The Development of an Intelligence and Electronic Warfare FOM to Bridge Constructive, Virtual, and Live Simulations

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ABSTRACT: *This paper describes the process of creating a Federation Object Model(FOM) which bridges constructive, virtual, and live simulation systems to create a synthetic environment that can stimulate Intelligence and Electronic Warfare (IEW) system operators. Under the Intelligence Electronic Warfare Tactical Proficiency Trainer (IEWTPT) program, we are creating a training system for operators of the ground stations associated with Joint Surveillance Target Attack Radar System (J-STARS), Tactical Unmanned Aerial Vehicle (TUAV), Tactical Exploitation System (TES), Guardrail, Airborne Reconnaissance Low - Multifunction (ARL-M), Aerial Common Sensor (ACS), PROPHET, Improved – Remotely Monitored Battlefield Sensor System (I-REMBASS), and Counter-intelligence Human-intelligence Automation Tool Set (CHATS).*

To provide a rich and dynamic combat scenario in which to train these operators, IEWTPT is developing an interface to the constructive Warfighter Simulation (WARSIM) and the live instrumentation systems of the Combat Training Centers (CTCs) (the National Training Center (NTC), Joint Readiness Training Center (JRTC), and Combat Maneuver Training Center (CMTC)) and future Homestation Instrumentation Training Systems (HITS). This data will be converted into a form that is appropriate for IEW system training through the use of filtering, disaggregation, and data enhancement algorithms.

The FOM development process of IEWTPT has included the analysis and integration of existing and proposed FOMs from a wide variety of existing simulations. These include the Joint Simulation System (JSIMS) FOM, Real-time Platform Reference (RPR) FOM, ACS FOM, existing Distributed Interactive Simulation (DIS) interfaces, and legacy custom data transfer formats. This will result in a standardized IEW FOM that will support the nine Army IEW systems listed above and which can be extended to additional systems in the future. This paper describes the process, engineering judgment, lessons learned, and products that have emerged in the course of this work.

1. Introduction

The operators of IEW systems occupy a unique niche when it comes to military training events. They focus their attention on large areas of the battlefield containing hundreds of enemy units, but they operate on data at the individual object and transmission level. An electronic intelligence system will watch for individual radar emissions, but will use the information to draw conclusions about the location and activities of an entire battery or battalion of equipment. Similarly, a J-STARS Common Ground Station (CGS) operator will watch a display containing thousands of individual moving targets, but will use this to identify the movements of many companies or battalions (Figure 1.1).

Therefore, during training, the IEW operators must be stimulated with the volume of data typically present in a brigade or division level exercise and they must have this data at the individual vehicle and transmission level of resolution.

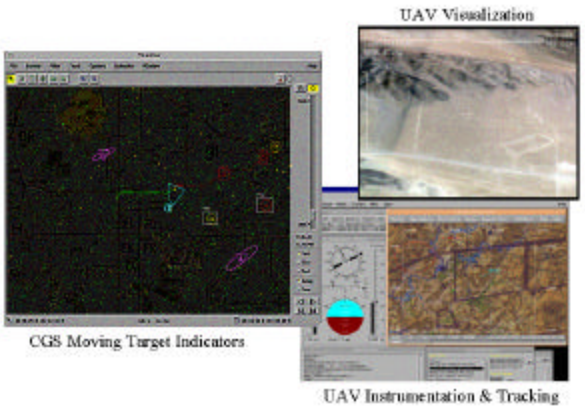

Figure 1.1 J-STARS and UAV Training System Displays

As a result, the IEW community has developed some very innovative approaches to tying into large division and corps exercises. J-STARS, UAVs, and other assets use a disaggregation computer as a gateway to receive aggregate level data from Joint Training Confederation (JTC) exercises and then disaggregate this into vehicle level data for presentation to the UAV or CGS operator (Figure 1.2). Over many years, several diverse approaches to this problem have emerged. These have included modifications to the Tactical Simulation

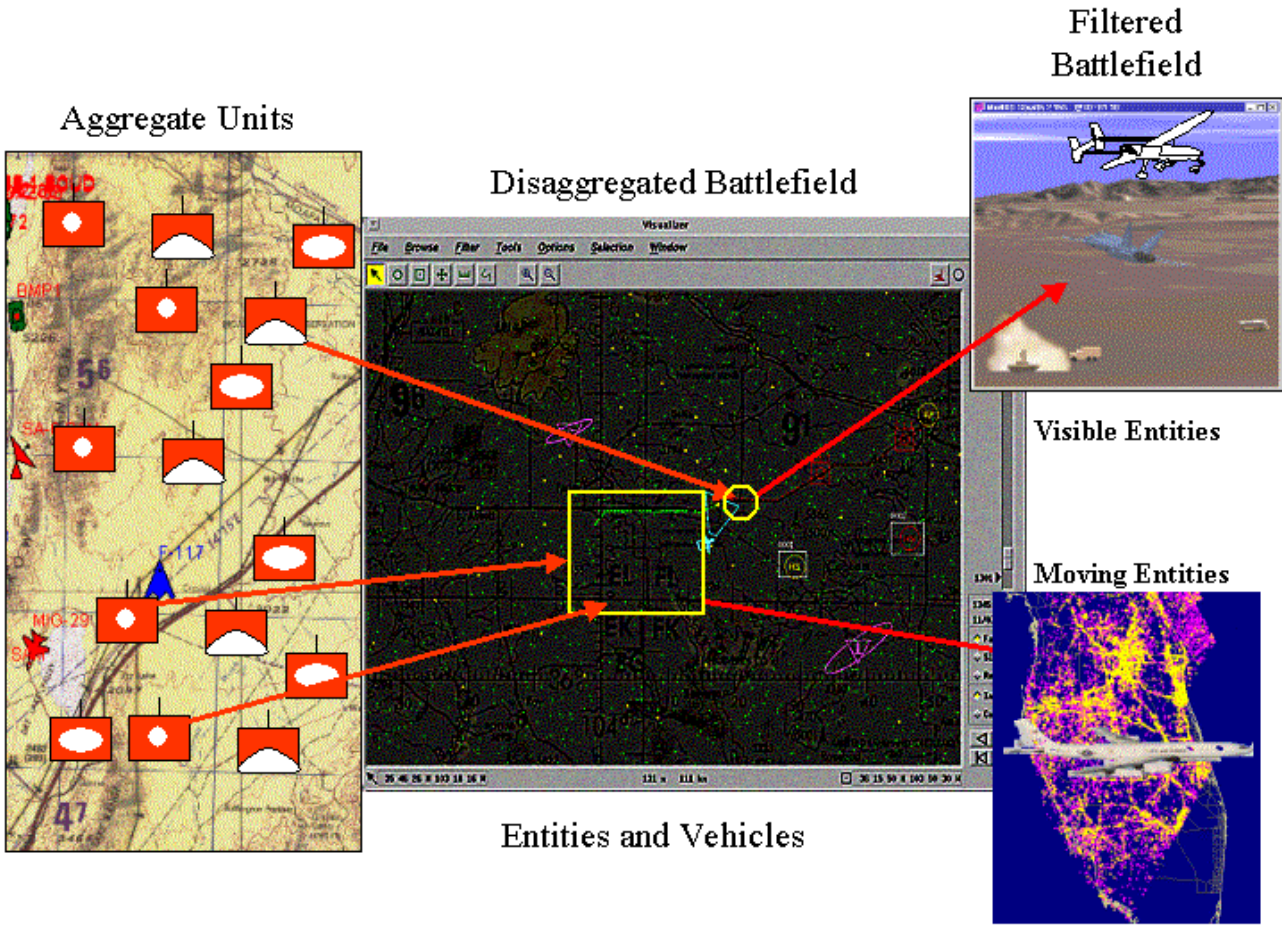

Figure 1.2 Constructive World Disaggregation, Filtering, and Enhancement for IEW Training

System (TACSIM); the emergence of the High Resolution Simulation System (HRSS); its evolution into the Federation of Intelligence, Reconnaissance, Surveillance, and Targeting Operations Requirements Models (FIRESTORM), and the creation of the Combat Synthetic Training Assessment Range (CSTAR) program.

The US Army Simulation, Training and Instrumentation Command (STRICOM) has taken steps to unify some of these capabilities and distribute them to sites worldwide by initiating the Intelligence and Electronic Warfare Tactical Proficiency Trainer (IEWTPT). This program will deliver a common gateway for connecting constructive simulations like WARSIM; live combat training centers like NTC, and virtual and embedded training systems for IEW systems and operators. The new system also uses the High Level Architecture (HLA) to achieve interoperability with these systems. This has led to the need for a FOM to bridge all three traditional domains of training simulation – constructive, virtual, and live. In this paper we describe the evolution of this FOM – the reuse that was made from the RPR-FOM, JSIMS FOM, and ACS FOM and the creation of new items for interaction.

2. Intelligence and Electronic Warfare Tactical Proficiency Trainer

IEWTPT uses simulated and live scenario data to stimulate and train IEW system operators. These operators generate products for all-source intelligence personnel who generate intelligence reports for the battle commander. IEWTPT is the bridge between live, virtual

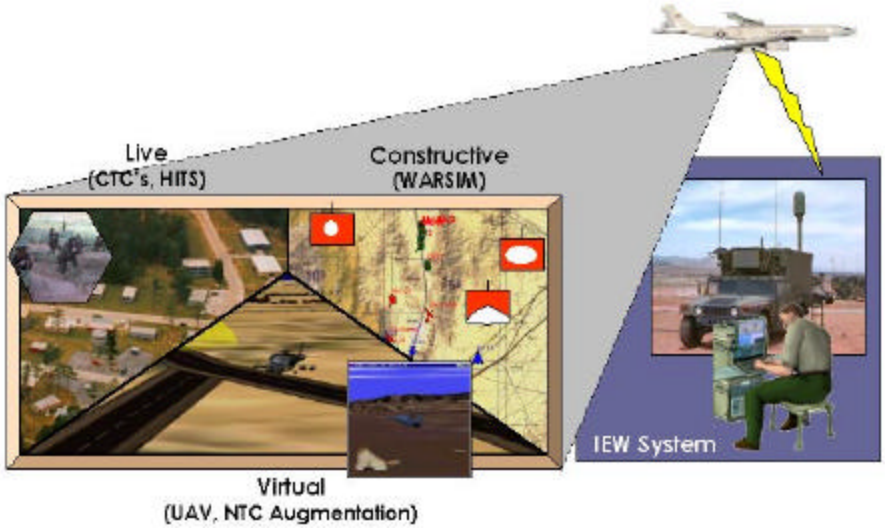

Figure 2.1 IEWTPT Bridges Constructive, Virtual and Live Training

and constructive simulations and the IEW operator (Figure 2.1). It receives live player data from the CTCs or HITS. The UAV IEW operator controls a simulated UAV and the position data for this virtual UAV is fed to IEWTPT. Finally, aggregate entity data and other simulation data is received from a constructive simulation like WARSIM.

IEWTPT is destined to stimulate the following nine IEW systems:

1. J-STARS Common Ground Station (CGS),
2. Tactical Unmanned Aerial Vehicle (TUAV),
3. Tactical Exploitation System (TES),
4. Guardrail Integrated Processing Facility (IPF),
5. PROPHET,
6. Aerial Common Sensor (ACS),
7. Airborne Reconnaissance Low - Multifunction (ARL-M),
8. Improved Remotely Monitored Battlefield Sensor System (I-REMBASS), and
9. Counterintelligence/Human Intelligence Automation Tool Set (CHATS),

IEWTPT receives ground target objects and interactions from WARSIM, CTCs, and HITS. These targets pass through a geographic and frequency Area Of Interest (AOI) filter to focus on information actually accessible to the IEW sensors. This AOI filter is a conglomerate of the individual IEW system's areas of interest. The IEW systems will define filters based on geographic location, target size, frequency, or other criteria that meet their processing needs. Any aggregate targets are input into a disaggregation algorithm to create individual entities. Finally, an enhancer component adds more detail to the targets and intelligence models determine which of the targets are detectable by an IEW system at the appropriate time.

3. Bridging Constructive, Virtual, and Live FOMs

Before creating an IEW FOM to support IEWTPT and the host of real IEW systems that are being stimulated, the project evaluated FOMs that were serving a number of existing programs.

Constructive JSIMS FOM

JSIMS is a federation of the next generation of staff training simulations. IEWTPT is required to interface with the Army's component, WARSIM / WIM. This constructive simulation generates over 90% of the data flowing into the system. IEWTPT subscribes to aggregate entity data, radio transmissions and jammer and radar emissions on the JSIMS RTI. The aggregate entity data must be disaggregated to individual vehicles before being sent to the real IEW systems [1].

Since WARSIM / WIM is part of the JSIMS Federation, our access to WARSIM / WIM objects and interactions is through the JSIMS FOM.

Live CTC and HITS FOMs

CTCs and HITS generate digital data about the status of live vehicles on a training range. Since IEWTPT is used in these training events as well, this data must be considered when creating the IEW FOM. The system receives live entity data and plans are being made to include RF transmissions and tactical messages from these live systems.

Virtual IEW System FOMs

Sensor platforms will be controlled by an operator in a real IEW system. Therefore, status data concerning these platforms is part of the IEW FOM as well. For example, the positional data from the TUAV operator that is flying a virtual TUAV is passed to IEWTPT. Some of these IEW systems had already built interfaces to legacy systems like TACSIM, FIRESTORM, and CSTAR and, as a result, had established their data exchange needs. This data was not being passed through the RTI, but the conversion to OMT was rather direct.

Included among these virtual simulations was the ACS that is scheduled to replace Guardrail, ARL-M and a host of other systems. Simulation experiments for this system had been conducted using HLA and had developed the ACS FOM [2].

Real-time Platform Reference (RPR) FOM

The RPR FOM was developed to allow federations who use DIS to switch to a common FOM by requiring only minor changes to their existing functionality. The RPR FOM is comprised of Guidance, Rationale and Interoperability Modalities (GRIM) and the FOM itself. "The GRIM principally defines what it means to be compliant with the RPR FOM, provides a mapping between DIS and the RPR FOM, defines default field values, and provides the guidance and rationale required for extensibility." [3] The IEW FOM borrowed heavily from the RPR FOM.

The formats of each of these existing FOMs were considered when developing the IEW FOM. The IEW FOM needed to be a bridge between these and the IEW systems. This FOM provides a common format to enhance data received from different simulations. Data that arrives from the simulations is enhanced to allow the data to map to the IEW FOM. Enhanced data is selected based on the values of state data received from WARSIM, CTCs, and HITS.

4. Emergence of the IEW FOM

An entity that was created with minimal information such as position, type, name, orientation and velocity is enhanced to allow an Imagery Intelligence (IMINT) IEW operator, for example, to visually see if the entity's headlights are illuminated. The acoustic signature of that same entity could be added to allow a Measurement and Signature Intelligence (MASINT) sensor to make detection determinations about the vehicles. The RF characteristics of radar emissions and radio transmitters are added to allow detailed RF models to make detection determinations.

Figure 4.1 provides a graphic depiction of the general flow of information through a fully connected IEWTPT system.

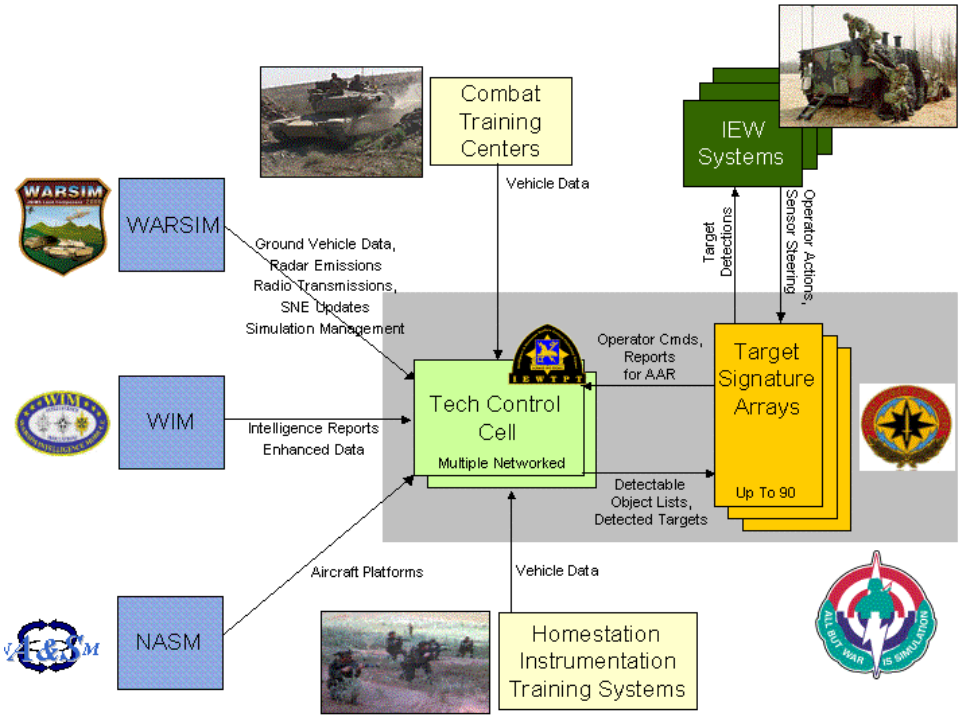

Figure 4.1 Simulation Data Flow Through IEWTPT

4.1 JSIMS FOM

Entity Data

IEWTPT joins the JSIMS federation to access data from its FOM. IEWTPT subscribes to aggregated entity data and platform data through the JSIMS classes org.land.equip_group, org.land.unit, and platform.fwa. Aggregate entity data must be disaggregated before being converted to the IEW FOM format. After disaggregation, the individual entities are mapped to RPR FOM BaseEntity.PhysicalEntity.Platform classes in the IEW FOM. IEWTPT also creates RPR FOM BaseEntity.-PhysicalEntity.Platform.Aircraft objects from JSIMS platform.fwa (Table 4.1).

Making these translations requires that entity data be enhanced. This includes:

MTI Enhancement – adding attributes such as radial velocity, target vehicle type (wheeled or tracked), and vehicle composition;

IMINT Enhancement – adding attributes such as the dimensions of an object or the 3D model associated with each object; and

MASINT Enhancement – adding attributes such as mass, velocity, and infrared signature of a vehicle.

JSIMS Object Class	IEW FOM	Origin
org.land.equip_group	BaseEntity.-PhysicalEntity.-Platform.-GroundVehicle	RPR FOM
abstract.land.equip_-type		
abstract.land.rotary_-wing_type		
org.land.unit		
platform.fwa	BaseEntity.-PhysicalEntity.-Platform.Aircraft	RPR FOM

Table 4.1 JSIMS FOM to IEW FOM – Entity Data

Radar and Jammer Emissions

Radar and jammer emissions are received from the JSIMS RTI and map to the IEW FOM as shown in the following table. The interaction event.physical_illumination and the object dynamic_emitter together describe radar emissions in WARSIM / WIM. The event.jamming interaction describes the jammer emissions in WARSIM (Table 4.2).

Radar and jammer emissions are enhanced with ELINT Enhancement – adding attributes such as pulse repetition frequency, pulse duration, and emitted power.

JSIMS Interaction	IEW FOM	Origin
dynamic_emitter abstract.emitter	EmitterBeam.-RadarBeam	RPR FOM
event.physical_-illumination	EmitterBeam.-RadarBeam	RPR FOM
event.jamming.comm_-jamming.stand_off	EmitterBeam.-JammerBeam	RPR FOM
event.jamming.radar_-jamming.self_protect		
event.jamming.radar_-jamming.stand_off_-air_search		
event.jamming.radar_-jamming.stand_off_-surf_search		

Table 4.2 JSIMS FOM to IEW FOM – Radar and Jammer Emissions

SNE Dynamic Updates

IEWTPT receives SNE dynamic updates from the JSIMS federation. These insure that the SNE data in IEWTPT is identical to that in the host constructive simulation. The data is used for line-of-sight calculations and visualization. The super class event.environmental contains many of these features as subclasses. All are mapped directly to corresponding classes in the IEW FOM and are therefore not listed here in detail (Table 4.3).

SNE dynamic updates are not enhanced.

JSIMS Name	IEW FOM	Origin
synthetic_natural_-environment.chem_-bio_strike	SyntheticNaturalEnv.-Chem_bio_strike	JSIMS FOM
synthetic_natural_-environment.dynamic_-feature	SyntheticNaturalEnv.-Dynamic_feature	JSIMS FOM
synthetic_natural_-environment.metoc_edit	SyntheticNaturalEnv.-Metoc_edit	JSIMS FOM
synthetic_natural_-environment.smoke_-strike	SyntheticNaturalEnv.-Smoke_strike	JSIMS FOM
event.environmental	event.environmental	JSIMS FOM

Table 4.3 JSIMS FOM to IEW FOM – SNE Dynamic Updates

Radio Transmissions

Radio transmissions that are received from the constructive simulation WARSIM are generated as commander-to-commander messages. As these pass through the IEWTPT system they must be reformatted into the form of spoken language. The initial steps convert them into ASCII text strings. They are carried through the system in this form until immediately before they are released to the IEW system operator. At that point they are converted into spoken audio. This conversion occurs after all data exchange through the RTI has occurred so that audio files such as MP3 files do not use the RTI as a transmission mechanism. IEWTPT will receive call_for_fire, oprep, order, situation, and salute reports as radio transmissions from the JSIMS FOM (Table 4.4).

Radio transmissions must be enhanced using COMINT Enhancement – adding attributes such as internal and external signal characteristics (modulation, encryption, language, power).

In addition to converting the messages, the amount and variety of these messages must be increased so that the IEW operator will face a challenging communications environment to hone his skills. If this were not done, the operator would hear nothing but the key messages generated by the constructive simulation. The system also generates communication traffic related to cultural areas – radio stations, airport communications, taxicabs, and other activities.

JSIMS Interaction	IEW FOM	Origin
event.message.call_-for_fire	RadioSignal.-ApplicationSpecificRadioSignal	RPR FOM
event.message.-oprep1_f002		
event.message.-oprep3_c487		
event.message.order_-a423		
event.message.-situation_report		
event.message.salute_-report		

Table 4.4 JSIMS FOM to IEW FOM – Radio Transmissions

Tactical Messages

Intelligence messages generated by WIM are passed through the IEWTPT system without being modified. These messages are required by the real IEW systems and require no modifications for delivery (Table 4.5). Tactical messages are not enhanced.

JSIMS Interaction	IEW FOM	Origin
event.message.iir_c100	iewevent.iewmessage.-iewiir_c100	JSIMS FOM
event.message.-intcollnom_d170	iewevent.iewmessage.-iewintcollnom_d170	JSIMS FOM
event.message.intrep_-c110	iewevent.iewmessage.-iewintrep_c110	JSIMS FOM
event.message.intreq_-d101	iewevent.iewmessage.-iewintreq_d101	JSIMS FOM
event.message.-intsum_g131	iewevent.iewmessage.-iewintsum_g131	JSIMS FOM
event.message.-reccexrep_c101	iewevent.iewmessage.-iewreccexrep_c101	JSIMS FOM
event.message.ri_f014	iewevent.iewmessage.-iewri_f014	JSIMS FOM
event.message.rri_f015	iewevent.iewmessage.-iewrri_f015	JSIMS FOM
event.message.salute_-s303	iewevent.iewmessage.-iewsalute_s303	JSIMS FOM
event.message.-tacelint_c121	iewevent.iewmessage.-tacelint_c121	JSIMS FOM
event.message.tacrep_-c111	iewevent.iewmessage.-tacrep_c111	JSIMS FOM

Table 4.5 JSIMS FOM to IEW FOM – Tactical Messages

4.2 CTC Data

Currently, the interface to the CTC instrumentation systems generates data in DIS 2.0.4 format. Only one Protocol Data Unit (PDU) is scheduled to be used at this time. The mapping of this PDU matches the mapping of the RPR FOM (Table 4.6).

PDU	IEW FOM	Origin
Entity State	BaseEntity.-PhysicalEntity.Platform	RPR FOM

Table 4.6 CTC Data to IEW FOM

4.3 HITS Data

Though IEWTPT is eventually required to interface with HITS, these systems have not been developed yet. However, we expect each of them to be very similar to the systems used at the CTCs. Therefore, we are planning to interface with them using the RPR FOM and the objects and interactions described for the CTCs.

5. Challenges

In the process of designing the IEWTPT system and its corresponding FOM, our team has identified a number of significant challenges. Most of these are associated with the need to join such a diverse set of systems and operators in a unified training environment.

5.1 WIM Reports

Each IEW system requires different intelligence reports that are generated by WIM. Also, intelligence reports generated by the IEW systems are published to WIM. The intelligence reports generated by WIM are in a unique simulation format, which can be converted to real world USMTF formats by a JSIMS gateway machine. The intelligence reports received from IEW system are in the original USMTF formats. Supporting the meaningful exchange of this data is a significant challenge.

5.2 Exercise Control

The IEWTPT system needs to be aware of the status of all the simulations it is connected to. Simulation management commands will be received from each of these systems, and decisions about the status of the entire training event must be made.

5.3 After Action Review (AAR)

WARSIM, CTCs, HITS, and IEW systems all have their own AAR systems, products, and processes. The challenge lies in utilizing each of these unique AAR systems in developing one unified AAR to meet the training needs of both the IEW system operator and the constructive training audience.

5.4 Voice

IEWTPT can produce data for IEW operators desiring communications transmissions. The method of delivering these messages involves sending an ASCII text string and an index to a pre-recorded database of audio content that lies in the adapter to each IEW system processing communications. Passing audio files required too much network bandwidth and proved impossible through the RTI. Therefore, the adapters will generate voice using the text-to-speech software and via index into prerecorded libraries in the target language after the information has passed through the RTI.

6. Conclusion

IEWTPT occupies a unique position between the constructive, virtual, live, and embedded simulation domains. Its design requires familiarity with all of these domains and the ability to craft a unique solution that meets the needs of IEW system operators. Developing the FOM lies at the center of the interoperability challenge for the system and allows us a clear view into the each of the surrounding systems.

This paper has presented the current state of the development of the IEW FOM. It has also illustrated some of the functionality of the system itself, but we have refrained from a detailed explanation. For a more general system overview see [4].

7. References

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Author Biographies

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