



**Simulation Interoperability
Standards Organization**

"Simulation Interoperability & Reuse through Standards"

SISO-REF-081-2024

**Final Report for the
Electronic Warfare (EW) Data Exchange
Model (DEM) Study Group (SG)**

10 February 2024

**Submitted to
SISO Standards Activity Committee**

SAC Approved: 02/21/2024

EXCOM Approved: 03/27/2024

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SISO Inc. Board of Directors
7901 4th St. N, Suite 300-4043
St. Petersburg, FL 33702, USA

Revision History

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	6.2.2	1/4/2024	Added information on RPR FOM DirectedEnergyFireClass
	6.2.2, 6.2.4	1/8/2024	Additional information about RPR FOM updates; first draft of TENA section
	6.2.1	1/9/2024	Added DIS section
	5.2, 6.1, 6.2.1, 6.2.2	1/12/2024	Added member list; produced first draft of executive summary; updated discussion of SISO-REF-030 extension records; updated RPR FOM figures
	6.2.4, etc.	1/18/2024	Completed details of the TENA section; several editorial corrections
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Table of Contents

1	Introduction	6
1.1	Purpose.....	6
1.2	Scope.....	6
1.3	Objectives	6
2	References	7
2.1	SISO Documents.....	7
2.2	Other Documents	7
3	Definitions.....	7
4	Acronyms and Abbreviations.....	7
5	Group Participants.....	10
5.1	Group Officers and TAD	10
5.2	Group Member List.....	10
6	Final Report.....	11
6.1	Executive Summary	11
6.2	Review of Existing EW Representations.....	11
6.2.1	Distributed Interactive Simulation.....	11
6.2.2	Real-time Platform Reference Federation Object Model	19
6.2.3	CyberBOSS.....	22
6.2.4	Test & Training Enabling Architecture	26
6.2.5	Army Reprogramming Analysis Team Simulation Modeling Framework	29
6.2.6	EW Tools/Systems Considered.....	35
6.3	Analysis of Existing EW Representations	37
6.4	Recommended Way Forward	37

Index of Figures

Figure 1.	DIS V7 Electromagnetic Emissions PDU	12
Figure 2.	DIS V7 Transmitter PDU	13
Figure 3.	DIS V7 Receiver and Signal PDUs	14
Figure 4.	Use Cases and Extension Records Used in the Design of the DIS V8 EE PDU.....	15
Figure 5.	DIS V8 Electromagnetic Emission PDU Draft as of January 2024.	18
Figure 6.	IOInteraction Class	20
Figure 7.	RadioTransmitter Object Class.....	20
Figure 8.	EmitterSystem and EmitterBeam Object Classes.....	21
Figure 9.	CyberBOSS System Architecture.....	22
Figure 10.	Laydown of Simulation and Live Training Systems Used for Experimentation of EW Effects and Communication during the 2022 AEWE.....	24

Figure 11. CDM Expression of CNO and RF Devices	25
Figure 12. ParameterizedEmitter OM.....	27
Figure 13. CharacterizedEmitter OM	28
Figure 14. ReportedEmitter OM.....	29

Index of Tables

Table 1. Examples of Common and Specific Cyberspace Parameters	26
Table 2. DIS V7 and SMF Mapping.....	30
Table 3. DIS V8 and SMF Mapping.....	32

1 Introduction

1.1 Purpose

We lack the ability to integrate kinetic, electromagnetic warfare (EW), and command and control (C2) simulations and C2 systems to evaluate the impact of EW effects on C2 and mission effectiveness.

The US Army Cyber EW Modeling and Simulation (M&S) Working Group has been burdened with the EW aspect identified in its gap, “Lack of standardized cyberspace electromagnetic activities (CEMA) / position, navigation, and timing (PNT) validated data exchange requirements across and between Live-Synthetic cyber and kinetic environments,” for years.

We invest in and develop of CEMA M&S tools and have M&S Frameworks to provide common reference and understanding for cyber-related M&S tools, services and data, designed to support M&S across the layers of applications in Live, Virtual and Constructive (LVC) and Gaming (LVC&G) environments.

Runtime DEMs like the Cyber DEM and proposed EW DEM are a critical interoperability enabler to achieve this vision, providing the means by which LVC kinetic and CEMA components can be integrated without the considerable expense of refactoring existing capabilities.

1.2 Scope

This SG has laid the groundwork for an EW DEM standard using the leadership and processes that successfully delivered the Cyber DEM. As with the Cyber DEM, this SG’s EW DEM effort in applying a process of engaging stakeholders to prototype and test the draft EW DEM throughout its development has identified and characterized the resolution of the entities and events necessary to meet validated data exchange requirements for CEMA and PNT across and between live and synthetic and cyber and kinetic environments.

1.3 Objectives

In addition to the prescribed administrative tasks, the Terms of Reference (TOR) specified the following tasks for this SG:

1. Identify potential contributors
2. Identify and analyze other existing EW representations including but not limited to:
 - a. Distributed Interactive Simulation (DIS)
 - b. Test & Training Enabling Architecture (TENA)
 - c. US Army Cyberspace Battlefield Operating System Simulation (CyberBOSS)
3. Identify scope of EW attacks and effects and necessary levels of resolution to be represented
4. Produce SG final report defining scope of EW DEM
5. Initiate a SISO Product Development Group (PDG) if the SG determines a standard to be feasible and valuable

2 References

2.1 SISO Documents

Document Number	Title
SISO-ADM-002-2017	SISO Policies and Procedures (P&P)
SISO-ADM-005-2011	Policy for the Style and Format of SISO Documents
SISO-TOR-040-2023	Terms of Reference (TOR) for the Electronic Warfare Data Exchange Model SG
SISO-REF-010-2023	Reference for Enumerations for Simulation Interoperability
SISO-STD-001.1-2015	Standard for Real-time Platform Reference Federation Object Model (RPR FOM), Version 2.0, 10 Aug 2015
2023-SIW-RPR-FOM3	Björn Möller, Aaron Dubois, and René Verhage, “Overview and Migration Advice for the New RPR FOM 3”
SISO-STD-001-DRAFT	Standard for Guidance, Rationale, and Interoperability Modalities for the Real-time Platform Reference Federation Object Model, Version 3.0
2023-SIW-001	Lance Call, “Advanced Radar and Jamming in DIS V8,” Proceedings of the 2023 Simulation Innovation Workshop, Orlando, FL.

2.2 Other Documents

Document Number	Title
IEEE 1278.1-2012	IEEE Standard for Distributed Interactive Simulation (DIS) – Application Protocols
IEEE 1516-2010	IEEE Standard for Modeling & Simulation (M&S) High Level Architecture (HLA)
UMLet	https://www.umlet.com/

3 Definitions

Term	Definition
Standards Activity Committee (SAC)	The SISO Committee responsible for oversight of the Cyber M&S SG.

4 Acronyms and Abbreviations

Acronym/Abbr	Definition
AAR	After Action Review
AESA	Active Electronically Scanned Array
AEWE	Army Expeditionary Warrior Experiment

ARAT	Army Reprogramming Analysis Team
BER	Basic Emitter Reports
BLUFOR	Blue Force
CEMA	Cyberspace Electromagnetic Activities
CENTS	Cyberoperations Enhanced Network and Training Simulators
CMOSS	C5ISR/EW Modular
CyberBOSS	Cyberspace Battlefield Operating System Simulation
Cyber DEM	Cyber Data Exchange Model
CyberVAN	Cybersecurity Virtual Assured Network
CDM	Cyberspace Data Model
CNO	Computer Network Operations
COBWebS	Cyber Operations Battlefield Web Services
COP	Common Operational Picture
CREW	Counter RCIED Electronic Warfare
DAC	Data and Analysis Center
DEVCOM	Development Command
DIS	Distributed Interactive Simulation
EA	Electromagnetic Attack
EE	Electronic Emission
EMOE	Electromagnetic Operating Environment
EMS	Electromagnetic Spectrum
EP	Electromagnetic Protection
ES	Electromagnetic Support
EW	Electromagnetic Warfare
EWPMT	Electronic Warfare Planning and Management Tool
FOM	Federation Object Model
GRIM	Guidance, Rationale, and Interoperability Manual
HLA	High Level Architecture
IEWTPT	Intelligence Electronic Warfare Tactical Proficiency Trainer
IO	Information Operations
ICATS	Intelligent Cyberspace Adversaries Tool Suite
IP	Internet Protocol
JADO	Joint All-Domain Operations
JLCCTC	Joint Land Component Constructive Training Capability
JSAF	Joint Semi-Automated Forces

LoB	Lines of Bearing
LRPF	Long-Range Precision Fires
LVC	Live, virtual, constructive
LVC&G	Live, virtual, constructive, and gaming
M&S	Modeling & Simulation
MDO	Multi Domain Operations
MI	Military Intelligence
MFEW	Multi-Function Electronic Warfare
MOUT	Military Operations in Urban Terrain
NE2S	Network Effects Emulation System
OM	(TENA) Object Model
OneSAF	One Semi-Automated Forces
P&P	Policies and Procedures
PDG	Product Development Group
PDU	Protocol Data Unit
PESA	Passively Electronically Scanned Array
PN	Product Nomination
PNT	Position, Navigation, and Timing
PRI	Pulse Repetition Interval
PW	Pulse Width
QRC	Quick Reaction Capability
RCIED	Radio-Controlled Improvised Explosive Device
RF	Radio Frequency
RPR FOM	Real-Time Platform Reference Federation Object Model
RSSI	Received Signal Strength Indicator
SAC	Standards Activity Committee
SDR	Software Defined Radio
SG	Study Group
SIGINT	Signals Intelligence
SISO	Simulation Interoperability Standards Organization
SMF	Simulation Modeling Framework
SOA	Service Oriented Architecture
TAD	Technical Activity Director
TADSS	Training Aids, Devices, Simulations, and Simulators
TDEWS	Tactical Dismounted Electronic Warfare & SIGINT

TDL	TENA Definition Language
TEWL	Tactical Electronic Warfare System Light
TEWS	Tactical Electronic Warfare System
TENA	Test & Training Enabling Architecture
TLS	Terrestrial Layer System
TOR	Terms of Reference
TTP	Tactics, Techniques, and Procedures
UML	Unified Modeling Language

5 Group Participants

5.1 Group Officers and TAD

Role	Name	Affiliation
Chair	Katherine L Morse, PhD	JHU/APL
Vice Chair	Allen Geddes	US Army DEVCOM SC STTC
Secretary	Jeff Welch	Dignitas Technologies, LLC
TAD	Curtis Blais	NPS

5.2 Group Member List

Name	Affiliation
Jim Bak	GBL Systems Corporation
Gert Berthold	NNData Corporation
Edward Bowen	L3Harris
Veronica Charlton	Leidos / USAF AFRL
Ian Coish	National Defence (Canada)
Kevin Cousin	NNData Corporation
Jacob Cox	Trideum Corporation
John Diem	Texas A&M University
Keith Elkins	NAWCTSD
David Frank	AIT Engineering
Timothy Friest	Trideum Corporation
David Haber	Collins Aerospace
Omar Hasan	Dignitas Technologies, LLC
Elizabeth Hosang	CAE Inc
Grace Jiau	ARAT
Orlando Laboy	CAE USA
Reed Little	Software Engineering Institute - Carnegie Mellon University
Farid Mamaghani	Self-Employed
James McCall	Retired Volunteer

Matthew McGlawn	Cutlass Systems Engineering LLC
Christopher Metevier	US Army DEVCOM SC STTC
Sara Meyer	453d Electronic Warfare Squadron (USAF)
Vikram Mittal	US Military Academy
William Oblak	NPS
Edward Powell	TRMC
Heath Rush	CAPE Technology Solutions
Graham Shanks	BAE Systems
Clyde Smithson	SAIC
Jason Strauss	US Army CCDC SC STTC
Neil Turner	BAE SYSTEMS
Stacy Van Winkle	TRMC (Trideum)
René Verhage	CAE
Gary Waag	Engility
David Wells	MITRE
Kevin Wood	Thales Australia
Timothy Yu	Department of National Defence (CANADA)

6 Final Report

6.1 Executive Summary

The EW DEM SG began its efforts by identifying and reviewing the completeness of existing EW representations in simulations and other EW tools:

- Distributed Interactive Simulation
- Real-time Platform Reference Federation Object Model
- CyberBOSS
- Test & Training Enabling Architecture
- Army Reprogramming Analysis Team Simulation Modeling Framework
- Fifteen other EW tools and systems

The SG developed a draft Unified Modeling Language (UML) model of DIS V7. This model supported the analysis of existing representations, which revealed DIS V7 to have the most complete representation currently available. DIS V8, which is just beginning development, will have EW representations that are even more detailed.

The EW DEM SG recommends forming a PDG to develop a full UML model of EW in DIS V8. This work would proceed in cooperation with the DIS and RPR FOM PDGs. Coordination of this has already begun. The PDG would also experiment with adaptation of this UML model into simulation interoperability solutions such as TENA.

6.2 Review of Existing EW Representations

6.2.1 Distributed Interactive Simulation

The DIS Standard is the oldest standard for communications between distributed entity-level simulations. DIS has modeled electromagnetic emissions since 1995. The current version of the

DIS standard, V7, has a number of constructs for electronic warfare, information operations, laser designation, IFF, and signals intelligence.

DIS uses protocol data units (PDUs) to describe a unit of information transmission. PDUs are constructed out of records that represent C-like structs (more or less). Records consist of fundamental types, enumerations, padding, and other low-level constructs. The number of PDUs relevant to the EW arena in DIS V7 are:

- Electromagnetic Emission (EE) PDU – a very general PDU that includes emissions (including beams), jamming, and various radar operations
- Designator PDU – used to support laser designation of targets
- Underwater Acoustic PDU – used to transmit both active and passive information about the underwater environment
- Identification Friend of Foe (IFF) PDU – used to transmit both military IFF system states as well as civilian air traffic control beacon information
- Supplemental Emission/Entity State (SEES) PDU - used to communicate supplemental information concerning passive emissions (infrared and radar cross section) and active emissions (acoustic), along with additional information pertaining to propulsion systems of a system
- Transmitter PDU – used to describe a radio communications system
- Signal PDU – used to contain the contents of a specific radio transmission, encoded in one of many different formats
- Receiver PDU – used to describe a radio receiver

Figure 1 provides a Unified Modeling Language (UML) class diagram of the DIS V7 EE PDU.

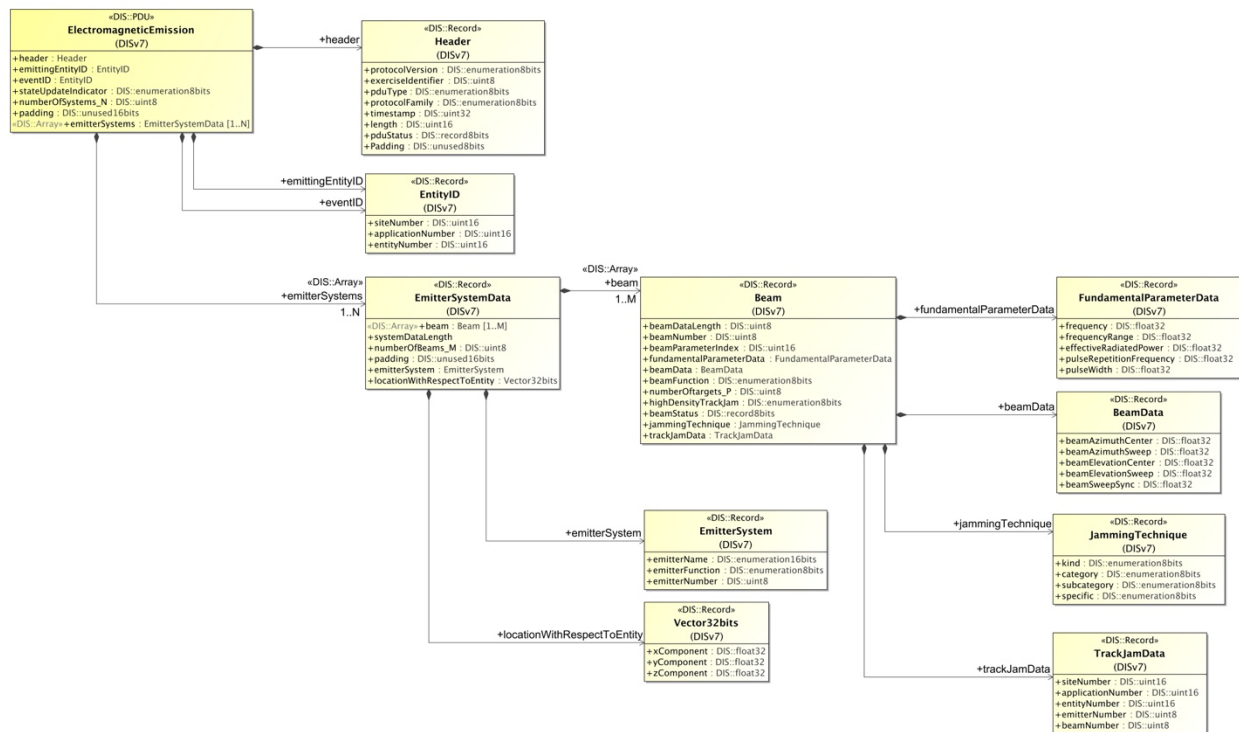


Figure 1. DIS V7 Electromagnetic Emissions PDU

The EE PDU consists of some base information and an array of Emitters, each with an array of beam information.

A UML class diagram of the Transmitter PDU is provided in Figure 2.

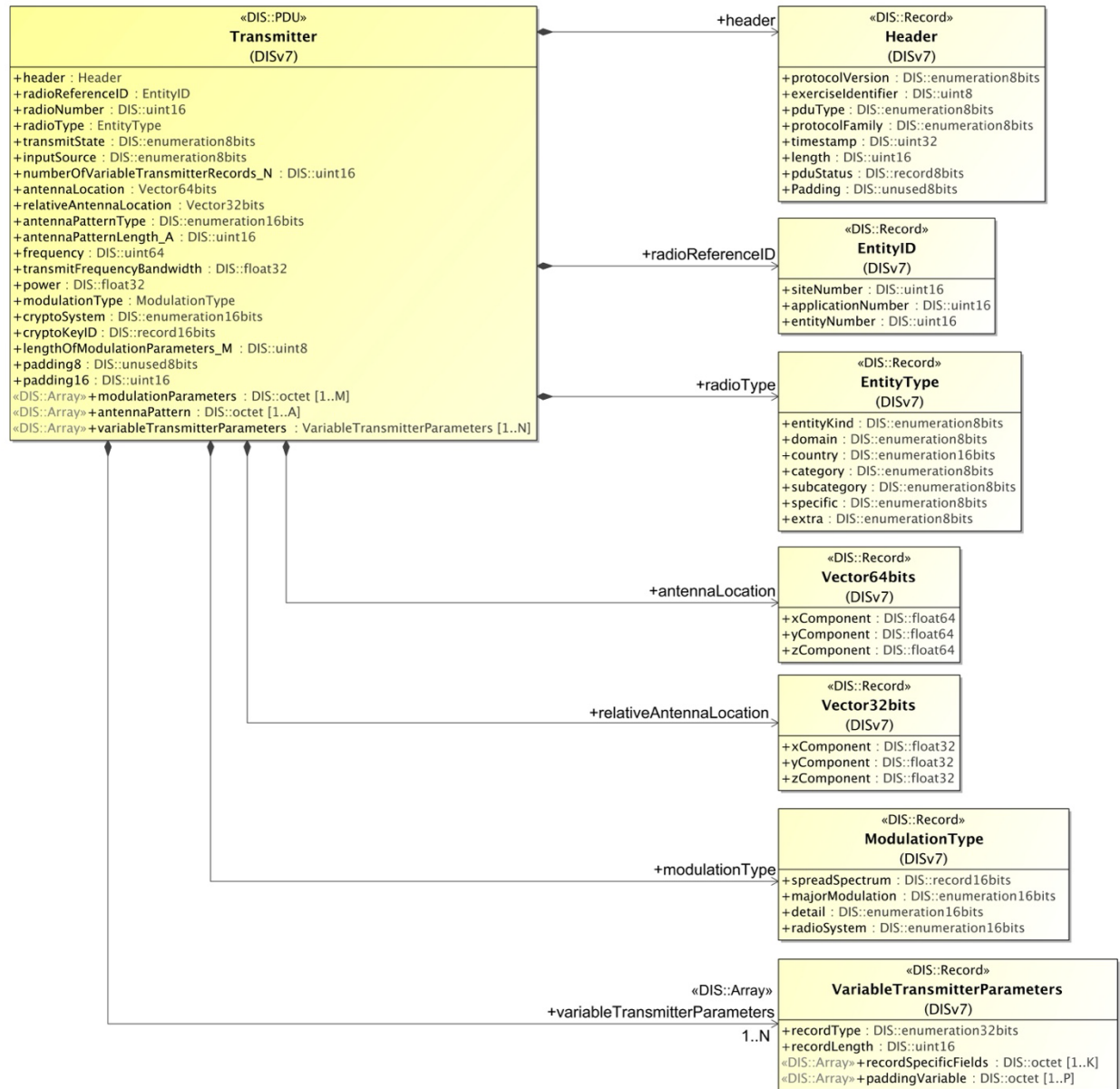


Figure 2. DIS V7 Transmitter PDU

This PDU contains detailed information about the transmitter, including antenna pattern, frequency, bandwidth, cryptography, and modulation parameters.

Finally, Figure 3 illustrates the Receiver and Signal PDUs.

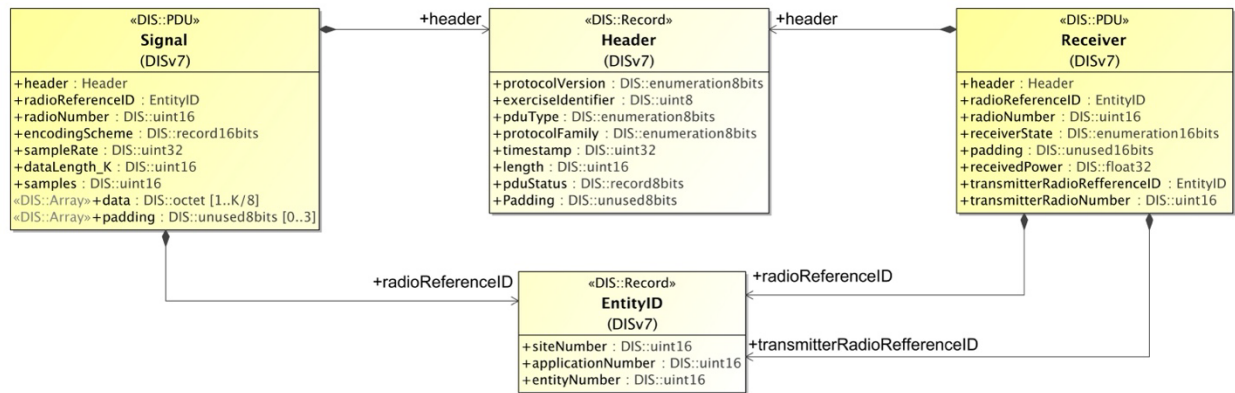


Figure 3. DIS V7 Receiver and Signal PDUs

The most important thing to note about these PDUs is that the Signal PDU contains an enumeration specifying the encoding scheme for the signal, as well as an array of octets in which the signal is encoded using that scheme.

DIS development started in 1989. At that time, Ethernet and IP networks were quite limited in capacity, and no high-speed switches existed. As a result, the DIS standard includes bit packing to make the most efficient use of space inside an IP packet. As a result, DIS PDUs are not entirely translatable into other information exchange standards except as verbatim strings or sequences of octets.¹ Given their extensive work in this domain, the DIS PDG comprises the most knowledgeable EW simulation modelers. For a fully architecture-neutral EW DEM to be developed, the EW DEM SG (or subsequent PDG) will have to generalize the DIS PDG's EW representations in a more general format that can be mapped into other interoperability solutions such as HLA and TENA.

The DIS V8 standard currently under development involves a radical redesign of the set of DIS PDUs to be more consistent and to enable PDU extensions between updates to the standard.² During this development effort, a subgroup of the DIS PDG examined the requirements for additional information to be inserted into the DIS EW PDUs to support modern Active Electronically Scanned Array (AESA)/ Passively Electronically Scanned Array (PESA) and mechanically scanned radars as well as jammers. The requirements came primarily from the U.S. Air Force's Combat Air Force Distributed Mission Operations program. As Lance Call writes in his "Advanced Radar and Jamming in DIS V8" paper [2023-SIW-001],

AESA/PESA radars use an array of antenna elements that can be controlled in such a way so that the beam(s) emanating from the array may be shaped and pointed very quickly. This can be accomplished in just a few microseconds. The beam may effectively be created and pointed at a desired target, then turned off and a new beam created and pointed at a second target, continuing until all targets have been visited. There is no requirement to sweep the beam between targets as required with a mechanical scan. ...

¹ The RPR FOM described in the next section must have dealt with this issue, so design patterns from that effort may be useful for the EW DEM.

² This extension process will be analogous to the process used for the SISO enumerations [SISO-REF-010-2023]. As with the enumerations, the intent is to design the records to be architecture neutral.

The AESA/PESA radar may use different waveform characteristics for each target and may dwell on each target for any desired amount of time depending on the fidelity and type of information the radar is trying to gather about the target. When not pointed at a target the beam may be scanned in a search pattern, or it may simply be turned off to reduce emissions and probability of detection by enemy receivers. The radar may revisit one target quite often, and another target less frequently if it is not of interest or of lesser threat. AESA radars may have multiple beams that can be active simultaneously, while PESA systems only have one beam. The dynamic nature of AESA/PESA radars makes it difficult, if not impossible, to model them in detail using only the current DIS V7 EE PDU.

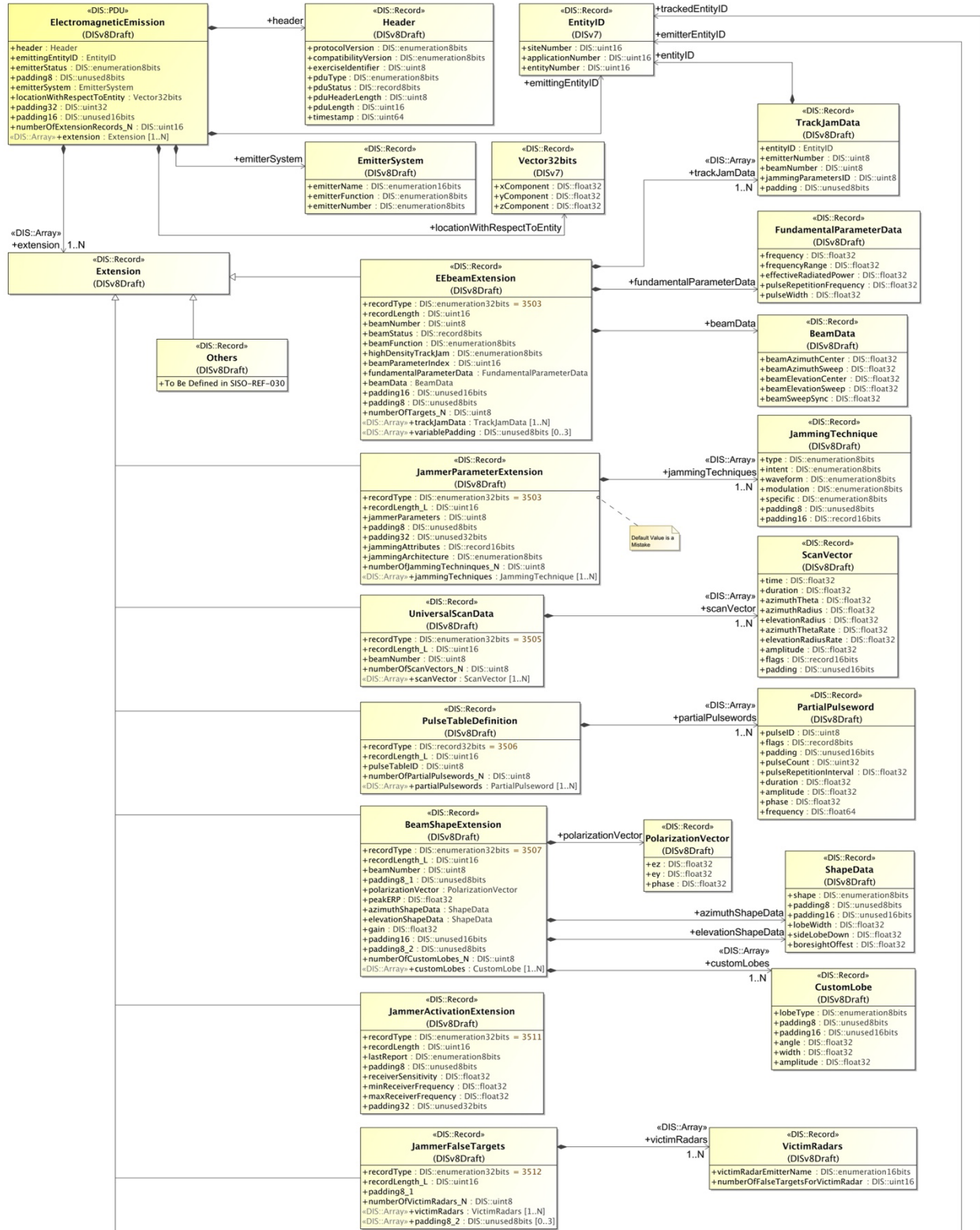
The extension records in DIS V8 are designed so each PDU can be easily extended for simulations that understand the extension, while not interfering with simulations that do not understand the extension. The DIS PDG identified eleven specific use cases and sixteen new extension records for the new DIS V8 EE PDU. An excerpt from the use cases and extension records in [2023-SIW-001] are shown in Figure 4.

Color Code Key		Radar Use Cases							Jammer Use Cases				
	New in DIS V8	Basic Radar	Advanced Mechanical Radars	ESA / LPI Radars	High Fidelity - No Local Database	Accurate Detailed Radar Scanning	Detailed Specific Pulse Usage	Obscuration Jammer	Basic Static State Jammers	Reactive Jammers	Training specific Jamming Display Results	Advanced Jamming	
ES	Essential												
RC	Recommend												
OP	Optional												
Record Name	Record Type												
EE PDU - Header	-	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	
EE PDU - Body	-	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	
EE Beam	3503	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	
Jammer Parameters	3504							ES	ES	ES	ES	ES	
Universal Scan Data	3505	OP	OP	ES	ES	ES	RC						
Pulse Table Definition	3506		OP	OP	ES	OP	ES					OP	
Beam Shape Definition	3507		OP	OP	ES	RC	OP					OP	
Fundamental Parameter List	3508		OP	ES	ES	ES	RC						
AZ/EL List	3509		OP	OP		OP	OP						
Beam Activity	3510		OP	ES	ES	ES	RC						
Jammer Activation	3511									ES			
Jammer False Targets	3512								RC	RC	ES	ES	
Jammer Triggered	3513									ES			
Blanking Sectors	3514	OP	OP										
Angle Deception	3515										ES		
Range Deception	3516										ES		
Velocity Deception	3517										ES		
False Targets Parameters	3518										ES		

Figure 4. Use Cases and Extension Records Used in the Design of the DIS V8 EE PDU

The use of the extension records will allow extremely complex radars and jammers to be modeled using DIS V8³, although at the cost of a substantial increase in complexity. A UML class diagram of a snapshot (January 2024) of the DIS V8 EE PDU is given in Figure 5.

³ It is the intention that SISO-REF-030 will not only support DIS v8 extension records but also DIS v7 Standard Variable records.



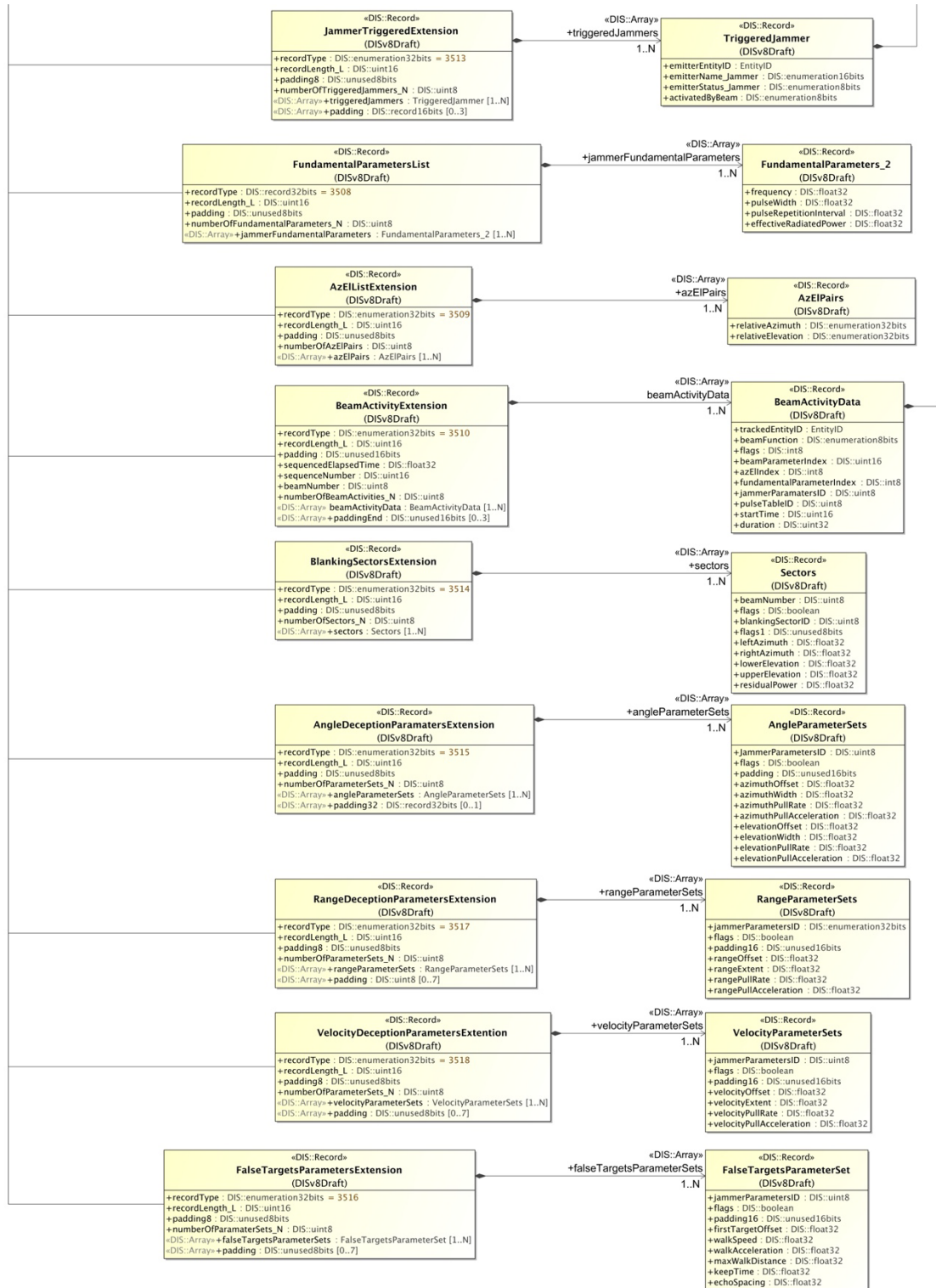


Figure 5. DIS V8 Electromagnetic Emission PDU Draft as of January 2024.

The new V8 EE PDU is extremely powerful and also exceptionally complex. The UML model above is faithful to the DIS V8 draft, so creating an architecture-neutral data exchange model

will be technically challenging, and will require consistent cooperation from and coordination with members of the DIS PDG. These coordination efforts have already begun.

6.2.2 Real-time Platform Reference Federation Object Model

SISO's RPR FOM is the FOM used most widely for defense simulations. At this writing, version 3 is preparing to go to balloting with many updates based on DIS 7.

Of particular interest to the EW DEM SG, RPR FOM 3 [SISO-STD-001-DRAFT] includes the DirectedEnergyFire Object Class. The following is excerpted from section 7.13.1.1 of the document.

The DirectedEnergyFire object class represents the firing of a DE weapon. Directed energy fire is implemented as an object class because it must preserve the state of the DE weapon fire over time. The update condition for the DirectedEnergyData attribute is dependent on what data is present in the array. If an item in the array uses the DEPrecisionAimpointRecord alternative, then the attribute shall be updated when this item meets the conditions specified in section 5.4.5.3.e of IEEE Std 1278.1TM-2012. If an item in the array uses the DEAreaAimpointRecord alternative, then the attribute shall be updated when this item meets the conditions specified in section 5.4.5.3.f of IEEE Std 1278.1TM-2012. The attribute shall also be updated when any items are added, any items are removed, or any items using another alternative are changed.

Section 7.13.1.1 also includes a table of attributes for the DirectedEnergyFire object class with:

- Attribute names
- The associated DIS PDU, Directed Energy Fire
- The associated field in the Directed Energy Fire PDU
- A reference to the associated section in IEEE Std 1278.1TM-2012
- The attribute's default value if the attribute is optional
- A definition (description) of the attribute

“An Information Operations (IO) module has been added to RPR FOM 3.0, which defines the new interaction classes IOaction and IOreport. These interactions will support the IO capabilities added to DIS V7 using the IO Action and IO Report PDUs. This capability will support electronic [electromagnetic] warfare (EW), computer network operations (CNO), psychological operations (PSYOP), military deception (MILDEC), and operations security (OPSEC).” [2023-SIW-RPR-FOM3] The IOinteraction class and its two subclasses, IOaction and IOreport, are illustrated in Figure 1.

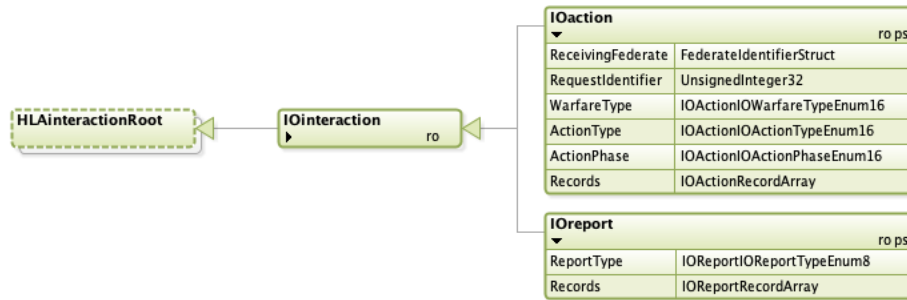


Figure 6. IOinteraction Class

The IOActionIOWarfareTypeEnum16 for EW is 1. IOActionIOActionTypeEnum16 has the following enumeration values:

- 1 - IO_Attack_Profile_Data_Parametrics_
- 2 - IO_Attack_Computed_Effects
- 3 - Intent_Based_EW
- 4 - Intent_Based_EW_Computed_Effects

Additionally, RPR FOM 3 has RadioTransmitter (Figure 2) and EmitterSystem and EmitterBeam object classes (Figure 3).

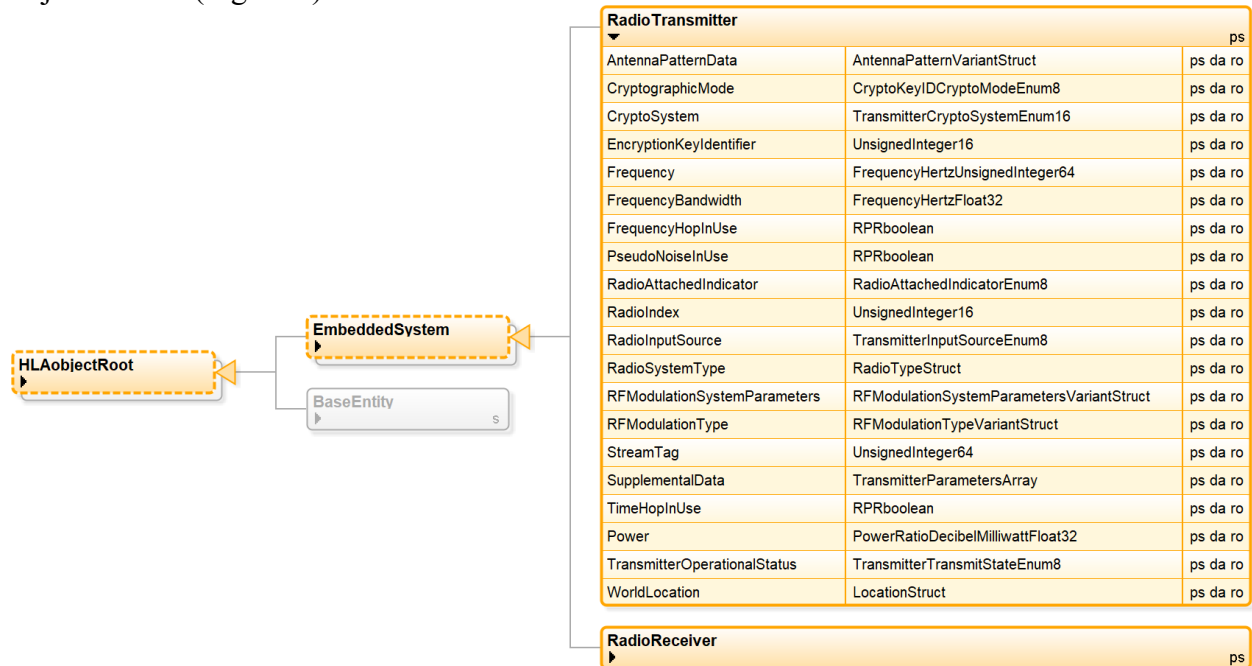


Figure 7. RadioTransmitter Object Class

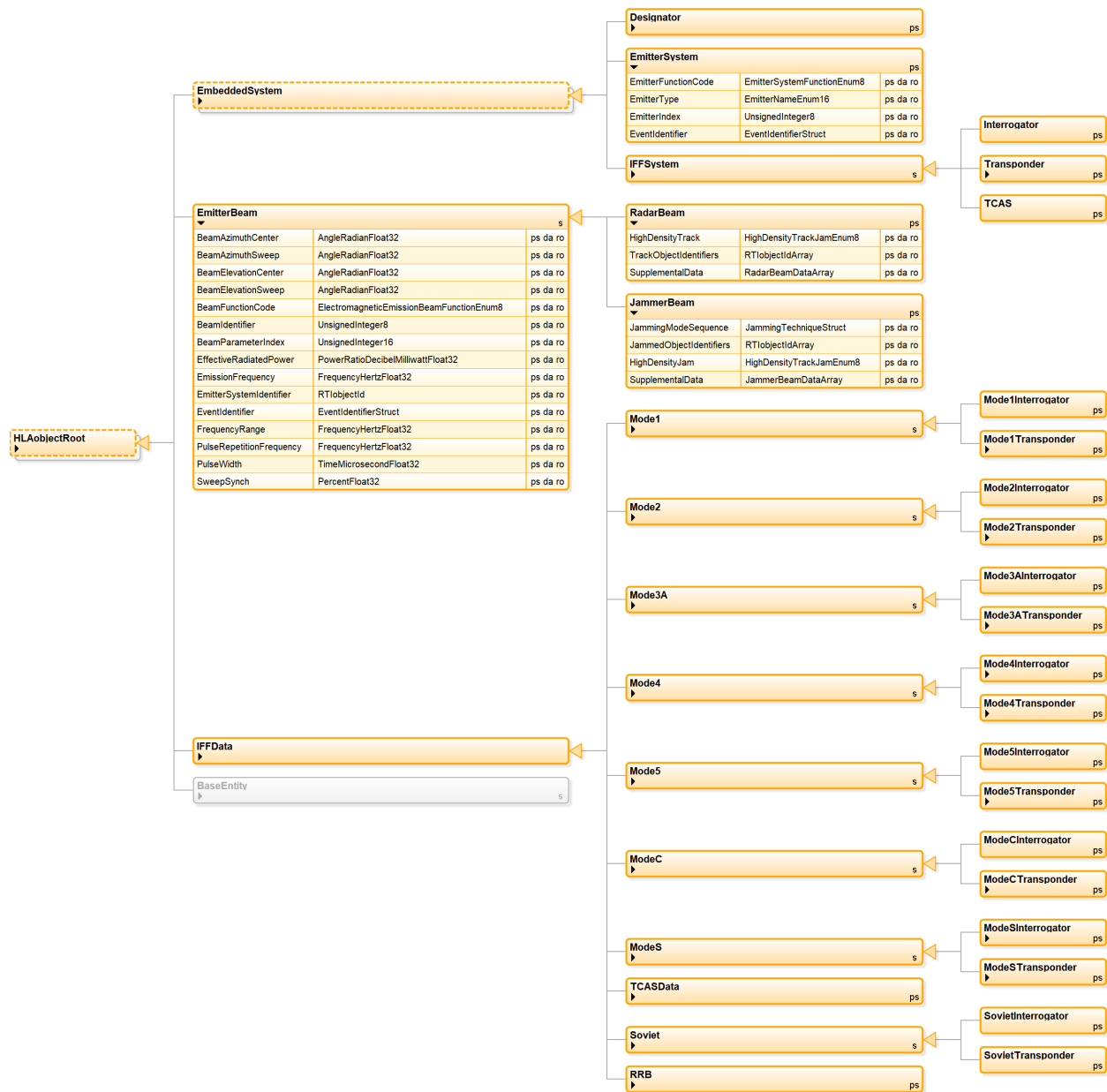


Figure 8. EmitterSystem and EmitterBeam Object Classes

In addition to these new object and interaction classes, RPR FOM 3.0 will also enhance the two existing publishable EmitterBeam child classes with attributes to provide supplemental data. This capability mirrors the ability in DIS 7 to extend the data provided in EE PDUs with Blanking Sector details (for radars) or Angle Deception or False Targets details (for jammers). Where in DIS 7 backward compatibility required this information to be provided in a separate Attribute PDU, in the RPR FOM the associated classes RadarBeam and JammerBeam have been extended. RPR FOM 3.0 has chosen to apply a common pattern for the generic DIS extension capability of Standard Variable (SV) records by defining dedicated variant records for each applicable class attribute or parameter. As these variant records are specified with the RPRextendedVariantRecord encoding (equivalent to the HLAextendableVariantRecord encoding added in the upcoming HLA 4), they can be easily extended with EW related (SV) records while

retaining full compatibility with the RPR FOM 3.0 standard. Using HLA 4, such variant record extensions can even be defined in separate FOM modules, if need be with limited distribution.

6.2.3 CyberBOSS

The CyberBOSS system provides an integrating architecture to integrate cyberspace and EW into LVC&G training environments. It supports *cyber-for-others* use cases, focusing on battle staff training to incorporate offensive and defensive cyberspace domain operations into their mission objectives. CyberBOSS connects a variety of systems, including constructive and virtual simulations, effects generators, visualization systems, and cyber ranges, to communicate cyberspace and EW effects across the training environment. CyberBOSS provides a cyberspace data model, software interfaces, and protocols to enable communication of cyberspace information across connected systems. The architecture is flexible and extensible with an emphasis on adaptation to future cyberspace training and analysis needs.

6.2.3.1 System Overview

An overview of the CyberBOSS system architecture is shown in Figure 1.

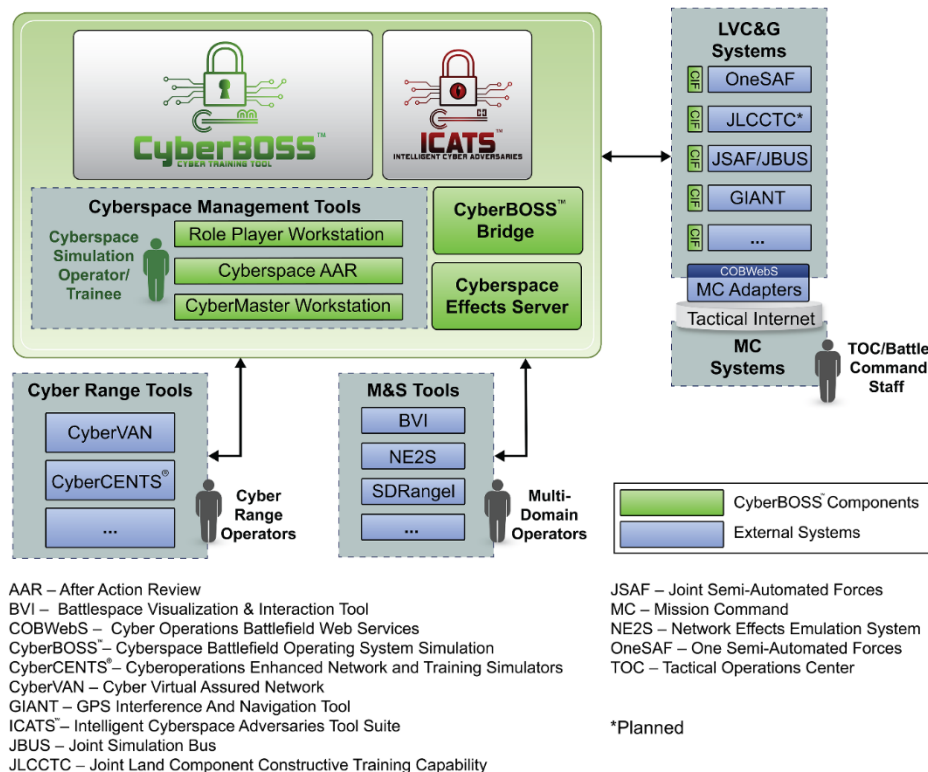


Figure 9. CyberBOSS System Architecture

All systems connected through CyberBOSS use a common Cyberspace Data Model (CDM) to communicate cyberspace information (e.g., cyber attacks/effects, device state, jamming areas). A wide variety of system types interoperate through the CyberBOSS system architecture, including LVC&G systems such as One Semi-Automated Forces (OneSAF) and Joint Semi-Automated Forces (JSAF), cyber ranges such as Cybersecurity Virtual Assured Network (CyberVAN) and Cyberoperations Enhanced Network and Training Simulators (CENTS), cyberspace effect and operation models such as reconnaissance models, network models, and intelligent adversaries,

and cyberspace effects tools such as Cyber Operations Battlefield Web Services (COBWebS), and Network Effects Emulation System NE2S). The CyberBOSS architecture delegates information between LVC&G systems and the cyber range to accomplish combined training of traditional warfighting functions and cyberspace domain operations using these disparate toolsets. CyberBOSS can broker cyberspace effects across federated LVC&G systems during times when no cyber range is used.

Additionally, CyberBOSS provides applications used to control and monitor cyberspace and EW effects across the federation and to provide After Action Review (AAR) data collection. For example, the CyberBOSS CyberMaster Workstation (CyberBOSS Control Tool) is a thin-client display solution that enables the cyber training facilitator to view and manage cyberspace effects and operations within the training scenario. Adding external cyberspace effects models through the CyberBOSS Cyberspace Effects Server brings enhanced modeling of cyberspace effects and cyberspace operation Tactics, Techniques, and Procedures (TTP). Automated cyberspace adversary modeling is performed using the Intelligent Cyberspace Adversaries Tool Suite (ICATS) services and tools. Finally, the CyberBOSS architecture contains the CyberBOSS Bridge application, used to communicate with external systems using a variety of protocols and standards.

6.2.3.2 *EW Training Capabilities*

CyberBOSS currently supports some EW training capabilities. This section documents a specific EW training capability that was developed within CyberBOSS to support the 2022 Army Expeditionary Warrior Experiment (AEWE). At that experiment, the CyberBOSS architecture was used to coordinate EW effects between the simulation and live training environments, demonstrating coordinated cyber training across those two environments to provide more realistic training to the warfighter. In the sections below, we provide a description of the CyberBOSS architecture and data model used to support this capability.

6.2.3.2.1 *AEWE 2022 Use Case Description*

In this capability, simulated threat actors in the constructive simulation produce areal jamming effects and those effects are communicated by CyberBOSS to the live training environment. These jamming effects are then placed on live tactical radios used by the Blue Force (BLUFOR) training audience to degrade or disrupt communication by participants, impacting their ability to execute their mission. The training goal is for the trainees to detect that their ability to communicate is degraded or denied and to trigger responses to determine mitigation strategies such as alternate communication paths or other methods to regain full operational capabilities. This approach is a significant improvement over current training in which exercise facilitators communicate the presence of CEMA effects in a manual fashion.

To demonstrate its usefulness to provide coordinated EW training between constructive simulations and the live environment, CyberBOSS was deployed during the 2022 AEWE held at Fort Moore, Georgia. The annual AEWE event assesses Cross Domain Maneuver concepts and capabilities at the lower tactical echelon in support of Multi Domain Operations (MDO). During the AEWE, CyberBOSS brokered EW effects across the distributed training environment, producing simulated jamming effects on live tactical radios in the range.

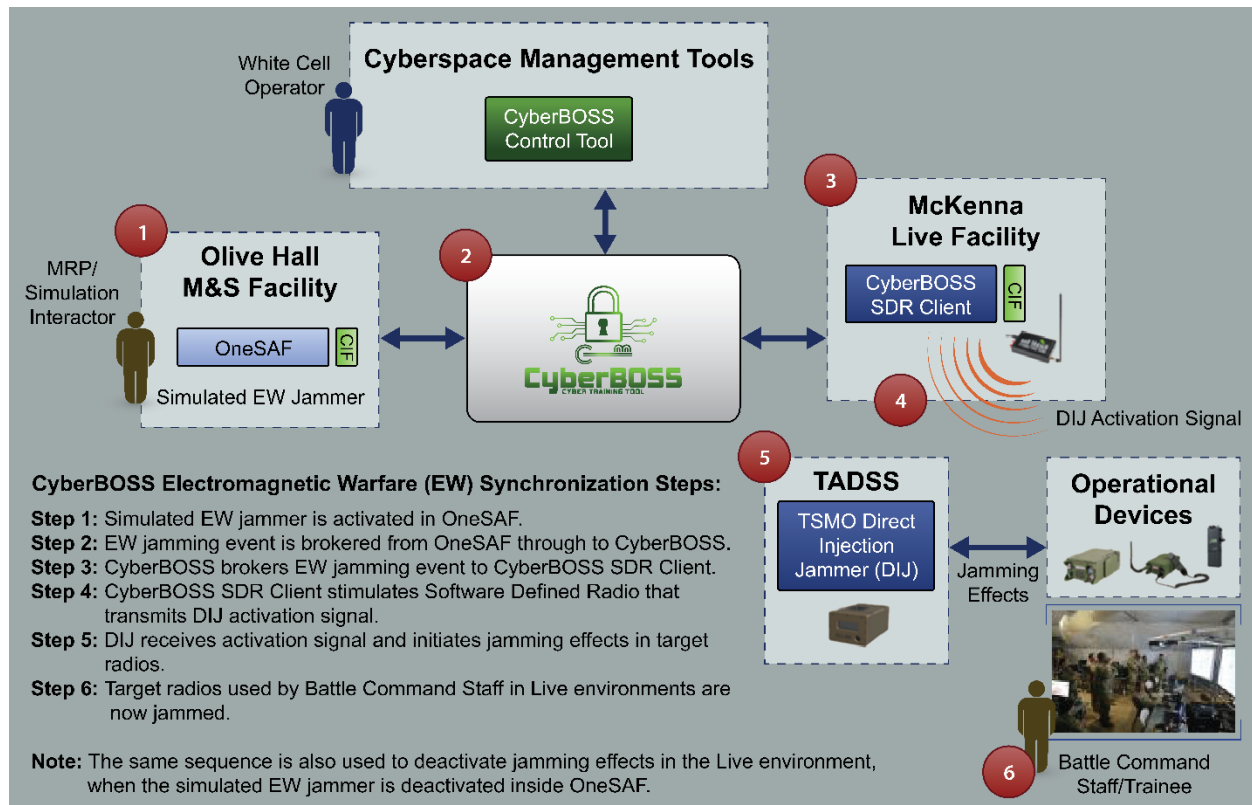


Figure 10. Laydown of Simulation and Live Training Systems Used for Experimentation of EW Effects and Communication during the 2022 AEWE

The laydown of the simulation systems and live systems used for CyberBOSS experimentation during AEWE is shown in Figure 2. Within the simulation environment at Olive Hall, a OneSAF simulation cluster was deployed. This cluster utilized a OneSAF v9.0 baseline with additional functionality maintained by the U.S. Army Combat Capabilities Development Command (DEVCOM) Data & Analysis Center (DAC). Within the simulation environment, a CyberBOSS federation was also deployed, consisting of one instance of the following components: CyberBOSS Server, CyberBOSS Control Tool, CyberBOSS Effects Server, and CyberBOSS Bridge. The OneSAF simulation was provided with an adapter with which it communicated cyberspace and EW objects and events with the CyberBOSS federation.

Upon activation of a simulated EW jammer in OneSAF, the jamming effect is modeled by the CyberBOSS Effects Server and the resulting jamming event is communicated from the simulation infrastructure to a CyberBOSS client application located at the McKenna Military Operations in Urban Terrain (MOUT) site. That site is in the vicinity of the live training audience and radio frequency (RF) signals from the McKenna site can reach the Training Aids, Devices, Simulations, and Simulators (TADSS) attached to the tactical devices in the live training environment. Communication between the CyberBOSS infrastructure at Olive Hall and the CyberBOSS client at the McKenna site performed using existing range instrumentation networks.

Throughout the course of the AEWE event, the coordination of jamming events within the simulation environment with jamming of tactical radios in the live environment was

demonstrated multiple times. Successful experimental results were achieved each time, with activation of simulated jammers in OneSAF resulting in jamming of inbound radio communications of live tactical devices. This experiment also demonstrated the ability to perform this jamming in the live environment without emitting jamming signals. Because this solution does not interfere with existing military and commercial RF signals in the environment, it significantly facilitates the deployment of this technology within Live training ranges.

6.2.3.3 Data Model Representation

As previously mentioned, federated CyberBOSS applications communicate the events and state of cyberspace activity using the CDM, which represents the cyberspace state and activity of both Internet Protocol (IP)-based connected devices (e.g., computers, routers, mobile phones, security cameras) and RF-based devices (e.g., radios, radars, sensors, satellites, and weapons). RF devices utilize various sections of the EMS (e.g., radio wave, microwave, infrared) for operation. EM devices, and their corresponding cyberspace properties and vulnerabilities, are intrinsically different from the IP-based devices that are used for network operations. For example, they do not use a scheme such as IP for addressing and routing, and thus are not vulnerable to IP-based scanning, spoofing, and other network operations. Instead, these devices may be interfered with or jammed altogether through manipulation of the EMS.

Due to the fundamental differences between EM devices and the traditional computer network operations (CNO) devices, the CyberBOSS CDM separates these objects into distinct types, as shown in Figure 3.

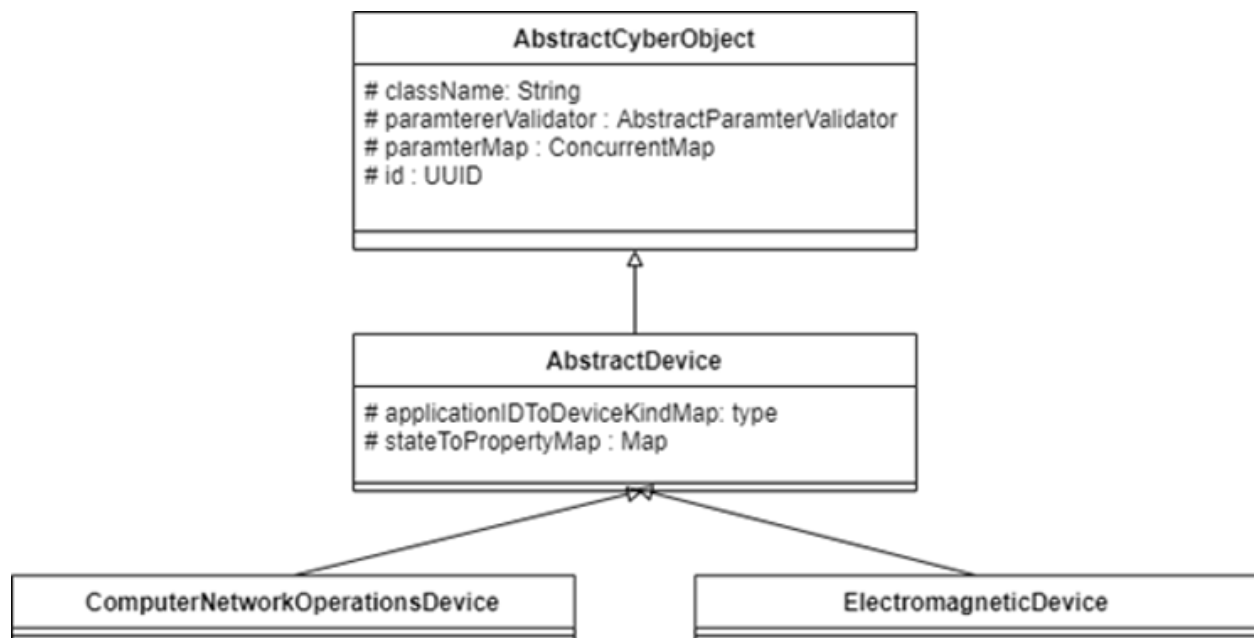


Figure 11. CDM Expression of CNO and RF Devices

An AbstractDevice object is the parent to all Device objects and is used to encapsulate common attributes. The ComputerNetworkOperationsDevice and ElectromagneticDevice object types

contain parameters specific to the device type. Example parameters for each type are shown in Table 1. The CyberBOSS framework uses validation services to ensure that the parameters set on each device type are appropriate. It is expected that additional EM device parameters will be added to the CyberBOSS CDM as they are identified for the EW DEM.

Table 1. Examples of Common and Specific Cyberspace Parameters

Common Device Parameters	CNO Device Parameters	EM Device Parameters
CAPABLE_OF_ATTACK DEVICE_NAME DEVICE_AFFILIATION DEVICE_KIND DEVICE_TYPE LOCATION MANUFACTURER ORIGIN OWNER_ENTITY_ID	ASSOCIATED_NETWORKS IP_ADDRESS OPERATING_SYSTEM_NAME OPERATING_SYSTEM_TYPE OPERATING_SYSTEM_VERSION DELAY_OF_SERVICE_VULNERABLE DENIAL_OF_SERVICE_VULNERABLE INJECTION_ATTACK_VULNERABLE INTERCEPTION_ATTACK_VULNERABLE PACKET_DEGRADATION_VULNERABLE	CENTER_FREQUENCY BANDWIDTH TRANSMITTING_POWER SCAN_RATE SENSITIVITY ANTENNA_GAIN ANTENNA_HEIGHT DUPLEX_MODE MODULATION_TYPE JAMMING_VULNERABLE

6.2.4 Test & Training Enabling Architecture

TENA Definition Language (TDL) is a text-based representation used to define TENA object models, which are the data contract for object model users. TDL files are used to generate TENA Middleware API code that enforces the data contract. TDL files are also used to generate supporting applications, including sample code and TENA Data Collection System data logging, data viewing, and replay applications. TENA has well-established Object Models (OMs) that represent and support the M&S of a variety of hardware, tactical, commercial and warfighting systems while promoting data interoperability for those systems under test. Examples of these OMs include the following:

- Instrumentation (sample list)
 - Radar surveillance system
 - Radar tracking system
 - Telemetry systems
 - Track, based on different measurements
 - Azimuth
 - Azimuth elevation
 - Radial velocity
 - Range
 - Range azimuth
 - State 3D
- LVC (sample list)
 - Engagement
 - Munition Fire
 - Munition Detonation
 - Detonation Results
 - Entity
 - IFF
 - Radar system

○ Track

TENA is also working on releasing an LVC Emitter OM based on DIS V7, which is intended to support the representation of an emitter and its electromagnetic emissions for M&S and LVC purposes. There are three types of emitter objects supported by this object model:

- **ParameterizedEmitter** - A representation that utilizes a few parameters to identify the emitter type and operating state that is then combined with a common database and models that are used to stochastically generate the emissions. Some of the common database models are the Electronic Warfare Integrated Reprogramming Database (EWIRDB), and the Next Generation EWIRDB System (NGES). This representation is often used with complex emitters where it is not feasible to send network updates at a high enough rate to properly represent the emissions. This representation requires the publisher and subscribers to use the same database model, which is not controlled by this object model. See Figure 7.
- **CharacterizedEmitter** - A representation that is based on the DIS EE PDU, and uses a number of individual attributes to characterize the emissions. See Figure 8.
- **ReportedEmitter** - A representation used when there is a report from a live emitter, such as the telemetry information from an aircraft with emitters or an update from a radar system. See Figure 9.

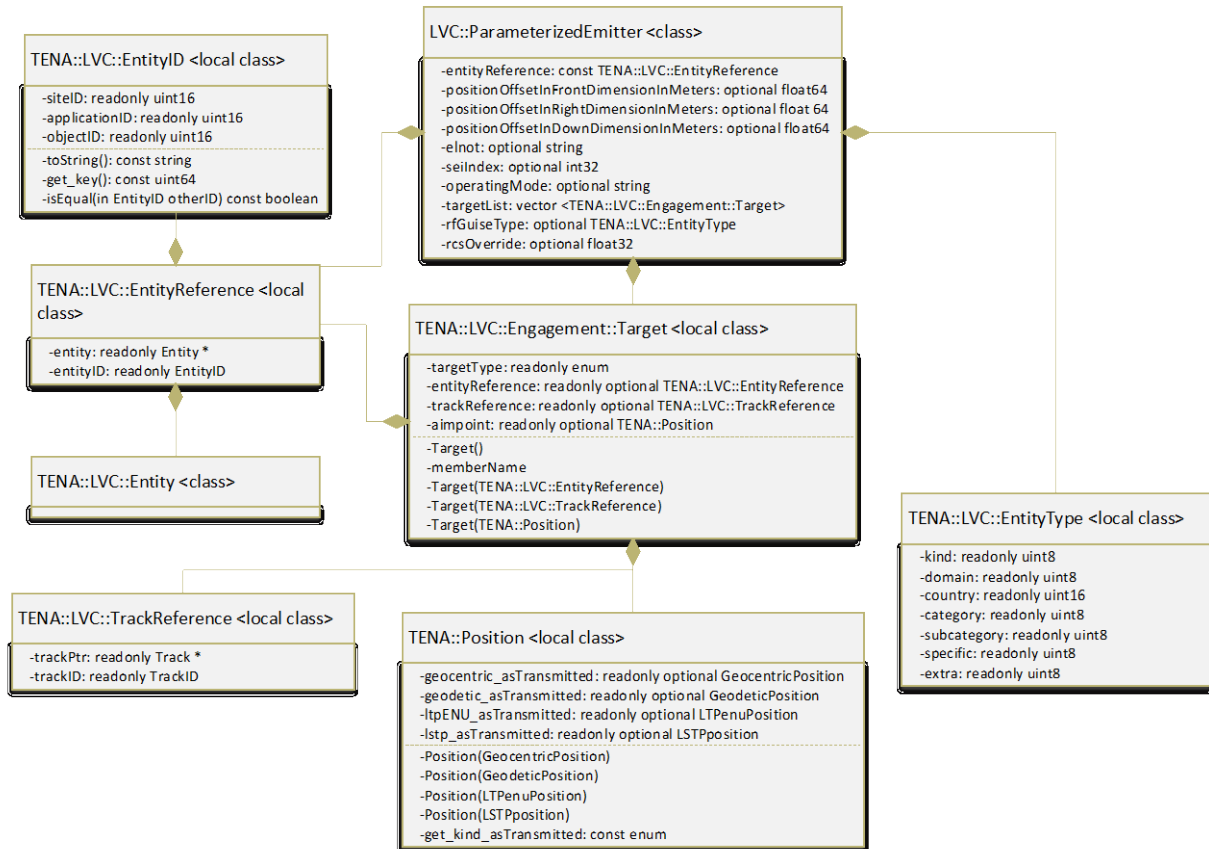


Figure 12. ParameterizedEmitter OM

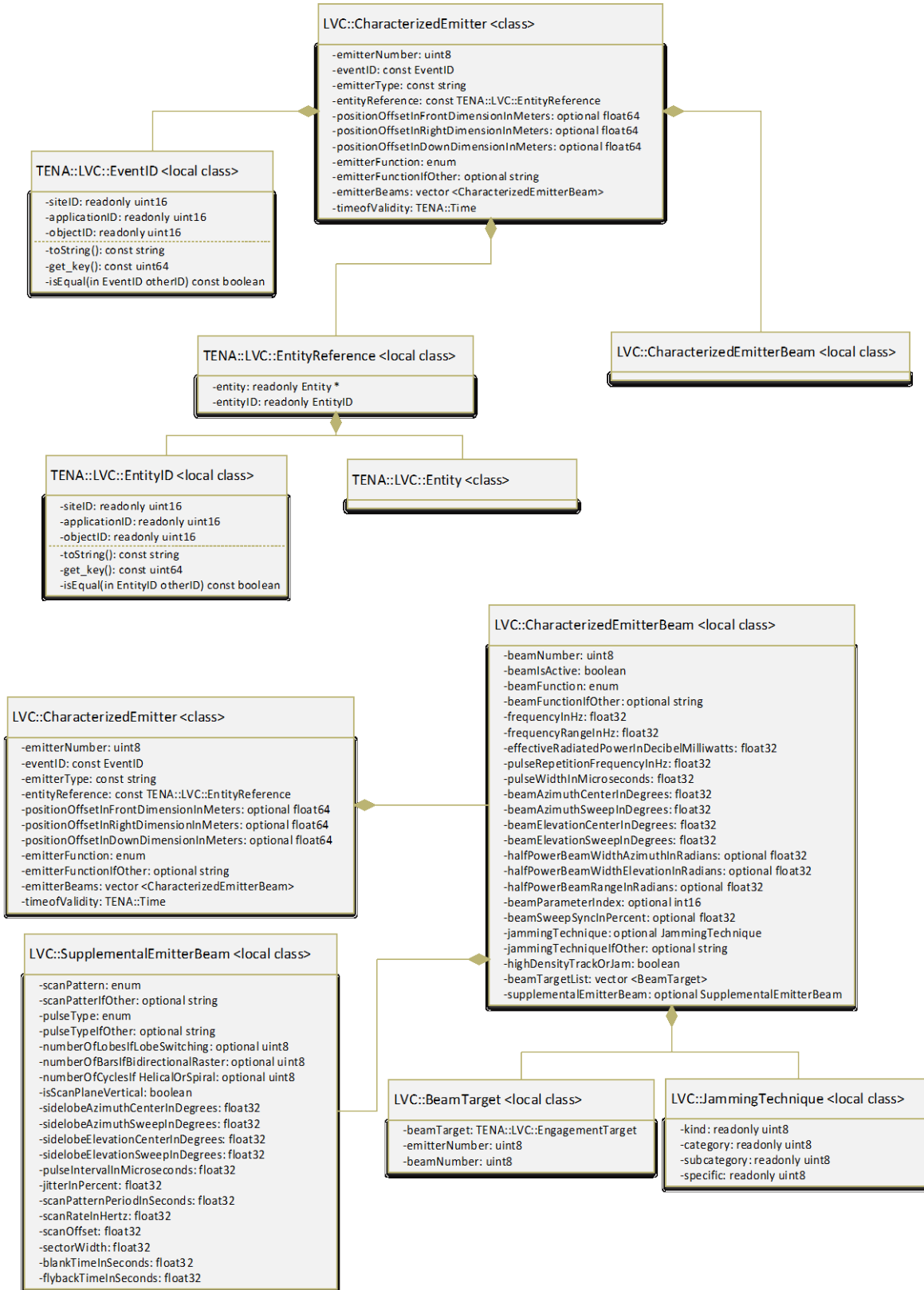


Figure 13. CharacterizedEmitter OM

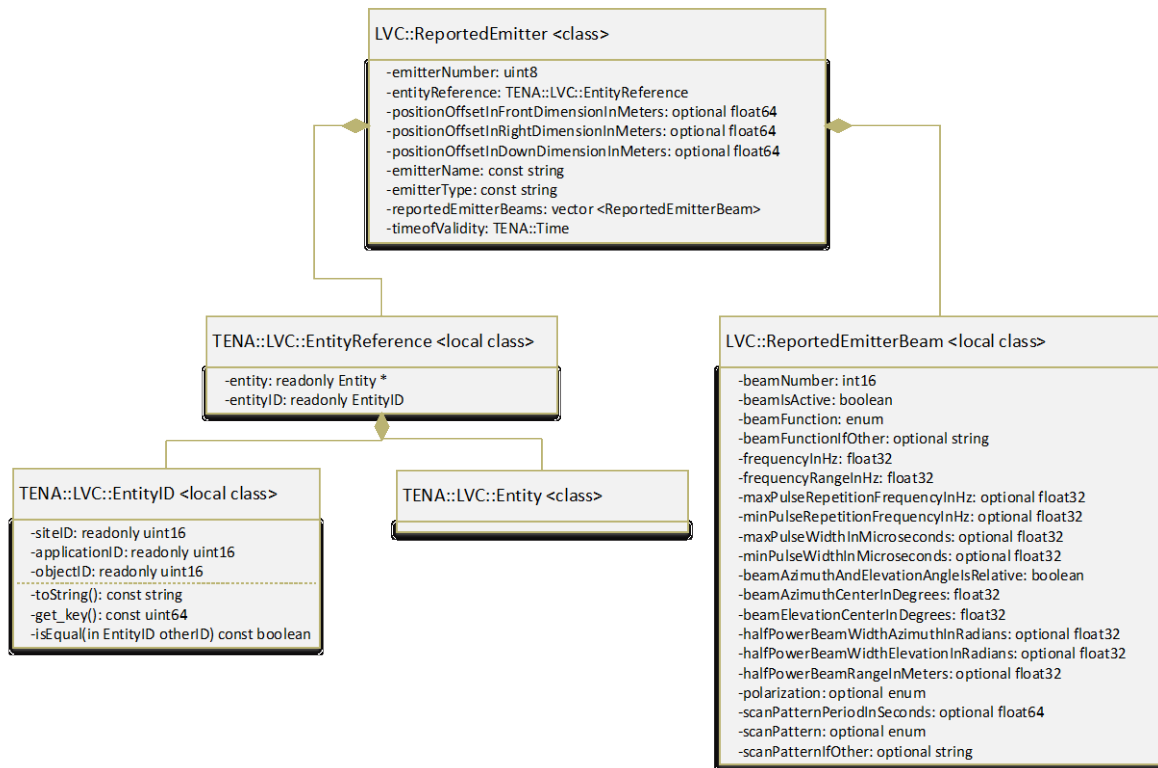


Figure 14. ReportedEmitter OM

6.2.5 Army Reprogramming Analysis Team Simulation Modeling Framework

The Simulation Modeling Framework is the general term that refers to how the Army Reprogramming Analysis Team (ARAT) simulates emitters. The products for a simulation include the code file, metadata, and report.

6.2.5.1 ARAT Terms

Code File: Scripts written in ARAT's programming language, the Pulse Descriptive Language (PDL), that produce files containing information that simulates an emitter's waveforms.

Metadata: A file created by executing a code file that contains parameter information for each mode simulated, such as: pulse repetition interval (PRI), pulse width (PW), RF, scan duration (if applicable), and maximum power.

Report: A report written by the simulation builder that provides reasoning for decisions made due to unclear/lack of information when creating the simulation.

6.2.5.2 General Thoughts

After comparing the UML diagrams and documentation from DIS V7 and DIS V8, it is ARAT's opinion that DIS V8 is a more detailed representation of the PDUs ARAT simulates and is the preferred version to base standards discussion from.

6.2.5.3 Table Notes

Jamming: ARAT's scope has changed to now include jamming in the simulations. As this is a very recent change, it is unknown which jamming parameters will be included going forward.

Know that currently, ARAT cares about all jamming parameters until further decisions are made regarding specifics.

Padding: Padding seems to be used to fill out sections of the EE PDU format. This aspect isn't applicable to how ARAT currently produces emitter waveforms and are excluded. Table 2 compares what is found in DIS V7 in the EE PDU and Transmitter PDU with what information is included in SMF. It also includes information that is needed for SMF, but not present in DIS V7.

Table 2. DIS V7 and SMF Mapping

DIS V7 EE PDU	SMF
5.7.3.2 a) Identification of the emitting entity	Included in code file, metadata, and report
5.7.3.2 b) Identification of the event	Not within our scope
5.7.3.2 c) Number of emitter systems described in the PDU	Included in report – 1 system at most
5.7.3.2 d) 1) Length of the emitter system data provided in the PDU	Excluded
5.7.3.2 d) 2) Number of beams described in the emitter system data section	Included in metadata
5.7.3.2 d) 3) Emitter system identification, including the emitter name, function for which the emitter system was designed, and emitter number	Included in report, except emitter number (outside scope)
5.7.3.2 d) 4) Location relative to the entity, providing the source location of all beams on the emitter system.	Will be included
5.7.3.2 d) 5) i) Length of the beam data in PDU.	Excluded
5.7.3.2 d) 5) ii) Beam number.	Included in metadata
5.7.3.2 d) 5) iii) Beam parameter index, with which receivers reference detailed local database parameters.	Excluded
5.7.3.2 d) 5) iv) Fundamental parametric data, describing basic characteristics of a beam that may vary for a given beam function.	Included in metadata
5.7.3.2 d) 5) v) Beam data, indicating the geometry of each emitting beam.	Included in report and code
5.7.3.2 d) 5) vi) Beam function identifier, indicating the purpose of each emitting beam.	Included in code file and metadata
5.7.3.2 d) 5) vii) Number of targets for which information is provided in the track/jam data section of the beam.	Will be included
5.7.3.2 d) 5) viii) High-Density Track/Jam field to indicate that a large number of entities may be under track or may be the target of jamming.	Will be included
5.7.3.2 d) 5) ix) Jamming technique to define electronic warfare methods being applied (e.g., noise jamming and Velocity Gate Pull-Off).	Will be included
5.7.3.2 d) 5) x) Beam status information for each beam (e.g., the beam is active or deactivated).	Included
5.7.3.2 d) 5) xi) For each beam provided in the emitter system, a track/jam data section to list one or more entities tracked or under illumination, or beams that are targets of jamming.	Will be included
5.7.3.3.1 Simulation applications shall issue EE PDUs: (1) when significant changes occur in any active emitter or (2) when the reference time elapsed since the emitter's last published EE PDU exceeds a predetermined timeout.	
A simulation shall issue an EE PDU when:	
5.7.3.3.2 a) An inactive emitter system becomes active or an active emitter system becomes inactive. An active emitter system is one that has at least one active beam. An active beam is one that is emitting or one that is in transition from emitting to not emitting (see 5.7.3.6).	Excluded
5.7.3.3.2 b) A simulation shall issue an EE PDU when... Emitter system operational parameters change. Operational parameters include number	Excluded

DIS V7 EE PDU	SMF
of emitter systems and beams, location with respect to entity, beam parameter index, beam function, number of targets, jamming technique, and track/jam data records.	
5.7.3.3.2 c) A simulation shall issue an EE PDU when... Changes in beam fundamental parameters contained in the PDU fields exceed specified thresholds. Fundamental parameters include Effective Radiated Power (ERP), frequency, frequency range, Pulse Repetition Frequency (PRF), and Pulse Width (PW). Fundamental parameter thresholds are identified by the symbolic names EE_ERP_THRSH, EE_FREQ_THRSH, EE_FRNG_THRSH, EE_PRF_THRSH, and EE_PW_THRSH, respectively (see 6.1.8).	Excluded
5.7.3.3.2 d) A simulation shall issue an EE PDU when... Changes in beam geometry descriptors exceed specified thresholds. Beam geometry descriptors include beam azimuth center, beam azimuth sweep, beam elevation center, and beam elevation sweep. The azimuth and elevation thresholds shall be identified by the symbolic names EE_AZ_THRSH and EE_EL_THRSH, respectively. (See 4.2.8.3 for parameter details and default values.)	Excluded
5.7.3.3.2 e) A simulation shall issue an EE PDU when... A predetermined timeout has elapsed since issuing the last emitter system update. A separate heartbeat timer shall be maintained for each emitter system associated with an entity (see 5.7.3.3.4). The EE PDU heartbeat parameter shall be identified by the symbolic name HBT_PDU_EE (see 6.1.8).	Excluded
5.7.3.3.3 a) Construction of the EE PDU shall not cause the length of the PDU to exceed the maximum PDU size (see 6.3.3).	Excluded
5.7.3.3.3 b) When an entity is destroyed but still active [Entity Appearance record Damage field (bits 3 to 4) set to Destroyed (3) but still issuing Entity State PDUs], each simulation application that models emitter systems associated with that entity shall issue final EE PDUs that turn off all active beams for all emitter systems modeled.	Excluded
5.7.3.3.3 c) When the number of tracked or illuminated entities or the number of beams being jammed exceeds a certain threshold, then the High-Density Track/Jam field shall be set to Selected (1), zero shall be entered in the Number of Targets field, and no Track/Jam Data records shall be included in the track/jam data field. The threshold parameter shall be identified by the symbolic name EE_HIGH_DENSITY_THRSH (see 6.1.8 for parameter details and default values).	Excluded
5.7.3.3.3 d) Continuous wave emissions shall be represented by 0.0 values in both the Pulse Repetition Frequency and Pulse Width fields.	Excluded (CW emissions are included, but not represented with 0 values)
5.7.3.3.3 e) Specific Field Requirements	Excluded
5.7.3.3.4 Issuance methods	Most similar to complete-beam issuance method
5.7.3.4 Receipt of the EE PDU	Excluded
5.7.3.5 Emission regeneration	Included but not with DIS specific fields
5.7.3.6 Beam and emitter system activation and deactivation	Excluded
5.7.3.7 Track/jam targets	Will be included
5.7.3.8 Jamming	Will be included
5.7.3.9 Phased array radars	Included
5.7.3.10 Supplementing the EE PDU	Excluded

DIS V7 EE PDU	SMF
Antenna pattern exists for the Transmitter PDU the info to the right doesn't seem to be included in that.	Antenna info: • Aperture illumination • Spoiled extent and side if applicable • Sidelobe levels • Pattern data (ERP vs Angle (deg))
Modulation is mentioned for the EE PDU but the level of detail for isn't very clear.	Modulations • Algorithms if applicable • Intra-pulse • Inter-pulse

Table 3 compares what is found in DIS V8 in the EE PDU and Transmitter PDU with what information is included in SMF. It also includes information that is needed for SMF, but not present in DIS V8. Information on DIS V8 is pulled from PCR265_Gen3EmissionPDU_VerM and PCR281_SupplementalERecords_VerJ.

Table 3. DIS V8 and SMF Mapping

DIS V8	SMF
9.2.3 a) PDU Header	Excluded
9.2.3 b) Emitting Entity ID	Included in report, code file, metadata
9.2.3 c) Emitter Status	Included in code file
9.2.3 d) Emitter System	Included in report, code file, metadata
9.2.3 e) Location with respect to entity	Included in code file
9.2.3 f) Number of Extension Records	Excluded
9.2.3 g) Extension Records	Included in code file (contents of Extension Records are included, but not formatted as Extension Records)
Destroyed But Still Active	Excluded
Beam Extension	Included in code file except for Record Type
Emitter Activation/Deactivation	Included in code file
All Track/Jam Parameters	Will be included
15.21.2 a) Record Type	Excluded
15.21.2 b) Record Length	Excluded
15.21.2 c) Beam Number	Included in metadata
15.21.2.d) Beam Status	Included in code file
15.21.2 e) Beam Function	Included in metadata, code file, and report
15.21.2 f) High-Density Track/Jam	Will be included
15.21.2 g) Beam Parameter Index	Included
15.21.2 h) Fundamental Parameter Data	Included in code file and metadata
15.21.2 i) Beam Data	Included in code file
15.21.2 j) Number of Targets	Included in code file and report
15.21.2 k) Array of Track/Jam Data	May be included
15.21.3 a) Continuous wave emissions shall be represented by the value 0.0 in both the Pulse Repetition Frequency and Pulse Width fields.	Excluded (Continuous wave emissions are not represented this way. There will be a separate object for it without a PW field.)

DIS V8	SMF
15.21.3 b) 1) Beam Number	Included in metadata
15.21.3 b) 2) Beam Sweep Sync	Included in code file
15.21.3 b) 3) Beam Function	Included in code file and metadata
15.58.2 a) Record Type	Excluded
15.58.2 b) Record Length	Excluded
15.58.2 c) Jammer Parameters ID	Will be included in metadata
15.58.2 d) Jamming Attributes	Will be included in code file
15.58.2 e) Jammer Architecture	May be included
15.58.2 f) Number of Jamming Techniques	May be included
15.58.2 g) Array of Jamming Techniques	May be included
14.11.2 a) Beam Azimuth Center	Included in code file
14.11.2 b) Beam Azimuth Sweep	Included in code file
14.11.2 c) Beam Elevation Center	Included in code file
14.11.2 d) Beam Elevation Sweep	Included in code file
14.11.2 e) Beam Sweep Sync	Excluded
14.22 a) Frequency	Included in code file
14.22 b) Frequency Range	Included in code file and metadata (range of frequencies are included in code file and metadata, but difference between lower and upper limit not included)
14.22 c) Effective Radiated Power	Included in code file and metadata
14.22 d) Pulse Repetition Frequency	Included in code file and metadata (as Pulse Repetition Interval in microseconds instead of PRF)
14.22 e) Pulse Width	Included in code file and metadata
14.48.2 a) Persistent	Will be included
14.48.2 b) Constant Power	Will be included
14.48.2 c) Coordinated	Will be included
14.48.2 d) Cooperative	May be included
14.48.2 e) Coherent	Will be included
14.48.2 f) Bounce	Will be included
14.48.2 g) Downlink	Will be included
14.49.2 a) Type	Will be included
14.49.2 b) Intent	Will be included
14.49.2 c) Waveform	Will be included
14.49.2 d) Modulation	Will be included
14.90 a) Entity ID	Included in report, code file, and metadata
14.90 b) Emitter Number	Will be included
14.90 c) Beam Number	Will be included
14.90 d) Jammer Parameters ID	Will be included
14.4 a) Beam State	Included in code file
14.4 b) Beam Stabilization	Included in code file
15.21.4.2 a) Record Type	Excluded

DIS V8	SMF
15.21.4.2 b) Record Length	Excluded
15.21.4.2 c) Beam Number	Included in metadata
15.21.4.2 d) Number of Scan Vectors	Excluded
15.21.4.2 e) 1) Time	Included in code file
15.21.4.2 e) 2) Durations	Included in code file
15.21.4.2 e) 3) Azimuth-Theta	Included in code file (degrees, polar not included)
15.21.4.2 e) 4) Elevation-Radius	Included in code file (degrees, polar not included)
15.21.4.2 e) 5) Azimuth-Theta Rate	Excluded
15.21.4.2 e) 6) Elevation-Radius Rate	Excluded
15.21.4.2 e) 7) Amplitude	Included in code file
15.21.4.2 e) 8) i) Polar Scan Type	Excluded
15.21.4.2 e) 8) ii) Secondary	Included in code file
15.21.5.2 f) Record Type	Excluded
15.21.5.2 g) Record Length	Excluded
15.21.5.2 h) Pulse Table ID	Excluded
15.21.5.2 i) Number of Partial Pulsewords	Excluded
15.21.5.2 j) 1) Pulse ID	Excluded
15.21.5.2 j) 2) iii) Discrete Amplitude	Included in code file
15.21.5.2 j) 2) iv) Discrete Frequency	Included in code file
15.21.5.2 j) 2) v) Discrete Phase	Included in code file
15.21.5.2 j) 3) Pulse Count	Included in code file
15.21.5.2 j) 4) Pulse Repetition Interval	Included in code file
15.21.5.2 j) 5) Duration	Included in code file
15.21.5.2 j) 6) Amplitude	Included in code file
15.21.5.2 j) 7) Phase	Included in code file (degrees)
15.21.5.2 j) 8) Frequency	Included in code file (MHz)
15.21.6.2 a) Record Type	Excluded
15.21.6.2 b) Record Length	Excluded
15.21.6.2 c) Beam Number	Included in metadata
15.21.6.2 d) Polarization Vector	Included, but less in depth with Ez and Ey combined into a single variable
15.21.6.2 e) Peak ERP	Included in code file and metadata
15.21.6.2 f) 1) Shape	Excluded
15.21.6.2 f) 2) Lobe Width	Included in code file
15.21.6.2 f) 3) Side Lobe Down	Included in code file
15.21.6.2 f) 4) Boresight Offset	Excluded
15.21.6.2 g) Elevation Shape Data	Same as 15.21.6.2 f)
15.21.6.2 h) Gain	Included in code file
15.21.6.2 i) Number of Custom Lobes	Excluded
15.21.6.2 j) Array of Custom Lobes	Excluded, can define position (az and el) and attenuation at each position

DIS V8	SMF
Excluded	Antenna Aperture Illumination
Excluded	Spoiled extent and side if applicable

6.2.6 EW Tools/Systems Considered

The EW DEM SG considered current and emerging EW systems, their functions, and the type of data they must exchange. This review offered insight into the capabilities that need to be represented with the EW DEM.

6.2.6.1 *Electronic Warfare Planning and Management Tool (EWPMT)*

EWPMT provides 18 major operations capabilities at varying levels of technical maturity. Future Operations (FUOPS) mode provides the ability to plan, model, and simulate EW effects. Current Operations (CUOPS) mode provide the means to receive geographical lines of bearing (LoB) and other sensor data to produce visualizations of the Electromagnetic Operating Environment (EMOE) enabling situational awareness. EWPMT enables cyberspace and electromagnetic activities (CEMA) and provides data for the overall Commander's Common Operational Picture (COP). Future development includes a more refined ability to ingest Terrestrial Layer System (TLS) and Multi-Function Electronic Warfare (MFEW) sensor data, provide PNT situational awareness, and the eventual means to command and control the sensors through EWPMT.

6.2.6.2 *Intelligence Electronic Warfare Tactical Proficiency Trainer (IEWTPT)*

The Intelligence Electronic Warfare Tactical Proficiency Trainer (IEWTPT) provides proficiency training for Military Intelligence (MI) and operators in multiple disciplines (e.g., All Source, Signals Intelligence, Geospatial Intelligence, and EW) and tasks in a distributed, multi-domain simulation environment. IEWTPT supports simulations and games with taskings for electromagnetic attack (EA) and electromagnetic support (ES) via virtual jammers and sensors. It offers basic emitter reports (BER), LoB, geolocation that include frequency, Received Signal Strength Indicator (RSSI), Notation, and other observed signal parametric data.

6.2.6.3 *C5ISR/EW Modular Open Suite of Standards (CMOSS)*

Command Control Communications Computers Cyber Intelligence Surveillance Reconnaissance (C5ISR)/Electronic Warfare (EW) Modular Open Suite of Standards (CMOSS) compliant EW Software Defined Radio (SDR) and/or related EW application software. The Army has defined a suite of open architecture standards named CMOSS to enable the reduction of C5ISR system size, weight and power – cooling (SWaP-C) and ensure commonality across multiple platforms by enabling the sharing of hardware and software components. The Terrestrial Layer System – Small (TLS-S) prototype platform will be used for operational assessment of these architectures. CMOSS enables the Army to insert cards, each embedded with networked capabilities such as communications waveforms, mission command applications, and PNT, into a common ruggedized chassis inside a tactical vehicle. It provides a plug-and-play alternative to custom-installing and upgrading individual communications systems and allows significant size, weight and power savings. Acknowledges a focus on standards.

6.2.6.4 *Counter RCIED Electronic Warfare (CREW)/Duke*

Duke enables spectrum dominance to protect vehicle convoys against a Radio-Controlled Initiation of Roadside Bombs (RCIED). CREW Duke is used in both mounted and fixed site configurations as well as for other non-CREW applications to include GATOR V3 and Sabre Fury. The Duke V5 is the RESET version of the legacy Duke V3 Program of Record that has increased jamming effectiveness against certain threats and improves reliability and maintainability.

6.2.6.5 *Modi Dismounted EW System*

Modi is a dismounted man-pack programmable Quick Reaction Capability (QRC) system that provides full spectrum coverage allowing the Warfighter the ability to maneuver with increased protection against RCIEDs. It is designed to counter an array of diverse threats through state-of-the-art capabilities.

6.2.6.6 *Multi-Function Electronic Warfare – Air Large (MFEW-AL)*

The Multi-Function Electronic Warfare – Air Large (MFEW-AL) is a single, self-contained, airborne electronic warfare pod which will be mounted onto Gray Eagle (GE) Unmanned Aircraft Systems. MFEW-AL is based on SDR /Digital Radio Frequency Memory architecture, which will utilize both pre-programmed signal characteristic information and real-time battlefield information to complete the intended mission. MFEW-AL will be interoperable with EWPMT to support command and control, remote operations, and dynamic tasking. It provides ES, EA, non-kinetic fires, dissemination of Military Information Support Operation (MISO), and support to offensive cyberspace operations in a podded form factor. MFEW-AL sees and shoots the furthest of all Army EW systems and is a key enabler of the Army Modernization Priorities, Assured Positioning, Navigation and Timing/Space Network, and Long-Range Precision Fires (LRPF) Cross Functional Teams.

6.2.6.7 *Prophet*

The Prophet is a dedicated, all-weather, 24/7 tactical signals intelligence and EW support sensor system fielded on a variety of ground vehicles that provides force protection, situational awareness, and target development for US Army units. It permits insertion and pre-planned product improvement updates, software modernization, and new equipment training.

6.2.6.8 *Prophet Enhanced Signals Processing*

Prophet Enhanced is a dedicated, all-weather, 24/7 ground-based tactical Signals Intelligence (SIGINT) and ES sensor system, providing Force Protection, Situational Awareness, and Target Development to the U.S. Army. PE is organic to the MI Company in the Brigade Combat Team (BCT) and to the Expeditionary – MI Brigade at Corps. The PE system detects, identifies, and locates enemy emitters through multiple configurations supporting Manpack, Vehicle-Mounted, and Dismounted / Fixed-site operations.

6.2.6.9 *Terrestrial Layer System - Brigade Combat Team (TLS-BCT)*

The Terrestrial Layer System-Brigade Combat Team (TLS-BCT) program, a critical component of the Army of 2028 vision that will help soldiers address signals found in the electromagnetic environment. It is the Army's next generation tactical vehicle-based system that delivers an integrated suite of SIGINT, EW, and Cyberspace Operations overmatch capabilities. This system provides the warfighter critical situational awareness of the enemy through detection, identification, location, exploitation, and disruption of enemy signals of interest. TLS-BCT equips the new force structure in the Multi-functional Platoon and the EW Platoon that are organic to the MI Company in the BCT and integrated on maneuver formation platforms.

6.2.6.10 *Terrestrial Layer System - Echelons Above Brigade (TLS-EAB)*

TLS-EAB is planned as an extended-range, terrestrial sensing, collection, and EA system with integrated SIGINT, EW and RF delivered Cyber capabilities for situational awareness / understanding, indications and warnings, command post protection operations, and support for the delivery of lethal and non-lethal effects in a holistic, synchronized manner for large-scale combat operations at Division, Corps, and the Multi-Domain Capable Force. TLS-EAB provides a capability to digitally interface with Brigade, Division, Corps, Army, unified action partners and mission command systems to sense, attack, deceive, and protect. When fielded, TLS-EAB

will be aligned with the IEW BN force structure and missions to support information superiority, targeting, and LRPF in Joint All-Domain Operations (JADO).

6.2.6.11 Tactical Electronic Warfare System (TEWS)

TEWS is a QRC that provides an ES and EA capability to BCTs. Each TEWS system consists of an integrated suite of RF antennas and receivers, processors, and EA hardware. TEWS processing includes machine learning signal recognition software as well as integration of Intelligence Community (IC) signal detectors and EA techniques.

6.2.6.12 Tactical Electronic Warfare System Light (TEWL)

TEWL is the corresponding TEWS capability for Light BCT formations. Each TEWL system consists of an integrated suite of RF antennas and receivers, and processors on a vehicle. TEWL conducts ES using the same or similar hardware and software, to include the machine learning signal recognition software as found in the integration of IC signal detectors in the TEWS.

6.2.6.13 Tactical Dismounted Electronic Warfare & SIGINT (TDEWS)

TDEWS is an EW and SIGINT ground-based, tactical sensor with radio. It is a dedicated, all-weather, tactical EW system, providing Protection and Situational Awareness to U.S. Army BCTs. One TDEWS System consists of a Multi-Channel Receiver and Networked Communications Ground Radio.

6.2.6.14 Tactical Electronic Warfare System – Infantry (TEWS-I)

TEWS-I is the corresponding TEWS capability for Infantry BCT formations. Each TEWS-I system consists of an integrated suite of RF antennas and receivers, and processors on an Infantry Squad Vehicle. TEWS-I conducts ES using the same or similar hardware and software, to include the machine learning signal recognition software as well as integration of IC signal detectors in the TEWS.

6.2.6.15 Universal Test Set

The Universal Test Set provides CREW personnel with a quick and effective field-level diagnostic capability. It is a Component Major Item to each of the Army developed CREW systems (Duke and Modi).

6.3 Analysis of Existing EW Representations

After reviewing all the existing EW representations described in the preceding sections, the EW DEM SG concluded that the forthcoming representation in DIS 8 is the most complete. Although RPR FOM 3 has not yet incorporated the new features of DIS 8, we expect that they will in a future version. In short, the EW DEM SG doesn't expect that they can improve on the DIS 8 model.

6.4 Recommended Way Forward

While the DIS 8 data model is the most complete, its structure in the standard is a barrier to adoption for simulation interoperability solutions based on object-oriented and object-based paradigms. For this reason, the EW DEM SG intends to submit a product nomination (PN) to extend the work illustrated in section 6.2.1 to an architecture-neutral UML model based on DIS 8. The EW DEM SG intends to use the UMLet [UMLet] tool to produce this model because it's free, lowering the barrier to new users investigating and exploring the model.