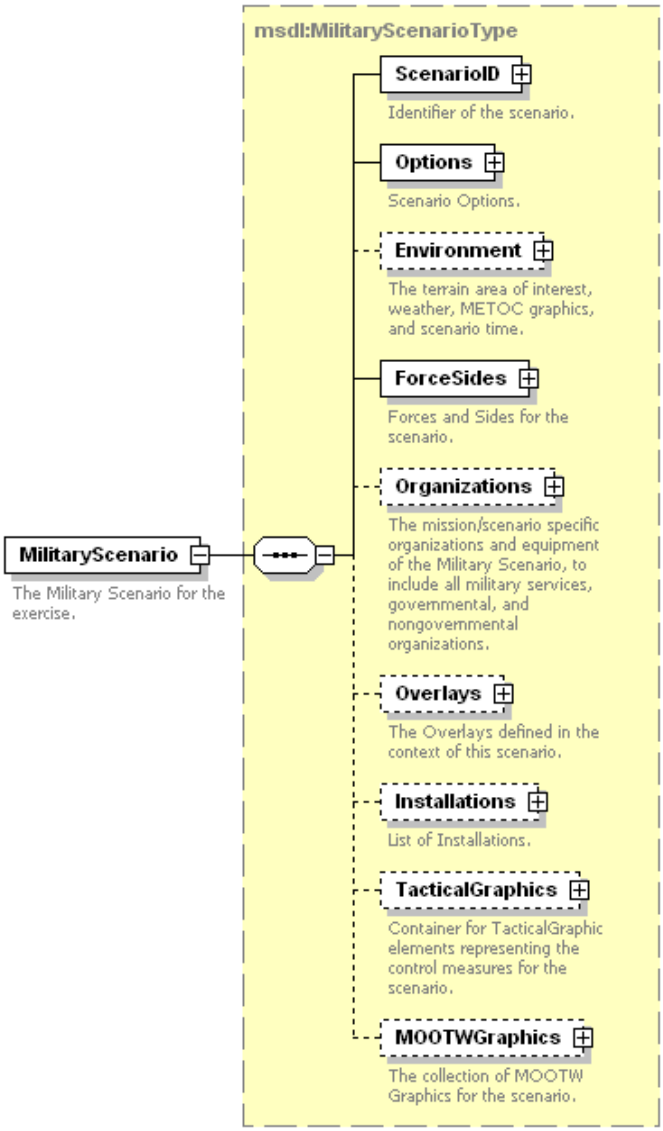

Figure 1. Top-Level MSDL Schema Structures

The ScenarioID element contains metadata about the scenario, including the following information: (1) name assigned to the scenario; (2) type of object model; (3) version of the scenario file; (4) date of last modification; (5) classification level; (6) release restrictions; (7) purpose of the scenario; (8) type or class of application to which the scenario applies; (9) description; (10) any limitations on use of the scenario; (11) history of use; (12) keyword (and identification of taxonomy) characterizing the scenario; (13) identification of the organization or person who has a particular role with respect to the scenario; (14) type and identity of any reference; (15) identification of a glyph for visually representing the scenario; and (15) other data deemed relevant by the scenario author. The ScenarioID element, defined through the ModelID schema, includes the *any* compositor, which allows any XML structure from other languages to be inserted and retain validity against the MSDL schema.

The XML design of MSDL employs certain vocabulary from other XML schemas; namely: (1) *ScenarioID* metadata defined in the ModelID_v2006.xsd schema from the Base Object Model Specification (SISO-STD-003-2006) [4]; and (2) meteorological and battlespace domain values defined in the Joint Command, Control, and Consultation Information Exchange Data Model

(JC3IEDM[4]) schema JC3IEDM-3.1-Codes-20061208.xsd. The MSDL XML schema declares namespaces assigned to these external schemas and imports these schemas in support of the definition of MSDL-specific elements and attributes.

The use of namespaces is important in dealing with XML vocabularies – the namespace enables a particular term to be uniquely identified within an XML document while permitting multiple vocabularies to be combined to create more complex languages, as in the case of MSDL's use of the ModelID and JC3IEDM vocabularies.

2.2 Scenario Representations in MSDL for Stability Operations

Standard structures in MSDL can describe factions and non-military, para-military, governmental, and non-governmental forces, but there are no data structures relating to political, economic, and social aspects, and very little relating to infrastructure (only the limited representations available in the *Installations* element).

The *MOOTWGraphics* element (MOOTW: Military Operations Other Than War; now referred to as SSTR Operations) is used to specify MOOTW information defined for the scenario. MOOTW graphics represent tactical information that is part of the common operational picture of the force, side, or unit specified in the *Owner* element of a *MOOTWGraphic* element. Each *MOOTWGraphic* element is described by a unique identifier (required), a symbol identifier (required), an affiliation (required), an owner (required), symbol modifiers, a list of associated overlays, symbol class modifiers, and a disposition (required). The graphics are tied to the MIL-STD-2525B [5] standard providing parameters for graphical icons indicating various information relevant to non-traditional or irregular warfare. For example, the parameters can describe a variety of actions such as death-causing violent activities (e.g., arson/fire, bomb/bombing, booby trap) and operations (e.g., recruitment, demonstration, food distribution, extortion, kidnapping), or various items such as refugees, known insurgent vehicle, or drug vehicle. These selections are currently limited to the parameter values provided in the MIL-STD-2525B.

[4] JC3IEDM is a well-established data model maintained by the Multilateral Interoperability Programme (MIP). See http://mip-site.org.

3. Modeling Approach and MSDL Extensions

The purpose of this work is to investigate methods for extending MSDL data structures for scenarios that incorporate PMESII aspects of warfare. As discussed earlier, the work focused on the stability operations task of restoring essential services. Such representations would be needed, for example, to simulate situations where we are interested in investigating civilian population responses to coalition actions regarding restoration of essential services (e.g., "Do such actions promote civilian support for the legitimate government?"). Before identifying portions of the MSDL data model of interest, we describe some of the modeling concepts involved.

Commanders and military simulation users recognize that the primary focus of military support to SSTR operations is the local populace. A first step in adding value to simulations is to frame the schema for this social dimension. Many social theorists use arc-node networks to describe and analyze social interactions. This has direct overlap with the Joint Operational Environment social dimension. The nodes represent an entity of importance to the simulation (e.g., an individual, a family, a population group) and the arcs represent relationships between nodes.

The nature of the relationship represented by the arc is the subject of numerous social theories. We chose to apply an approach where the social arcs or ties are of three different types: affective, authoritative, and instrumental [6]. An *affective* tie is characterized by a family/friendship relationship. An *authoritative* tie exists for entities that have a superior/subordinate relationship. Many of the military command relationships can be characterized as authoritative ties. The *instrumental* tie describes relationships that exist for business or commercial exchanges of goods and services. According to this social theory, the three social ties are an all-inclusive list. MSDL's current representation of the military force structure uses a single connection "up the chain of command." In other words, a subordinate unit has the commander's handle as an optional data element that establishes a command link. However, in the social dimension these links are not symmetrical and require the arc to be represented from the source node to another node in a single direction. Keeping in line with the commander's link precedent, the proposed social schema can be nested under the source unit to store the destination unit's handle in addition to other relevant arc data. As such, each of the ties can be specified separately in the proposed MSDL data structure. For two recent uses of

this theory at the Naval Postgraduate School, the social tie data was specified as a floating point number between -1.0 and 1.0. Social theory supports this representation; however, simulations may utilize the number for different purposes. Examples include the Representing Cultural Geography for Stability Operations project at the US Army Training and Doctrine Command Research and Analysis Center, Monterey (TRAC-Monterey), where the number was restricted to values between 0.0 and 1.0 and used as a probability of propagating social events. Another example is the Beris/Whittington thesis that simulated restoration of essential services and utilized the larger range of the floating point number as a sorting key for prioritizing social events to be executed [7].

With respect to representation of resources for describing the flow of materials from essential services such as food and water, the holdings of units need to be extended to track various kinds of resources (i.e., supplies), of various quantities. Similar to the approach for social ties, the proposed supply element uses a string handle as the primary key and introduces wrapper elements that are common to any mathematical containers to describe different units of measure.

XML Schema complex and simple data types developed for these models are shown in Table 1 below. To incorporate the information into the MSDL structure, we chose to define new complex types that reuse data structures from the MSDL schema, rather than directly modifying the MSDL data structures and schemas. One advantage of this approach is that a scenario stored in the standard MSDL format can be easily converted to an "SSTR-extended" scenario file using the Extensible Stylesheet Language Transformations (XSLT) by simply copying over the standard MSDL content into respective parts of the extended structure (and vice versa). We defined a new complex type for the root element of the extended scenario structure, The new root element is called *SSTRExtendedMilitaryScenarioType*,. This is shown in Figure 2. Relevant components of the MSDL data model extended by the SSTR structures include units, unit organizational relationships, equipment ownership, and graphic overlays (OOTW, Infrastructure, etc.).

Table 1. SSTR Extensions to MSDL

Data	Name	Description
complexType	SSTRExtendedForceSidesType	Forces and Sides for the scenario.
complexType	SSTRExtendedForceSideType	Force or Side description information.
complexType	SSTRExtendedAssociationsType	Associations between forces and sides.
complexType	SSTRExtendedAssociationType	Association between this force/side and another force/side.
complexType	SSTRExtendedUnitsType	The identification of Units of a Military Scenario.
complexType	SSTRExtendedUnitType	The description of a Unit of a Military Scenario.
complexType	SSTRExtendedOrganizationsType	The mission/scenario specific organizations and equipment of the Military Scenario, to include all military services, governmental, and nongovernmental organizations.
complexType	SSTRExtendedMilitaryScenarioType	The complex content of a Military Scenario.
complexType	SSTRExtendedOptionsType	Scenario Options.
complexType	TiesType	Container for the three types of social ties between entities.
complexType	TieType	Represents a specific connection between two entities.
complexType	ComprehensiveRelationshipType	Contains the standard MSDL Relationship and the Ties container element.
complexType	QuantityType	Data type that will represent a numeric value and the corresponding measurement type.
complexType	SuppliesType	Container for Supply Type.
complexType	SupplyType	Used to represent supplies that a military simulation relevant unit might need. (Bullets, Water, etc.)
complexType	UnitOfMeasurementsType	Represents the data associated with the measurement system. Used in conjunction with Quantity Type elements.
complexType	ResourcesType	Container for Military Resources used in the scenario.
complexType	ResourceType	Defines the framework for basic resources. These resources can be required resources for military equipment or personnel.
simpleType	enumUSVolumeMeasurement	List of common Units of Measurement for supplies and resources.

Data	Name	Description
simpleType	enumMetricVolumeMeasurement	List of common Units of Measurement for supplies and resources.
simpleType	enumMetricMassMeasurement	List of common Units of Measurement for supplies and resources.
simpleType	enumMetricMagnitudeModifier	List of magnitude modifiers such as Kilo and milli.
simpleType	enumUSMassMeasurement	List of common Units of Measurement for supplies and resources.
simpleType	enumLoadType	List of resource and supply load templates
simpleType	VolumeMeasurementType	Union of Enumerations that restrict to acceptable Units of Measure.
simpleType	MassMeasurementType	Union of Enumerations that restrict to acceptable Units of Measure.

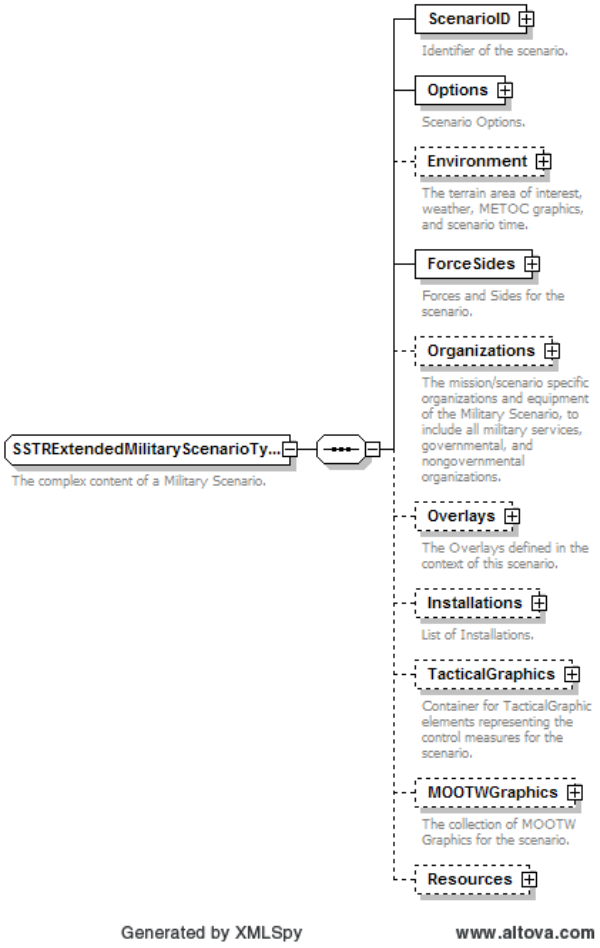

Figure 2. SSTR-Extended Military Scenario Element

A quick comparison of the *SSTRExtendedMilitaryScenarioType* structure with the standard MSDL *MilitaryScenario* structure shown in Figure 1 reveals an identical structure at this level of the scenario file, with exception of the addition of the *Resources* element to describe various kinds of resources (water, food, fuel, etc.) represented in the scenario. It is not possible in this paper to describe in detail all of the SSTR-extended data types listed in Table 1. Instead, the following discussion provides a brief overview of several of the changes made in MSDL data structures to support the SSTR modeling. For further detail, the XML Schema can be requested from the authors.

At the metadata level, the MSDL *Options* element was changed in our *SSTRExtendedOptionsType* to provide a version number for the associated social and essential services model (see [7]). This is peculiar to our modeling effort, but can be considered as a general approach for other implementations.

The *ForceSides* element structure was changed in our *SSTRExtendedForceSidesType* to add a parallel structure to the MSDL *ForceSide* element called *SSTRExtendedForceSide*. This element has the same structure as the MSDL *ForceSide*, but with removal of the optional *MilitaryService* element which is not considered to be applicable to the representation of civilian populations in the scenario. Our *SSTRExtendedForceSideType* provides a structure that can be modified as needed to address other aspects of civilian population modeling. Within this type is the Associations element. We extended this element structure to provide description of ties (affective, authoritative, instrumental) to other force-side entries to define the social network.

The *Organizations* element structure still has container elements for *Units* and *Equipment*, but the *Units* element is extended to provide a list of MSDL Unit elements and our *SSTRExtendedUnit* elements that are used to identify and describe non-military units in the scenario (e.g., non-governmental organizations, civilian population groups, etc.). The latter have a new *Supplies* child element to describe supplies the unit possesses at the beginning of the scenario execution.

The Supplies structure provides a handle to a type of supply, a quantity (amount and unit of measurement), and a list of one or more suppliers for that item.

4. Conclusion

In order to prevent future versions of MSDL from being incompatible with previous versions utilized by simulations, MSDL extensions should reuse existing structures or use an "either/or" approach as illustrated in this paper until the extension is fully embraced by the community and integrated into the standard. Existing MSDL structure includes the use of string *handles* as the primary key for data structures. Also, when two entities are connected, the destination key is stored under the source element. The current work continues that approach for describing social connections. The *ties* container element provides capability for further extension. If other tie types are desired, the *ties* element can be "extended" to allow for a new tie type and associate range of values. Also, the simplicity of just a number stored in the schema allows for future extensions to store more information as required.

Preliminary investigations into the application of MSDL are revealing broad applicability for scenario description and interchange across numerous systems [8]. Various organizations are already moving forward on development of scenario generation tools using MSDL as the common interchange format to produce initialization data for multiple simulation programs (e.g., see [9, 10]). MSDL has a well-defined scope of coverage that maintains coherence and ease of use to help achieve the greatest level of acceptance. However, to maintain its relevance with new directions in military M&S development, the MSDL PDG needs to consider other aspects of the battlespace beyond just the military dimension. This is still a very immature and growing area, so collaboration across many projects and nations will be needed to obtain the greatest benefit to emerging capabilities. Others in the M&S community are encouraged to comment on these issues through participation in the workshops or MSDL PDG activities.

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