BUILDING AN INTEROPERABILITY SPECIFICATION FOR THE MARINE CORPS

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ABSTRACT

This paper describes an ongoing effort to define an interoperability specification for the Marine Corps, specifically the Marine Air Ground Task Force (MAGTF) training community. The focus of the research effort is on combined arms training in a distributed Modeling and Simulation (M&S) environment. The interoperability specification is built upon the High Level Architecture (HLA), and it includes the development of a Conceptual Model of the Mission Space, an HLA Federation Object Model (FOM), and an interoperability agreements specification to compliment the FOM. The development of this specification is addressing a wide range of considerations. It is addressing Marine Corps operations, doctrine and programmatic considerations, which emphasize the need to address a heterogenous set of mission domains in order to support such concepts as asynchronous warfare and operations other than war (OOTW). It is addressing issues of fidelity related to modeling the warfighter's perspective of the mission, support of an integrated learning methodology to facilitate control of the environment and measurement of performance and effectiveness, and support of scalable training at both the team and individual levels. This project is also addressing issues related to compatibility with training systems that are currently in the development cycle, as well as implementation of a flexible and evolutionary design to accommodate technological advancements. The primary purpose of this specification is to facilitate standardized interoperability of future Marine Corps training systems. This paper is a follow-up to one that was published last year entitled "Baseline Interoperability for Marine Corps Air and Ground Simulators: The Marine Air Ground Task Force Federation Object Model (MAGTF FOM)".

BIOGRAPHICAL SKETCH

Mark Biddle is a senior systems engineer with over six years of experience in the distributed interactive simulation industry, and eight years of experience with in-service engineering support of mission critical systems. He has performed project management, requirements analysis, systems engineering, design, integration and testing in a program manager and project lead capacity for two years with SAIC, four years with the Naval Air Warfare Center Training Systems Division, and eight years with the Naval Undersea Warfare Center. Mr. Biddle received his Masters of Science degree in Engineering Management from Old Dominion University in Norfolk Virginia, and a Bachelor's degree in Electrical Engineering from the Pennsylvania State University.

Mr. Steve Zeswitz is an Information Systems Engineer with the MITRE Corporation. His work is focused on advanced Modeling and Simulation applications that support Marine Corps operational forces. He is currently supporting the Marine Corps' Training and Education Command and the Commander, Marine Forces Atlantic. Mr. Zeswitz has been active in the Modeling and Simulation community for the last 7years. Prior to joining the MITRE Corporation he served as the Chief, Technology Applications Division of the Defense Modeling and Simulation Office and as the Lead Scientist for the Marine Corps Modeling and Simulation Management Office.

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BACKGROUND

The United Stated Marine Corps continues to increase its reliance on simulators to prepare for tactical operations and augment live-fire training. To fully capitalize the benefits of the USMC simulator investment, these systems must support the Marine Corps' need for collective, combined arms tactical training for battalion, company and platoon operations. Efficient and effective training is vital for Marine Air Ground Task Forces (MAGTFs) to maintain balanced, highly trained combined arms teams that operate with agility and strength across the spectrum of conflict. This level of training emphasizes tactical execution, decision-making, team coordination and efficient communication. The trainer's task is to provide realistic, challenging and instructive training to measurably improve the critical team skills required in tactical employment of MAGTF capabilities. Over the past decade, this training mission has been enhanced through the use of simulators. However, legacy simulator systems were designed to support specific individual and small crew training tasks and they do not interact with other systems to support collective training. Advances in distributed simulation technology have opened the door for the Marine Corps training community to conduct collective, combined arms training using simulators. The goal of this program remains unchanged. It is to achieve a technical standard that clearly defines the baseline specification for interoperability of real-time platform-level training systems that support training of MAGTFs and their subordinate elements. The adoption and evolution of the High Level Architecture (HLA) has shown HLA is a promising approach for achieving the required interoperable environment.

In pursuit of the realization of the Marine Corps goal, an effort was begun in January 2000 to develop an interoperability specification, geared toward the design of future Marine Corps training devices for the MAGTF community. SAIC was tasked to develop the interoperability specification under the direction of the Marine Corps Training and Education Command (TECOM), with program support from MITRE and the Naval Air Warfare Center Training Systems Division (NAWCTSD).

This interoperability specification consists of a High Level Architecture (HLA) Conceptual Model (CM), an HLA Federation Object Model (FOM), and a Federation Agreements and Implementation Document (FAID). The CM outlines a specific sample scenario as a use case for federation development. The FOM includes definitions of data structures, which effectively embody the agreed upon terms that training applications will use to communicate with one another over a distributed network. The FAID is a textual description of rules that specify how the data structures in the FOM are to be used and implemented by the federates.

Phases 1 and 2 of the project were completed in 2000, and an initial draft version of the MAGTF CM, FOM, and FAID were produced. The CM was based loosely on a model of a Close Air Support (CAS) mission scenario. The FOM was developed using the Real Time Platform Reference (RPR) FOM version 1.0 draft 2 as an initial baseline, and a draft FAID was also created to support the FOM.

During phase 3, a concept of demonstration (COD) report was developed to provide a detailed description of the planning, integration, schedule and risk issues associated with the creation of a MAGTF FOM proof of concept demonstration. This COD report outlined a federation execution concept that focused on functions to support the management of training exercises from a trainer's perspective. This focus included such concepts as Instructor Operator Station (IOS) functionality, Subject Matter Expert (SME) observation station functionality, and interoperability with an integrated Learning Management System (LMS) to incorporate Advanced Distributed Learning (ADL) technologies into the distributed simulation based training environment.

The project is currently in phase 4, which includes development of a detailed technical implementation plan for the demonstration. The

original plan was to expand upon the concept outlined in the COD report; however, a new Navy and Marine Corps initiative to develop a shipboard training capability for deployed Marine forces warranted closer examination of the warfighter's view of the federation. The new initiative is the Deployable Virtual Training Environment (DVTE) program. Another significant point to make about the DVTE initiative is that it turns the project focus away from being a demonstration toward being a first use case opportunity for Marine Corp trainees. This change refocuses the concept of the use case, deferring the trainer perspective to instead concentrate on issues related to integration of representations of a specific set of training systems. This change provides an early opportunity to prove the viability of the MAGTF FOM. The target set of training systems includes a Combat Vehicle Appended Trainer (CVAT) prototype, prototypes of desktop CH-46 and AH-1 simulators, a Fire Support Team/Forward Air Controller (FST/FAC) trainer, Individual Simulated Marksmanship Trainer (ISMT-E), and the Joint Semi-Automated Forces (JSAF) simulation. This integration will initially focus on the warfighter's view of the conceptual model to assure baseline system interoperability.

The remainder of this report will describe the CM, FOM and FAID in more detail, and it will outline some of the original concept of demonstration issues as well as the issues being highlighted by the new focus to support the shipboard training capability initiative

FEDERATION DEVELOPMENT PROCESS

The Defense Modeling and Simulation Office (DMSO) published a set of guidelines for FOM and federation development, called the Federation Development and Execution Process or FEDEP. This process is being followed, tailored as necessary, to create the MAGTF FOM (see figure 1).

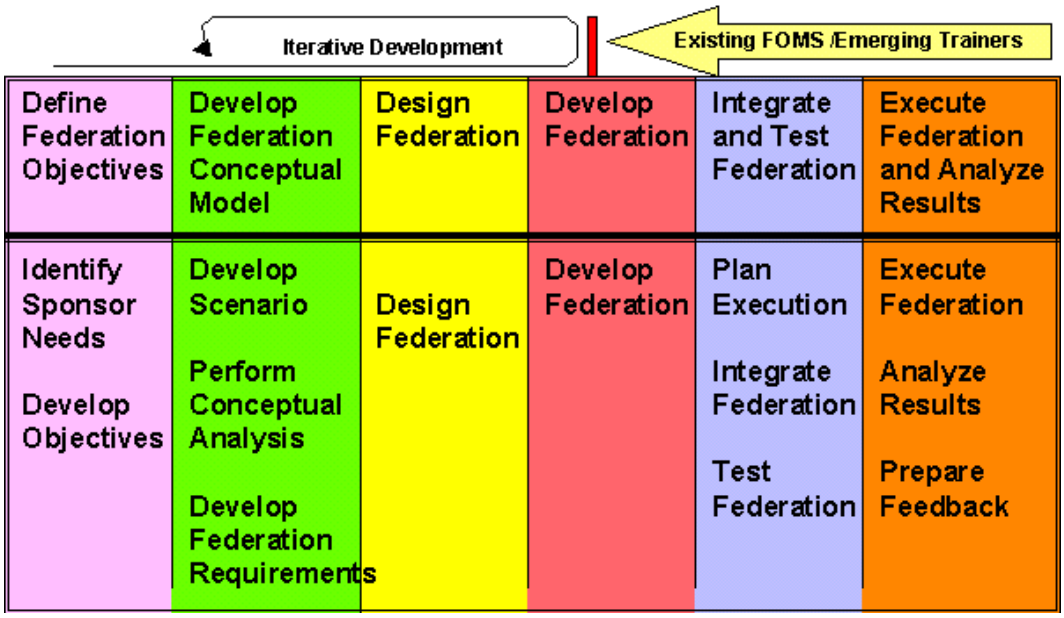

Figure 1: Tailored FEDEP for MAGTF

For the Phase One through Four efforts of the project, the tailored version of the process was used to produce iteratively improved versions of the MAGTF CM, FOM, and FAID. At the same time, existing resources such as other FOMs and requirements for emerging Marine Corps training systems were taken into consideration for their potential reuse or impact on the MAGTF FOM effort.

A point to be highlighted regarding the FEDEP is that the definition of the objectives and the development of the conceptual model are critical steps and should not be bypassed. Often there is

a tendency for federation developers to select a FOM first (RPR FOM for example) and then build the system around the FOM. Reuse of FOMs is fine, as long as it facilitates the requirements of the project, and not the other way around.

CONCEPTUAL MODEL

In the case of the MAGTF project, the FOM and associated products are being designed in such a way as to provide a mechanism that is flexible and evolutionary enough to facilitate support of a wide range of training objectives. For this reason, the entire scope of the MAGTF mission space had to be considered to some extent. First, a study was done to outline the basic MAGTF structure, which includes a Ground Combat Element (GCE), and Air Combat Element (ACE), and a Combat Service Support Element (CSSE). After this effort was completed, the focus was narrowed to an engagement envelope that centered loosely around the CAS (Close Air Support) mission, and the proof of concept demonstration conceptual model was built upon this more narrow focus.

The conceptual model was also developed using an approach that separates the system architecture into 3 orthogonal views, which are the warfighter view, the trainer view, and the technical view. This orthogonal 3-view approach to developing the conceptual model is not dictated by the HLA specification. Rather, it was a preferential choice made by the MAGTF FOM development team for use in this particular project to ensure that the unique requirements of these 3 critical perspectives were adequately addressed.

Warfighter View

The warfighter view of the conceptual model includes details for the various entities and aggregate groups of entities in the synthetic environment, as well as their actions and interactions, and details of the synthetic environment itself. As stated previously, the CAS mission was selected as the basis for the warfighter view of the MAGTF conceptual model, with an emphasis on air-ground operations in the combined arms setting. A road to war and order of battle scenario was developed to illustrate the warfighter perspective, and it is based upon a hypothetical combat scenario (see figure 2). The basic premise is that there has been an engagement with a hostile force near a strategic geographical position, and the MAGTF forces are preparing to deal with a counterattack by the enemy.

Several threads of activity within the synthetic battlespace were further outlined to serve as a basis for examining issues related to the MAGTF federation environment. These threads describe the activity to be supported by the proof-of-concept use case federation.

Thread #1 - LAR Platoon Commander

A LAR (Light Armored Reconnaissance) Battalion has been assigned the mission of screening the western flank of the Division. Within that screen line the Company has been assigned specific Named Areas of Interest (NAIs) to orient upon. While observing an NAI, the Opposing Forces (OPFOR) counter attack force (company size or smaller composed of tanks and armored personnel carriers) enters the NAI. The company commander is now challenged to destroy this force using maneuver and supporting arms to include artillery and Close Air Support (CAS).

The use case mission action will start off with this thread and follow it until a FO/FAC (Forward Observer / Forward Air Controller) prepares to call in requests for fire support, at which time the focus will transition to thread #2.

Thread #2 - FO/FAC

As part of a Company Fire Support Team assigned to a LAR Company, the FO/FAC must plan, coordinate, and execute a SEAD (Suppression of Enemy Air Defense) mission. The FO will operate a MULE (Modular Universal Laser Equipment) to provide the primary mark. Additionally, the FAC must coordinate the use of CAS to complete the destruction of the counter attack force. Upon initiation of the first call for fire support, the use case focus will move to thread #3, then thread #4, and back to thread #2 as necessary to complete a full evolution of a CAS mission scenario.

The development of these threads has been researched such that activities to be conducted throughout the use case can be directly traced to doctrinally correct MCCRES (Marine Corps Combat Readiness Evaluation System) and ITS (Individual Training Standards) objectives and performance standards for the correct MOS (Military Occupational Specialty) of the trainee. In this case the role of "trainee" is generally focused the FO.

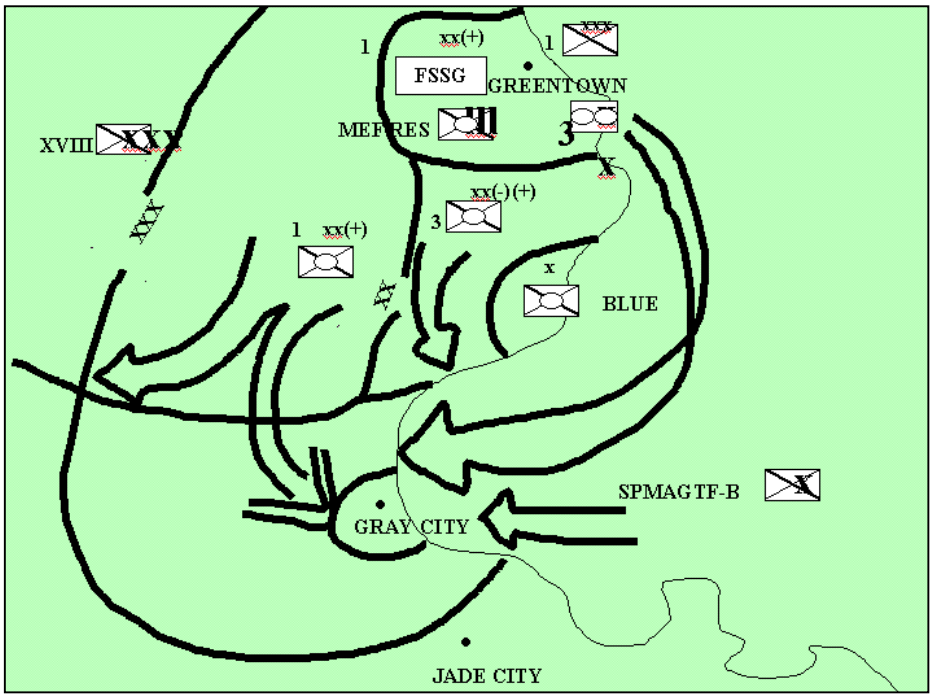

Figure 2: MAGTF Warfighter View Conceptual Model Scenario

Thread #3 - DASC/FSC
When in receipt of a SEAD mission, the FSC (Fire Support Coordinator) must de-conflict firing missions, establish an Air Coordination Area, and approve the firing call for fire. The DASC (Direct Air Support Center) will process Joint Tactical Air Requests (JTARs), assign aircraft to the missions, and pass the aircraft to the FAC for terminal control.

Thread #4 - Trigger Puller
The pilot of the aircraft has been assigned a mission by the DASC and is in receipt of a standard format nine-line mission brief. Once he has established communications with the FAC, he will deliver his ordnance on the specified target, guided by a MULE (Modular Universal Laser Equipment) as the primary marking devise and White Phosphorous as a back-up mark.

Trainer View

While the warfighter view is the one that most directly addresses the specific mission related training objectives, the trainer view was given special emphasis for the MAGTF interoperability specification, and for the initial concept of demonstration plan as well. The significance of the warfighter view is obvious, so much so that the trainer view has been relatively obscured by it in the past, and often overlooked by federation development efforts. However, specifications for new systems are beginning to include requirements for the systems to accommodate training at team as well as individual levels. They are including requirements for training to be tailored to individual student needs. They are including requirements for systems to facilitate measurement of student performance against doctrinally accurate mission objectives. They are including requirements to accommodate logging of performance data to student records. These things are all part of the trainer view, and the design of future Marine Corps training systems will benefit significantly from the inclusion in the MAGTF interoperability specification of constructs that support these requirements. This is the premise upon which the trainer view of the conceptual model was developed.

The trainer view of the conceptual model includes descriptions of functionalities that support an integrated learning methodology architecture. This architecture includes a concept for implementing a scenario specification that links mission objectives to MOEs (Measures of Effectiveness) and MOPs (Measures of Performance) and drives the general order of

battle for SAF (Semi-Automated Force) elements. The architecture addresses facilitation of instructor control of the scenario and the exercise, capture and integration of subject Matter Expert (SME) observations and comments, and infusion of learning content that is tailored to individual student needs. In the runtime environment, these capabilities are used to maximize the training value of the event, to help measure that training value, and to feed a data collection source that captures relevant information for after action review (AAR) (see figure 3).

Technical View

Completing the view trilogy, along with the warfighter and trainer views, is the technical view. The technical view looks at infrastructure support requirements of the federation, and as such it addresses many issues that are managerial in nature and issues that go beyond HLA or M&S to include just about anything not otherwise addressed in the warfighter or trainer views. Examples of issues to be addressed by the technical view include the following:

- Allocation of federation objects to federates
- Allocation of federates to specific computer platforms
- Bandwidth consumption requirements of federates
- Port addresses of networked computers
- RTI RID file configuration
- Facility access requirements
- Power requirements
- Configuration management of the federation hardware/software
- Staffing requirements
- Simulator access time scheduling
- Etc..

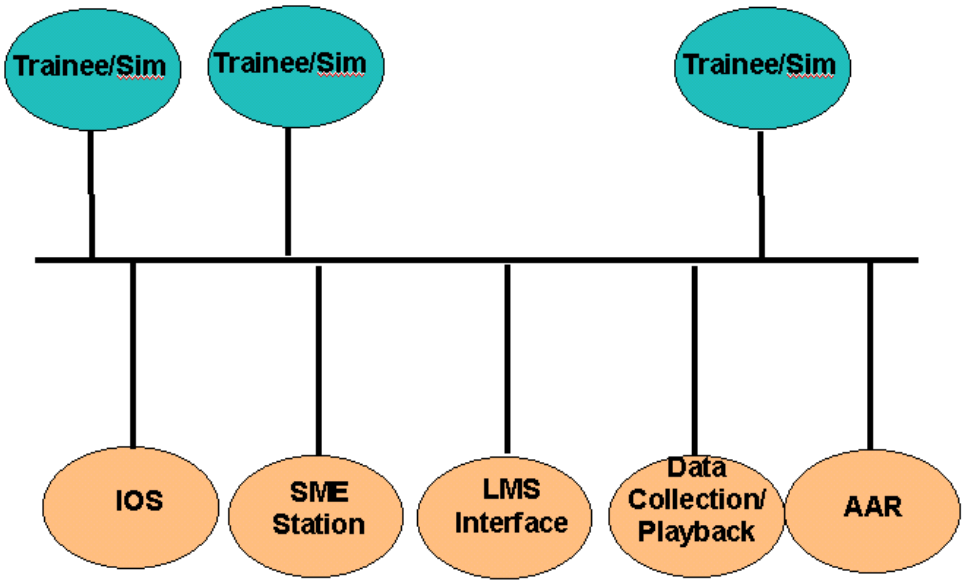

Figure 3: MAGTF Federation Trainer View Architecture

FEDERATION OBJECT MODEL

The MAGTF FOM is a derivation of RPR FOM 1.0 draft 2, with extensions that were taken from other FOMs, and some custom extensions as well.

Using the RPR FOM as a baseline was not a project requirement. This choice was made on the basis that a majority of contemporary DoD M&S based training applications are in fact derivatives of the RPR FOM, and it has become a sort of lowest common denominator for platform level

simulation interoperability. The decision to depart from the RPR FOM baseline was made on the basis that the conceptual model for the MAGTF federation indicates a need for constructs that were not available in the RPR FOM 1.0 draft 2, and this was the latest version available at the time.

The major departures from the RPR FOM 1.0 draft 2 are focused in the areas of aggregation/disaggregation, simulation management, and individual combatant representation. The MAGTF FOM has implemented a scheme for facilitating aggregation and disaggregation of component elements into composite representations. An example of this might include a sensor model being simulated within a server application, being aggregated to a particular platform level entity, say an aircraft. Another example might include an individual combatant climbing into a troop transport platform and temporarily aggregating the synthetic representation of the two entities for the purpose of bandwidth conservation. Yet another example might include the aggregation of several simulation control objects for the purpose of assigning a common authority of these controls over a set of synthetic entities. The *EmbeddedSystem* object class of the RPR FOM, which was a class meant to capture aggregated types of objects, was removed and its subclasses modified to be consistent with the new MAGTF scheme.

Another area of significant deviation from the RPR FOM baseline is concerned with implementation of a simulation management control scheme. In this scheme, only specifically designated instances of control objects can initiate simulation control interactions. The extensions to the RPR FOM include addition of the control object classes and the simulation management interactions. In addition to these extensions, the existing RPR FOM simulation management interactions were eliminated or modified as necessary to be consistent with the new MAGTF scheme.

A third major area of extension to the RPR FOM is in the area of individual combatant representation. A *Human* object class was added, and some of the attributes for this class were taken from another existing FOM (the Human FOM Starter Set).

There are other areas of deviation from the RPR FOM that are under consideration for implementation in the MAGTF FOM, but since the MAGTF FOM is still a work in progress, these areas have not been matured enough to warrant inclusion here. In fact, the extensions and modifications described above are also subject to change, pending completion of the MAGTF demonstration federation.

Another FOM development effort that is being monitored for impact on the MAGTF FOM is the Navy Training Meta FOM (NTMF) development. This FOM is being developed with the intent of providing a reference FOM for Navy M&S based training systems. In fact, the NTMF effort currently envisions an eventual integration of the NTMF and the MAGTF FOMs. The difference in the approach to the two efforts is that the NTMF has been focusing more on blue water Naval operations, while the MAGTF FOM is looking more at combined arms air-ground operations, with an emphasis on land warfare. The MAGTF development team has participated in several NTMF working group meetings and is tracking NTMF developments verses MAGTF developments in order to maximize compatibility where feasible.

FEDERATION AGREEMENTS AND IMPLEMENTATION DOCUMENT

The requirements and conceptual model give humans a good understanding of federation design from a requirements and concept of operations standpoint. The FOM provides a technical description of the data constructs to be used to pass information between federates in the distributed environment. In order to complete the interoperability specification, there also needs to be an additional technical understanding of how the FOM data constructs are to be used by the federates. For example, the RPR FOM includes some enumerations for identifying type information about platform entity objects. This enumeration is left over from the Distributed Interactive Simulation (DIS) days, and the enumeration values are described in an enumerations document but not in the FOM itself. If the defined values of this enumeration are to be commonly understood by the participating federates, then the enumerations document must be made part of the specification. For the MAGTF FOM effort, this type of information is being captured in a document called a Federation Agreements and Implementation Document (FAID). It will describe information not captured elsewhere that is needed in order to

establish a common understanding of how federates will interoperate.

DEPLOYABLE VIRTUAL TRAINING ENVIRONMENT SUPPORT

As mentioned earlier, the Deployable Virtual Training Environment (DVTE) provides an early opportunity to build a federation based on the MAGTF FOM. The short-term goal of the DVTE effort is to network a specific set of Marine Corps training systems into a proof-of-concept virtual training environment. The eventual goal is to produce a capability that can be deployed with Marine Corps forces afloat to significantly improve warfighting readiness by providing a virtual combined arms air/ground training package where none currently exists.

The MAGTF FOM plays a critical role in this effort, in that it is the FOM that will be used to integrate the various trainer systems. Training systems that are planned to participate in this part of the DVTE proof-of-concept use case include the following:

- JSAF
- ISMT-E
- CVAT
- CH-46 simulator
- AH-1 simulator
- FST/FAC training system

EVOLUTIONARY ISSUES

The MAGTF FOM and associated products are designed to be evolutionary. In other words, it is understood that version 1.0 of the MAGTF FOM will not capture everything that is necessary to support all MAGTF mission areas at a high level of fidelity. New CMs will be developed to address new mission areas and/or changing mission requirements. The FOM will need to evolve to accommodate changes in technology and mission requirements, as will the FAID.

These evolutions will occur over time, and a good maintenance philosophy for the MAGTF FOM and products is crucial.

Some of the targeted areas to be reserved for consideration as evolutionary improvements to the baseline MAGTF FOM include the following:

- Laser Designation
- RF Propagation
- Aggregation/Disaggregation
- Human Representation
- Individual Combatant Gear
- Articulated Parts
- C4I
- Synthetic Natural Environment
- Logistics
- Instructor Operator Station
- SME Station
- Simulation Management Control Objects
- Scenario Driven Exercise
- ADL LMS Interface
- Intelligent Tutoring Agents
- Synchronization Tagging
- Context Tagging
- Etc..

The list above does not address all of the issues of interest, and any sort of in-depth discussion of them is beyond the scope of this paper. Also, although some of the issues on the list are being partially addressed in the current effort to produce the V1.0 MAGTF FOM baseline, it is recognized that some of the solutions may need to be modified to accommodate lessons learned as the FOM is put into use by the Marine Corps.

SUMMARY AND CONCLUSIONS

The current version of the MAGTF CM, FOM, and FAID is V0.3, with one more pre-baseline version (V0.4) to be produced as part of the development effort. The first baseline version, V1.0, will be the output from the DVTE short-term use case development effort.

The original plan for the MAGTF FOM development was to focus on a trainer view of the conceptual model, while still addressing issues for the warfighter and technical views. A refocus of the effort to assist the DVTE development has changed the emphasis to the warfighter view, leaving elements of the trainer view implementation as evolutionary issues.

The outputs of the current project will include the following products:

- MAGTF Conceptual Model (CM)
- MAGTF Federation Object Model (FOM)
- MAGTF Federation Agreements and Implementation Document (FAID)
- Concept of Use Case Report
- Detailed Use Case Implementation Plan

The FOM and products are understood to be evolutionary, and many issues have been

recognized as needing further investigation and testing. Even so, the baseline V1.0 of the MAGTF FOM and products will serve as an enabler for facilitating interoperability among MAGTF training systems.

The continuing need for affordable and effective training solutions is being addressed by the development of the MAGTF FOM. This effort is producing an interoperability solution for current and future MAGTF simulations while evaluating the utility of distributed simulation based training. This effort can serve as a model for service implementation of distributed simulation technology for M&S based applications.

The benefit from this project for the future will rely on development of a MAGTF based interoperability approach that provides for collective, combined arms training to the operating forces of the Marine Corps. This capability will enhance preparations for live Combined Arms Exercises (CAXs), augment Marine Expeditionary Unit (MEU) pre-deployment training, and support the Deployed Virtual Training Environment. In addition, this capability will provide a baseline definition of Marine Corps requirements for interoperability within the joint community. Finally, many of the lessons learned from the project will benefit not just the Marine Corps but the M&S community as a whole, including Government, academia, and industry.

[1] SISO-STD-001.1-1999 (RPR FOM 1.0)

[2] 1516-2000 IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) - Framework and Rules

[3] M. Biddle, (2000). A Proposed Scheme for Implementing Aggregation and Disaggregation in HLA, Simulation Interoperability Workshop, Fall 2000. www.sisostds.org

[4] S. Zeswitz, C. Bouwens, (2000). Baseline Interoperability for Marine Corps Air and Ground Simulators I/ITSEC 2000.