SISO-STD-005-2023

Standard for
Link 11/11B Simulation

Version 1.0

15 June 2023

Prepared by:
Tactical Digital Information Link
Technical Advice and Lexicon for Enabling Simulation (TADIL TALES)
Product Development Group and
Product Support Group

7901 4th St. N, Suite 300-4043
St. Petersburg, FL 33702, USA

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

Revision History

Version	Section	Date (MM/DD/YYYY)	Description
1.0	All	06/15/2023	Original standard

Participants

At the time this product was submitted to the Standards Activity Committee (SAC) for approval, the Tactical Digital Information Link Technical Advice and Lexicon for Enabling Simulation (TADIL TALES) Product Development Group and Product Support Group (PDG PSG) had the following membership and was assigned the following SAC Technical Area Director:

Product Development Group

Joe Sorroche (Chair)
Steve Weiss (Vice-Chair)
Pat Merlet (Secretary)

John Hughes (SAC Technical Area Director)

Curtis Blais
Larry Boyce
Lance Call
Aaron Carlson
Mary Christopher
Chris Dolan
Murray Gamble
Isaac Lindland
Lance Marrou
Laurent Mounet
Robert Murray
Ivar Oswalt
David Ronnfeldt
Graham Shanks
Mike Stroz
René Verhage
Roger Werner

The Product Development Group would like to especially acknowledge those individuals that significantly contributed to the preparation of this product as follows:

PDG Drafting Group

Steve Weiss (Editor)

Lance Call
John Hughes
Lance Marrou
Pat Merlet
Robert Murray
Graham Shanks
Joe Sorroche
Mike Stroz
René Verhage

The following individuals comprised the ballot group for this product.

Ballot Group

Curtis Blais
Donald Brutzman
John Hughes
Bjorn Moller
Laurent Mounet
Jonathan Searle
Graham Shanks
Joe Sorroche
René Verhage
Steve Weiss

When the Standards Activity Committee approved this product on 24 May 2023 it had the following membership:

Standards Activity Committee

Grant Bailey (Chair)
Curtis Blais (Vice Chair)
David Drake (Secretary)

Peggy Gravitz
John Hughes
Patrice Le Leydour
Clyde Smithson
Keith Snively
Michael Woodman

Executive Committee

Kenneth Konwin (Chair)
Mark McCall (Vice Chair)
Mark McCall (Secretary)

Grant Bailey
Zack Crues
Damon Curry
Paul Gustavson
Lana McGlynn
Chris Metevier
Katherine Morse
Michael O'Connor

Introduction

Tactical Digital Information Link (TADIL) A/Link 11 is a secure half-duplex TADIL radio link used by the North Atlantic Treaty Organization (NATO) that receives or transmits, but not both simultaneously, sequential digital data. It exchanges digital information among airborne, land-based, submarine, and ship-board tactical data systems. It is one of the primary means to exchange data such as radar tracking information beyond line of sight. TADIL A/Link 11 data exchanges can use either the High Frequency (HF) or Ultra High Frequency (UHF) radio bands.

TADIL B/Link 11B is a secure, full-duplex, point-to-point digital data link used by NATO that connects two reporting units. Operations are normally conducted over multichannel radio, satellite communication, telephone lines, or cables. Information is typically transmitted at 2400, 1200, or 600 bits per second (bps). TADIL B/Link 11B is generally limited to providing connectivity between ground-based units.

Link 11 relies on participant platforms to report their own positional information and tracks generated from their sensor detections. This positional information can be amplified with additional data to qualify the identity of the detected track. Because Link 11 and Link 11B use the same message standard, and have virtually identical operational capabilities, they are often referred to together as Link 11/11B. An interface between them is provided by a Forwarding Participating Unit (FPU). If an FPU is deployed, then from an operational standpoint, they may be viewed as a single data link network.

Table of Contents

List of Tables

1 Overview

1.1 Scope

This standard applies to Link 11/11B and includes Link 11B over Satellite Communications (SATCOM). In developing a protocol for simulating Link 11/11B in Distributed Interactive Simulation (DIS) and High Level Architecture (HLA), it is recognized that there are widely varying requirements for achieving needed fidelity among different users. This standard establishes procedures that may be used by the vast majority of users, by establishing discrete, scalable, interoperable levels of fidelity for different users. This, in turn, allows for low-cost initial implementation with a path toward upgrading to detailed Link 11/11B emulation as requirements evolve.

The DIS simulation protocol for Link 11/11B is described in terms of the established DIS Transmitter and Signal PDUs. There has been no change to the Transmitter or Signal PDUs described in Reference 4. Link 11/11B specific enumerations have been created to populate the standard fields and records. The implementation of Link 11/11B exploits the fact that both these PDUs are variable length. In the case of the Transmitter PDU, this protocol sets forth how the variable length Modulation Parameters field has to be populated. In the case of the Signal PDU, Link 11/11B specific information is relegated to the variable length Data field.

The Link 11/11B HLA specification is defined in the form of a Federation Object Model (FOM) module, in compliance with Reference 6. For actual exchange within an HLA federation, it should be incorporated into a FOM; for instance, the Real-time Platform Reference (RPR) FOM. Furthermore, a mapping is provided between the DIS PDU implementations and the corresponding HLA objects and interactions.

1.2 Purpose

There are immediate operational requirements for existing military simulations to exchange Link 11/11B data using a single, interoperable standard. As military distributed simulation evolves further in mission scale and complexity, tactical data link implementations need to interoperate, not only within a single tactical data link, but with multiple data links on one or more networks. This protocol provides the guidance to simulate Link 11/11B and interoperate with other simulated tactical data links on one network.

1.3 Objectives

It is the objective of this protocol to establish a standard for Link 11/11B message exchange and network simulation in the DIS and HLA interoperability frameworks. The intent is to prescribe the content of the standard fields of the Transmitter and Signal PDUs (and the corresponding Link 11/11B FOM module interactions) and establish procedures for their use. Compliance with these procedures will facilitate interoperability among Link 11/11B simulation systems.

1.4 Intended Audience

This standard is intended to be used by implementers of Link 11/11B data link message exchange over DIS or HLA protocols.

2 References

The following documents are referenced herein. For undated references, the latest published version of the document applies, including any amendments. If a conflict exists with a referenced document, this document shall take precedence.

Ref #	Document Number	Title
1	SISO-STD-001.1	Standard for Real-time Platform Reference Federation Object Model, Version 2.0, 10 August 2015
2	SISO-STD-001	Standard for Guidance, Rationale, and Interoperability Modalities for the Real-time Platform Reference Federation Object Model, Version 2.0, 10 August 2015
3	SISO-REF-010	Reference for Enumerations for Simulation Interoperability
4	IEEE Std 1278.1™	IEEE Standard for Distributed Interactive Simulation – Application Protocols
5	IEEE Std 1516™	IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA)
6	IEEE Std 1516.2™	IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) – Object Model Template (OMT) Specification
7	MIL-STD-6011	Department of Defense Interface Standard Tactical Digital Information Link (TADIL) A/B Message Standard
8	STANAG 5511	NATO STANAG 5511, Tactical Data Exchange - Link 11/11B
9	MIL-STD-188-203-1A	Interoperability and Performance Standards for Tactical Digital Information Link (TADIL) A
10	MIL-STD-188-212	Subsystem Design and Engineering Standards for Tactical Digital Information Link (TADIL) B
11	ISBN-10: 0877798095	Merriam-Webster's Collegiate Dictionary, Eleventh Edition forward
12	RFC 5905	Network Time Protocol Version 4: Protocol and Algorithms Specification, June 2010
13	135-02-005	Understanding Voice and Data Link Networking, Northrop Grumman’s Guide to Secure Tactical Data Links

3 Definitions, Acronyms, and Abbreviations

English words are used in accordance with their definitions in the latest edition of Merriam-Webster's Collegiate Dictionary [11] except when special SISO product-related technical terms are required.

3.1 Definitions

Term	Definition
Address	A number applied to a Participating Unit (PU) or Reporting Unit (RU) to associate information and directives with interface units or tracks for both digital and voice communications
Conventional Link Eleven Waveform (CLEW)	A Doppler frequency shift correction at ±75 Hz and tracking at 3.5 Hz on a 605 Hz pilot tone independent sideband operation per MIL-STD-188-203-1A (Reference 9).
Data Net Control Station (DNCS)	The participating unit performing the initiation and termination of the data net and controlling the order in which units are called.
Fidelity Level	In terms of this standard, a fidelity level is a measure of the level of functionality of the implementation of this Link 11/11B simulation standard. This allows for a standard nomenclature to be used within the community to describe the functionality of implementations of this standard. See section 4.1.2 for additional information and Table 1 for definitions of fidelity levels in this standard.
Forwarding Participating Unit (FPU)	An FPU is a PU which has the additional responsibility for transferring data between Link 11 and one or more Link 11B data links.
Forwarding Reporting Unit (FRU)	A reporting unit which has the additional capability of relaying data between two or more Link 11B links.
Frame	A 30-bit word consisting of 24 data bits and six Hamming Error Detection and Correction (EDAC) bits.
Link 11/11B	See TADIL A/B.
Live Encrypted Data	Link 11/11B message data that has been encrypted using a live cryptographic device. This may be used to support secure interoperability between live Link 11/11B systems and Link 11/11B simulations.
Metering	A control of data transmission rates to match real world Link 11/11B network constraints.
Net Control Station (NCS)	A Link 11/11B station which acts as the interrogating station during Roll Call.
Net Cycle Time	The length of time between reporting opportunities, as measured by each PU.
Net Sync (NS)	A Link 11/11B net mode of operation for synchronizing all stations that are on the link. It consists of the continuous broadcast of preambles.
Net Test (NT)	A Link 11/11B net mode of operation where control codes are generated and transmitted by the data terminal. The sequence of receive codes can be compared with a locally generated sequence to determine whether information is being received on all channels.
Participating Unit (PU)	A unit operating in a Link 11 net in any mode of operation.
Picket (PK)	A PU on the Link 11/11B network that is not the NCS.

Term	Definition
Reporting Unit (RU)	A unit operating in a Link 11B network.
Roll Call (RC)	A Link 11/11B mode of operation, where the NCS calls each participating unit in turn to transmit data, while all other units receive the data.
Roll Call Timeout	A period of time defined by the number of frames that the NCS will delay before re-polling a picket.
Single Tone Link Eleven Waveform (SLEW)	Disburses data bit errors uniformly utilizing data interleaving and employs Full Tail Biting Convolutional Block (FTBCB) encoding. This greater Electronic Countermeasures (ECM) resistance provides a data rate of 1800 bps. SLEW mode always uses the 2250 bps baud rate.
Tactical Data System (TDS)	The system within PU or RU responsible for releasing tactical data information to the Link 11/11B network.
Tactical Digital Information Link (TADIL) A/B	Employs netted communication techniques and a standard message format, the M-series messages, for exchanging digital information among airborne, land-based, and shipboard tactical data systems.
Transmission Control	Modeling the rules of transmission in compliance to the Link 11 modes of operation, i.e., Roll Call, Short Broadcast, and Broadcast.
Unique Identifier	Enumeration fields have values and descriptions defined in SISO-REF-010. The table for each enumeration is identified by a Unique Identifier (UID) in the form “[UID nnn]”. In this standard, references to SISO-REF-010 tables use the same UID syntax; for example, “see [UID 874]”.

3.2 Acronyms and Abbreviations

Acronym/Abbreviation	Definition
API	Application Programming Interface
bps	bits per second
C2	Command and Control
C4ISR	Command, Control, Communications, and Computers Intelligence Surveillance Reconnaissance
CLEW	Conventional Link Eleven Waveform
CRC	Cyclic Redundancy Check
DIS	Distributed Interactive Simulation
DM	Declaration Management
DNCS	Data Net Control Station
ECM	Electronic Countermeasures
EDAC	Error Detection and Correction
FOM	Federation Object Model
FPU	Forwarding Participating Unit
FRU	Forwarding Reporting Unit
FTBCB	Full Tail Biting Convolutional Block

Acronym/Abbreviation	Definition
FTD	Full Transmission of Data
GRIM	Guidance, Rationale, and Interoperability Modalities
HF	High Frequency
HLA	High Level Architecture
IAW	In Accordance With
ID	IDentifier
IEEE	Institute of Electrical and Electronics Engineers
LTD	Limited Transmission of Data
M&S	Modeling and Simulation
MIL STD	Military Standard
ms	milliseconds
NA	Not Applicable
NATO	North Atlantic Treaty Organization
NCS	Net Control Station
NS	Net Sync
NT	Net Test
NTP	Network Time Protocol
OMT	Object Model Template
PDG	Product Development Group
PDU	Protocol Data Unit
PK	Picket
POC	Point of Contact
PSG	Product Support Group
PU	Participating Unit
RC	Roll Call
RPR	Real-time Platform Reference
RTI	Run Time Infrastructure
RU	Reporting Unit
SAC	Standards Activity Committee
SATCOM	SATellite COMmunications
SI	International System of Units
SLEW	Single Tone Link Eleven Waveform
SISO	Simulation Interoperability Standards Organization
STANAG	STANdardization AGreement

Acronym/Abbreviation	Definition
TADIL	Tactical Digital Information Link
TALES	Technical Advice and Lexicon for Enabling Simulation
TDL	Tactical Data Link
TDS	Tactical Data System
UID	Unique IDentifier
UHF	Ultra High Frequency
UTC	Coordinated Universal Time
XML	Extensible Markup Language

4 Requirements

4.1 Link 11/11B Operating Characteristics

Link 11/11B encompasses two types of Tactical Digital Information Link (TADIL): Link 11 and Link 11B, otherwise known as TADIL A and TADIL B.

Link 11 employs netted communication techniques and standard message formats for the exchange of digital information among airborne, land-based, submarine, and shipboard tactical data systems. It provides for the mutual exchange of information among net participants via High Frequency (HF) or Ultra-High-Frequency (UHF) radio. Link 11 is a half-duplex, netted, secure link that operates in a Roll Call mode among all Participating Units (PUs), under the control of a Net Control Station (NCS). In Roll Call, pickets are polled sequentially and respond with their Link 11 messages.

Link 11B is a full-duplex, two-way, point-to-point link that provides for the serial transfer of data between participants. Its participants are referred to as Reporting Units (RUs). Because it is point-to-point, each pair of RUs operates on a separate Link 11B channel, often referred to as a “B-Link.” Data is forwarded among the RU pairs by Forwarding RUs (FRUs). Link 11B employs the same message standard as Link 11. However, the equipment, some message protocols, and the data rate are different from those of Link 11, thus requiring special forwarding units to interface with Link 11 and Link 11B.

Because Link 11 and Link 11B employ the same message standard and have virtually identical operational capabilities, they are often referred to together as Link 11/11B. An interface between them is provided by a Forwarding Participating Unit (FPU) and, from an operational standpoint, they may be viewed as a single Link.

Operations involving only Link 11 and Link 11B are referred to as Link 11/11B operations. These are fully described in MIL-STD-6011/STANAG 5511 [7, 8].

4.1.1 General Requirements

This section describes general requirements for simulation of Link 11/11B independent of the simulation protocol used. The specific implementation under DIS is described in section 4.2. The specific requirements for implementation under HLA are described in section 4.3. Simulators in compliance with this standard shall at a minimum have the capability to identify the PU or RU of transmitted data for all levels of fidelity as defined in section 4.1.2.

1. All Link 11/11B messages shall be bit encoded in accordance with the MIL-STD-6011/STANAG 5511 [7, 8].

   Actual Link 11 Conventional Link Eleven Waveform (CLEW) messages consist of two 30-bit frames. Each frame contains 24 bits of data along with six Hamming Error Detection and Correction (EDAC) bits. In effect, the messages allow 48 bits of tactical information [9].

   Actual Link 11 Single Tone Link Eleven Waveform (SLEW) messages consist of two 24-bit frames. These data frames are followed by 12 Cyclic Redundancy Check (CRC) bits. In effect, the messages allow 48 bits of tactical information [9].

   Actual Link 11B messages consist of 72 bits, containing eight groups of 9 bits each. The start and check groups use 18 bits, while each of the six data groups use 1 bit each to precede the 8 information bits. In effect, the messages allow 48 bits of tactical information [10].

2. It is not required to perform error detection encoding for the Link 11/11B messages. If error detection encoding is not performed for CLEW messages, the EDAC bits of the message shall be set to 0. If error detection encoding is not performed for SLEW messages, the CRC bits of the message shall be set to 0. If error detection encoding is not performed for Link 11B messages, the check group bits of the message shall be set to 0. Usage of error detection encoding and interpretation of the corresponding bits may be specified in exercise agreements.

3. For Link 11, the NCS shall at a minimum, have the capability to transmit Roll Call messages.

4. For Link 11, the default Roll Call Timeout time is 15 frames. Simulations at Fidelity Level 2 shall have the capability to change this parameter as required. The timeout period depends on the two network net speeds: 13.33 milliseconds (ms) and 22 ms. The timeout period for the default of 15 frames is 200 ms (if the data signaling rate is 2250 bps) or 330 ms (if the data signaling rate is 1364 bps).
5. For Link 11 simulations at Fidelity Level 1 and higher, systems shall transmit data upon receipt of a Roll Call message from the NCS. During the remainder of the time, the PU shall receive reports from other PUs.
6. All systems shall have some representation of periodic clock time.
7. All information in the Link 11/11B Message Data field following the Link 11/11B Simulation Network Header of the Signal PDU, and the corresponding parameters of the HLA interactions, shall be treated as a bit stream. The individual bit fields of the bit stream shall be packed into bytes (octets) as follows:
   A. Bit 0 of the first bit field shall begin at bit 0 of the first octet in the opaque data and continue until the number of bits in the field are consumed.
   B. Bit 0 of the next bit field shall begin in the next available bit of the current octet or in bit 0 of the next octet if all bits of the current octet have been consumed exactly.
   C. If insufficient bits remain in an octet for a bit field, as many bits as will fit in the current octet shall be consumed, then the bit field shall continue to be packed starting with bit 0 of the next octet.
   D. Subsequent bit fields shall be packed in a like manner.
   E. Individual bit fields may span multiple octets as necessary to fit all bits in the bit field.

4.1.2 Levels of Fidelity

This protocol allows simulations to achieve different levels of fidelity by assigning one of three fidelity levels. If the simulator allows for a settable level of fidelity, the level of fidelity shall be set at runtime. The level of fidelity shall be set in Modulation Parameter #2 (Fidelity Level) of the transmitter message with an enumeration of 0, 1, or 2 as described in Table 1 and Reference 3 [UID 467].

Table 1: Link 11/11B Levels of Fidelity

Fidelity Level	Fidelity	Network Fidelity	Issues	Recommended Usage
0	Low	Low	Does not emulate Link 11/11B network characteristics. Data rates are not constrained.	Experiments and/or training concerned with message exchange only.
1	Medium	Low	Emulates some Link 11 network characteristics. Link 11/11B data rates may be modeled.	Experiments and/or training where Link 11 roll call modeling is important.
2	Medium	Medium	Emulates most Link 11/11B network characteristics. Sensitive to network and application latencies.	Experiments and/or training concerned with all Link 11/11B procedures, including net establishment and control.

4.1.2.1 Fidelity Level 0

Fidelity Level 0 is the lowest level of fidelity, and allows for Link 11/11B message exchange only. Tactical information messages may be provided at any time, via multiple Link 11/11B messages in a single signal message, or immediately as the data comes available. All data within the signal message shall be from the

same PU or RU. There is no message metering or transmission control modeling, and the maximum number of messages (as specified in the DIS standard) can be packed into the data area of a single signal message.

The following information shall be provided at this fidelity level:

1. Link 11/11B Modulation Parameters in the transmitter message
    A. Participant/Reporting Unit
    B. Fidelity Level
2. Link 11/11B Simulation Network Header in the signal message
    A. Participating/Reporting Unit Number
    B. Sequence Number
3. Link 11/11B Message Data in the signal message

For the Link 11 Modulation Parameters, the Net Cycle Time shall be set to 0. For the Link 11 Simulation Network Header, the Message Sub Type, Message Type Identifier, Data Signaling Rate, Signal Waveform, and Encryption Flag shall be set to No Statement (0) IAW their respective enumerations. All bits of the Perceived Transmit Time field shall be set to one to indicate a no statement/wildcard. Usage of the Modulation Parameters Terminal Mode and Mode of Operation is optional. When not used, they shall be set to No Statement (0) IAW their respective enumerations.

For the Link 11B Simulation Network Header, the Message Sub Type, Data Signaling Rate, Modulation Standard, and Encryption Flag shall be set to No Statement (0) IAW their respective enumerations. All bits of the Perceived Transmit Time field shall be set to one to indicate a no statement/wildcard. Usage of the Link 11B Modulation Parameters Link State and Mode of Operation is optional. When not used, they shall be set to No Statement (0) IAW their respective enumerations.

A setting of No Statement (0) shall be treated as a wildcard, indicating data terminal mode compatibility with any other setting.

4.1.2.2 Fidelity Level 1

Fidelity Level 1 is the next level of fidelity and incorporates modeling of Link 11 roll call transmission control. Consequently, tactical information messages may only be provided by pickets after NCS callup, or by the NCS after picket reply and before the next callup. As there is no equivalent transmission control between RUs, for Link 11B no additional requirements are imposed. Fidelity Level 1 allows for signal message properties to be set, enabling simulation of signal compatibility.

Fidelity Level 0 defined information shall be provided plus:

1. Link 11 Modulation Parameters in the transmitter message
    A. Terminal Mode
2. Link 11 Simulation Network Header in the signal message
    A. Message Sub Type
    B. Message Type Identifier
3. Link 11 Message Data shall only be included in the signal message with the Message Sub Type set to Data (3).
4. Link 11B Message Data shall only be included in the signal message with the Message Sub Type set to No Statement (0) or Transmission Frame (1).

The enumeration value No Statement (0) is not allowed for the above listed fields, except as specified in item 4 above.

Usage of the Link 11 Modulation Parameters Mode of Operation and Net Cycle Time is optional. When not used, they shall be set to No Statement (0) and 0, respectively. Also, the Link 11 Simulation Network Header

fields Data Signaling Rate, Signal Waveform, and Encryption Flag shall be considered optional, and set to No Statement (0) IAW their respective enumerations when not used.

Usage of the Link 11B Simulation Network Header fields Message Sub Type, Data Signaling Rate, Modulation Standard, and Encryption Flag is optional. When not used, they shall be set to No Statement (0) IAW their respective enumerations.

A setting of No Statement (0) shall be treated as a wildcard, indicating data terminal mode or signal compatibility with any other setting.

4.1.2.3 Fidelity Level 2

Fidelity Level 2 incorporates most Link 11/11B network modeling, including initiating, leaving, and terminating the net. All Link 11/11B Modulation Parameters and Simulation Network Header fields shall be filled in with meaningful data. All Link 11/11B network transmission rules shall be followed in accordance with MIL-STD-6011/STANAG 5511 [7, 8].

Fidelity Level 1 defined information shall be provided plus:

1. Link 11 Modulation Parameters in the transmitter message
    A. Mode of Operation
    B. Net Cycle Time (applies to NCS only)
2. Link 11B Modulation Parameters in the transmitter message
    A. Link State
    B. Mode of Operation
3. Link 11 Simulation Network Header in the signal message
    A. Data Signaling Rate
    B. Signal Waveform
    C. Encryption Flag
    D. Perceived Transmit Time
4. Link 11B Simulation Network Header in the signal message
    A. Message Sub Type
    B. Data Signaling Rate
    C. Modulation Standard
    D. Encryption Flag
    E. Perceived Transmit Time
5. Link 11B Message Data shall only be included in the signal message with the Message Sub Type set to Transmission Frame (1).

The enumeration value No Statement (0) is not allowed for the above listed fields of the Modulation Parameters and Simulation Network Header, other than for the Net Cycle Time for a PU not operating as the NCS.

4.1.2.4 Fidelity Level Summary

Table 2 and Table 3 summarize the valid field values for the different Fidelity Levels for Link 11 modeling for transmitter and signal messages. Table 4 and Table 5 summarize the valid field values for the different Fidelity Levels for Link 11B modeling for transmitter and signal messages.

Table 2: Transmitter Message Link 11 Modulation Parameters – Valid Field Values for Different Fidelity Levels

Modulation Parameter #	Field Name	Fidelity Level		
		0	1	2
1	Participating Unit	Required		
2	Fidelity Level	0	1	2
3	Terminal Mode	Optional (Default: “No Statement”)	Required	
4	*Padding*	*Set to 0*		
5	Mode of Operation	Optional (Default: “No Statement”)		Required
6	Net Cycle Time	Set to 0	NCS: Optional (Default: 0)	NCS: Required
			Non-NCS: Set to 0	

Table 3: Signal Message Link 11 Simulation Network Header - Valid Field Values for Different Fidelity Levels

Field Name	Fidelity Level		
	0	1	2
Message Sub Type	Set to “No Statement”	Required	
Participating Unit Number	Required		
Sequence Number	Required		
Message Type Identifier	Set to “No Statement”	Required	
Padding	*Set to 0*		
Data Signaling Rate	Set to “No Statement”	Optional (Default: “No Statement”)	Required
Padding	*Set to 0*		
Signal Waveform	Set to “No Statement - CLEW Format”	Optional (Default: “No Statement - CLEW Format”)	Required
Encryption Flag	Set to “No Statement / No Encryption Used”	Optional (Default: “No Statement / No Encryption Used”)	Required
Perceived Transmit Time	4 294 967 295 and 4 294 967 295		Required

Table 4: Transmitter Message Link 11B Modulation Parameters – Valid Field Values for Different Fidelity Levels

Modulation Parameter #	Field Name	Fidelity Level		
		0	1	2
1	Reporting Unit	Required		
2	Fidelity Level	0	1	2
3	*Padding*	*Set to 0*		
4	Link State	Optional (Default: “No Statement”)		Required
5	Mode of Operation	Optional (Default: “No Statement”)		Required
6	*Padding*	*Set to 0*		

Table 5: Signal Message Link 11B Simulation Network Header - Valid Field Values for Different Fidelity Levels

Field Name	Fidelity Level		
	0	1	2
Message Sub Type	Set to “No Statement”	Optional (Default: “No Statement”)	Required
Reporting Unit Number	Required		
Sequence Number	Required		
Padding	*Set to 0*		
Padding	*Set to 0*		
Data Signaling Rate	Set to “No Statement”	Optional (Default: “No Statement”)	Required
Padding	*Set to 0*		
Modulation Standard	Set to “No Statement”	Optional (Default: “No Statement”)	Required
Encryption Flag	Set to “No Statement / No Encryption Used”	Optional (Default: “No Statement / No Encryption Used”)	Required
Perceived Transmit Time	4 294 967 295 and 4 294 967 295		Required

4.1.3 Link 11/11B Fidelity Level Operations

4.1.3.1 Fidelity Level 0 Operation

Fidelity Level 0 operations are applicable to simulation systems interested primarily in providing Link 11/11B message exchange only. Participants are allowed to exchange Link 11/11B messages without being encumbered by actual Link 11/11B message exchange requirements.

1. No NCS or other modeling of link 11/11B network roles is required. All Fidelity Level 0 participants shall have the ability to accept Link 11/11B messages at any time from any fidelity level, and shall buffer these messages as necessary.
2. Any Fidelity Level 0 participant may transmit Link 11/11B messages at any time.

At this Fidelity Level it is also possible to directly exchange messages between Link 11 PUs and Link 11B RUs, without requiring dedicated FPUs or FRUs. When both Link 11 and Link 11B Fidelity Level 0 simulations are present in the same exercise, it is advised to set the optional Modulation Parameter fields to No Statement (0) IAW their respective enumerations to prevent misinterpretation and unexpected filtering of messages. Note however, that participants still need to process the TDL Type in the signal message as the message data is encoded differently, using the CLEW Message Format for Link 11 and the Link 11B Message Format for Link 11B.

4.1.3.2 Fidelity Level 1 Operation

Fidelity Level 1 operations are applicable to simulation systems requiring transmission control as part of an operational scenario.

4.1.3.2.1 Link 11

1. It is assumed that the NCS knows all of the pickets in the network.
2. The NCS shall be able to transmit tactical messages and roll call interrogations.
    A. When in Roll Call mode and reporting its own data, the NCS shall issue signal messages with the field values as indicated in Table 6. The number of signal messages may be different with each data report.
    B. When in Roll Call mode and interrogating a picket, the NCS shall issue a signal message with the field values as indicated in Table 7.
3. The pickets shall be able to respond to a roll call interrogation with tactical messages. When in Roll Call mode, the picket shall issue signal messages with the field values as indicated in Table 8. The number of signal messages may be different for each picket and may be different with each reply.
4. Neither the NCS nor pickets are required to support the Short Broadcast, Broadcast, and Radio Silence modes. When tactical data is reported in these modes, signal messages shall be issued with the field values as indicated in Table 9. The number of signal messages may be different with each transmission sequence in Broadcast mode.
5. The NCS may model the net cycle time. If modeled, the Net Cycle Time field shall be set with this estimated or actual value.

When both Link 11 and Link 11B networks are modeled within the same exercise, an FPU is required if tactical messages are to be exchanged between the networks. Similarly, an FRU is required if tactical messages are to be exchanged between two Link 11B networks.

Table 6: Link 11 Signal Message Field Values for NCS Roll Call Data Reporting

Field Name	Value		
	First Signal Message	Signal Message(s)	Last Signal Message
Message Type Identifier	Roll Call (2)		
Message Sub Type	Data Start (2)	Data (3)	Data Stop (4)
Participating Unit Number	NCS PU address		
Sequence Number	0	1..S	S+1
Message Data	No data	Tactical messages as provided by the TDS	No data

Table 7: Link 11 Signal Message Field Values for NCS Roll Call Interrogation

Field Name	Value
Message Type Identifier	Roll Call (2)
Message Sub Type	Interrogation (1)
Participating Unit Number	Picket PU address
Sequence Number	S+2 if preceded by data reporting 0 otherwise
Message Data	No data

Table 8: Link 11 Signal Message Field Values for Picket Roll Call Reply

Field Name	Value		
	First Signal Message	Signal Message(s)	Last Signal Message
Message Type Identifier	Picket Reply (2)		
Message Sub Type	Data Start (2)	Data (3)	Data Stop (4)
Participating Unit Number	Own PU address		
Sequence Number	0	1..R	R+1
Message Data	No data	Tactical messages as provided by the TDS	No data

Table 9: Link 11 Signal Message Field Values for Short Broadcast and Broadcast Mode

Field Name	Value		
	First Signal Message	Signal Message(s)	Last Signal Message
Message Type Identifier	Short Broadcast (4) or Broadcast (5)		
Message Sub Type	Data Start (2)	Data (3)	Data Stop (4)
Participating Unit Number	Own PU address		
Sequence Number	0	1..Q	Q+1
Message Data	No data	Tactical messages as provided by the TDS	No data

4.1.3.2.2 Link 11B

Fidelity Level 1 operations are not applicable for Link 11B.

4.1.3.3 Fidelity Level 2 Operation

Fidelity Level 2 operations are applicable to simulation systems requiring simulation of the Link 11/11B network including establishment and control of the net as part of an operational scenario.

4.1.3.3.1 Link 11

1. The NCS and the pickets shall support the Net Sync mode. It is not required to issue signal messages in this mode. When Net Sync signal messages are issued, the field values as indicated

in Table 10 shall be set. Whether the Net Sync mode is used, and if so, its minimum duration to achieve successful tactical message exchange in Roll Call mode, are expected to be addressed in exercise agreements.

2. The NCS and the pickets shall support the Net Test mode. It is not required to issue signal messages in this mode. When Net Test signal messages are issued, it is recommended to include the test pattern in the Message Data. The field values as indicated in Table 11 shall then be set. Alternatively, it may be specified in exercise agreements to issue Net Test signal messages without the test pattern. In that case, the field values as indicated in Table 12 shall be set. Whether the Net Test mode is used, and if so, its minimum duration prior to Roll Call mode, are expected to be addressed in exercise agreements.
3. The Roll Call mode shall be supported as described for Fidelity Level 1.
4. The NCS shall determine the net cycle time, and use it to populate the Net Cycle Time parameter.
5. The NCS shall model the Roll Call interrogation of pickets according to the Link 11 network characteristics. To represent realistic timing of the message exchange, the simulation application of the NCS shall match the relative issuance of the signal messages to the start of the Link 11 signals as close as its internal simulation frequency allows. Typical transmission times are shown in Table 13.

   A. The time to wait before polling the next picket (time between the start of this signal message and the subsequent signal message) is calculated from the Link 11 signal overhead, the number of tactical messages in the reply, and the network characteristics.

      $T_{wait\_next} = T_{callup} + T_{switch} + T_{reply} + T_{switch}$ [seconds]

      Where

      $T_{callup} = N_{callup\_overhead}. / \{Net\ Speed\}$ [seconds]

      $T_{reply} = (N_{reply\_overhead} + N_{reply\_data})$

      $N_{callup\_overhead} = N_{preamble} + N_{address}$ [frames]

      $N_{reply\_overhead} = N_{preamble} + N_{start} + N_{stop}$ [frames]

      $N_{reply\_data} = \{number\ of\ tactical\ messages\} * 2$ [frames]

      $N_{preamble}$: 6 frames

      $N_{address}$: 2 frames

      N_{start}: 2 frames

      N_{stop}: 2 frames

      T_{switch}: The time (in seconds) it takes to switch from signal reception to signal transmission. Typically, receive-to-transmit and vice versa switching takes between 1 and 3 frames. In addition, the signal propagation may be included in the calculation.

      Net Speed: The rate of the transmission in frames per second. The usual (or fast) rate is 75 frames/s (2250 bps). The alternative (slow) rate is $45.\overline{45}$ frames per second (approximately 1364 bps).

      Note that although the SLEW waveform is not defined in terms of frames but a sequence of blocks, its timing is effectively equal to the CLEW waveform fast data rate.

   B. The time to wait before polling the first picket after the NCS data report is different, as with the actual Link 11 signal the picket address is included in the same transmission.

      $T_{wait\_first} = T_{report} - T_{callup}$ [seconds]

      Where

      $T_{report} = (N_{report\_overhead} + N_{report\_data}) / \{Net\ Speed\}$ [seconds]

$N_{report\_overhead} = N_{preamble} + N_{start} + N_{stop} + N_{address}$ [frames]

N_{report_data} = {number of tactical messages} * 2 [frames]

Note that for the SLEW waveform the start and address frames are combined in one header block. Consequently, a typical SLEW interrogation with message is the equivalent of 2 frames (at fast data rate) shorter. However, some NCS models may repeat the header at the end of the report, effectively equating the (fast data rate) CLEW timing.

C. The time to wait before polling the same picket, i.e., the time within the first signal message indicating a reply should be received, is defined as

$T_{wait\_recall} = (N_{callup\_overhead} + N_{timeout} - (N_{preamble} + N_{start})) / \{Net\ Speed\}$ [seconds]

$= N_{timeout} / \{Net\ Speed\}$ [seconds]

Where

$N_{timeout}$: The number of frames in which a response to an interrogation is expected, measured from the end of the callup to the full reception of the reply start frames. Normally 15 frames are allotted, and may be extended to up to 250 frames.

Table 10: Link 11 Signal Message Field Values for Net Sync

Field Name	Value
Message Type Identifier	Net Sync (6)
Message Sub Type	No Statement (0)
Participating Unit Number	PU address
Sequence Number	Starting at 0, incremented with every signal message while in Net Sync
Message Data	No data

Table 11: Link 11 Signal Message Field Values for Net Test with Test Pattern Data

Field Name	Value		
	First Signal Message	Signal Message(s)	Last Signal Message
Message Type Identifier	Net Test (1)		
Message Sub Type	Data Start (2)	Data (3)	Data Stop (4)
Participating Unit Number	PU address		
Sequence Number	0	1..T	T+1
Message Data	No data	Test pattern words	No data

Table 12: Link 11 Signal Message Field Values for Net Test without Test Pattern Data

Field Name	Value
Message Type Identifier	Net Test (1)
Message Sub Type	No Statement (0)
Participating Unit Number	PU address

Field Name	Value
Sequence Number	Starting at 0, incremented with every signal message while in Net Test
Message Data	No data

Table 13: Link 11 Typical Transmission Times

Phase	Number of frames	FAST mode Tx time	SLOW mode Tx time
Roll call	8	107 ms	176 ms
Picket reply	16 (minimum)	214 ms	352 ms
NCS report	18 (minimum)	240 ms	396 ms
NCS wait time before recalling a picket	15 (default) 250 (maximum)	200 ms 3333 ms	330 ms 5500 ms

4.1.3.3.2 Link 11B

1. The RUs shall support the Link State modes Inactive, Ready, Active, and Operational.
   A. It is not required to issue signal messages while the Link State is Inactive. When signal messages are issued in this mode, they shall only represent the standby signal.
   B. In the Link State modes Ready, Active, and Operational, signal messages shall be issued with the field values as indicated in Table 14. A consecutive transmission of tactical messages may be provided in multiple signal messages. The number of signal messages (S+1) may be different with each consecutive tactical data sequence. A new signal message or set of signal messages shall be issued for a transmission of a next sequence of one or more tactical messages following the standby signal.
   C. It is not required to issue signal messages representing the standby signal. When standby signal messages are issued, the field values as indicated in Table 15 shall be set. The frequency of signal messages while the standby signal is transmitted is expected to be addressed in exercise agreements.
2. The RUs shall support the initialization/reinitialization modes Full Transmission of Data (FTD) and Limited Transmission of Data (LTD).
3. The Perceived Transmit Time of each signal message shall match the start of the transmission frame of the first tactical message included or the start of the Standby Signal.
   A. The start of transmission of each frame contained in the signal message can be calculated from:

$$T_{frame\_start}(n,i) = T_{perceived\_transmit\_time}(n) + (i(n) - 1) * 72 / \{Net\ Speed\} \quad [seconds]$$

   Where

   n: A counter for the signal messages issued by the radio transmitter.

   $T_{perceived\_transmit\_time}(n)$: The simulated transmission time of the first bit of the start group of the first tactical message included in signal message n.

   i(n): The index of the tactical message within signal message n, starting at 1.

   Net Speed: The rate of the transmission in bits per second.

B. The time to wait before issuing the next signal message (time between the start of this signal message and the subsequent signal message), be it representing one or more transmission frames or the start of the standby signal following data transmission, is defined as:

$T_{wait\_next}(n+1) = i_{max}(n) * 72 / \{Net\ Speed\}$ [seconds]

Where

$i_{max}(n)$: The total number of tactical messages within signal message n.

Table 14: Link 11B Signal Message Field Values for Tactical Messages

Field Name	Value
Message Sub Type	Transmission Frame (1)
Reporting Unit Number	RU address
Sequence Number	0..S
Perceived Transmit Time	Simulation time of the first tactical message included
Message Data	Tactical messages as provided by the TDS

Table 15: Link 11B Signal Message Field Values for the Standby Signal

Field Name	Value
Message Sub Type	Standby Signal (2)
Reporting Unit Number	RU address
Sequence Number	Starting at 0, incremented with every successive standby signal message
Perceived Transmit Time	Simulation time of the start of the standby signal, updated with every successive standby signal message
Message Data	No data

4.1.4 Communication between Link 11 and Link 11B Units

For Fidelity Level 1 and 2, communication between Link 11 and Link 11B units shall follow the procedures listed in MIL-STD-6011/STANAG 5511 [7, 8].

4.1.5 Communication between Link 11/11B Units with Different Fidelity Levels

In the event that participants in a simulated Link 11/11B network cannot set their respective simulations to operate at a common level of fidelity (i.e., Fidelity Level) the following procedures apply:

4.1.5.1 Link 11

1. The NCS shall be a Fidelity Level 1 or 2 PU.
2. If a Fidelity Level 1 or 2 NCS receives signal messages from a Fidelity Level 0 picket outside of the transmission opportunity for this picket, the NCS shall buffer these messages until it interrogates that picket. Then all buffered messages shall be processed as reply to that interrogation.
3. If a Fidelity Level 2 NCS receives signal messages from a Fidelity Level 1 picket, and the picket Mode of Operation is set to No Statement (0), it shall imply the picket Mode of Operation from the Message Type Identifier of the picket signal message. If the Fidelity Level 2 NCS receives Short

Broadcast or Broadcast signal messages from a Fidelity Level 1 picket, it shall assume net synchronization.

4. If a Fidelity Level 2 picket is in a simulated Link 11 network with a Fidelity Level 1 NCS, and the NCS Mode of Operation is set to No Statement (0), it shall imply the NCS Mode of Operation from the Message Type Identifier of the NCS signal message. Also, the Fidelity Level 2 picket shall then assume net synchronization was successfully performed once the NCS issues a Roll Call, Short Broadcast, or Broadcast signal message.
5. A lower Fidelity Level PU shall accept higher Fidelity Level signal messages if these are correctly formatted according to the issuing PU Fidelity Level. A lower Fidelity Level PU is not required to process signal message fields from higher Fidelity Level PUs declared optional at its own Fidelity Level.
6. A higher Fidelity Level PU shall accept all lower Fidelity Level signal messages if these are correctly formatted according to the issuing PU Fidelity Level. A higher Fidelity Level PU shall treat lower Fidelity Level PU fields set to No Statement (0) as a wildcard, indicating compatibility with the higher Fidelity Level PU setting.
7. If a Fidelity Level 0 RU is participating in a simulated Link 11 network, and no FPU is modelled for the corresponding Link 11B network, Fidelity Level 1 and 2 PUs shall process the RU's signal message as forwarded by a Fidelity Level 0 FPU. The NCS shall take the Fidelity Level 0 RU into account as FPU for the calculation of the Net Cycle Time.

4.1.5.2 Link 11B

1. A Fidelity Level 1 or 2 RU shall have the ability to accept signal messages from a Fidelity Level 0 RU at any time, and shall buffer these messages as necessary until processing is possible according to its Link State.
2. If a Fidelity Level 2 RU receives signal messages from a Fidelity Level 0 or 1 RU, and the latter RU Link State is set to No Statement (0), it shall imply this RU's Link State from the tactical messages included in the signal messages.
3. A lower Fidelity Level RU shall accept higher Fidelity Level signal messages if these are correctly formatted according to the issuing RU Fidelity Level. A lower Fidelity Level RU is not required to process signal message fields from higher Fidelity Level RUs declared optional at its own Fidelity Level.
4. A higher Fidelity Level RU shall accept all lower Fidelity Level signal messages if these are correctly formatted according to the issuing RU Fidelity Level. A higher Fidelity Level RU shall treat lower Fidelity Level RU fields set to No Statement (0) as a wildcard, indicating compatibility with the higher Fidelity Level RU setting.
5. If a Fidelity Level 0 RU is exchanging messages with a Fidelity Level 1 or 2 RU without being directly connected, and there is no path through one or more FRUs, the Fidelity Level 1 or 2 RU shall process the Fidelity Level 0 RU's signal messages as forwarded by a Fidelity Level 0 FRU.
6. If a Fidelity Level 0 PU is exchanging messages with a Fidelity Level 1 or 2 RU, and the RU's Link 11B network does not contain an FPU, the Fidelity Level 1 or 2 RU shall process the Fidelity Level 0 PU's signal messages as forwarded by a Fidelity Level 0 FPU.

4.2 Link 11/11B Implementation Using DIS

This section contains the requirements for simulation of Link 11/11B using the DIS Signal and Transmitter PDUs. For the DIS Application Protocols, issuance and receipt of PDUs, and general service requirements, refer to Reference 4.

4.2.1 Transmitter PDU Description

Table 16 shows the format and values for the Transmitter PDU fields for Link 11/11B simulation.

Transmitter PDUs used in Link 11/11B simulation shall comply with requirements established in References 4 and 3, and the following requirements:

1. *Radio Type Category*. This field shall be set to 22 for Link 11 Terminal and 23 for Link 11B Terminal IAW Reference 3 [UID 22].
2. *Transmit State*. This field shall specify the transmit state of the Link 11/11B radio IAW Reference 3 [UID 164]. When the Link 11 PU is transmitting a signal, the Transmit State shall be set to On and transmitting (2). When the Link 11 PU is switched to signal reception, the Transmit State shall be set to On but not transmitting (1). When a Link 11B radio is on, then the Transmit State shall be set to On and transmitting (2), since a Link 11/11B radio will be transmitting the Standby Signal when not transmitting a message. When a Link 11/11B radio is not in use the Transmit State shall be set to Off (0).
3. *Input Source*. This field shall be set to 8 for Digital Data Device IAW in Reference 3 [UID 165].
4. *Modulation Type*. This field specifies the type of modulation used for radio transmission and consists of a record containing the following fields:
    A. *Spread Spectrum*. This field is a 16-bit record and all bits shall be set to 0 to indicate that no spread spectrum techniques are in use for Link 11/11B.
    B. *Major Modulation*. This field specifies the major classification of the modulation type. This standard does not specify additional requirements for this field.
    C. *Detail.* This field provides certain detailed information depending on the major modulation type. This standard does not specify additional requirements for this field.
    D. *Radio System*. This field specifies the radio system associated with this Transmitter PDU and shall be set to 9 for Link 11 and 10 for Link 11B IAW Reference 3 [UID 163].
5. *Length of Modulation Parameters*. This field shall specify the length in octets of the modulation parameters. This field shall be set to 8.
6. *Modulation Parameters*. These fields shall specify the modulation type-specific characteristics of the Link 11/11B portion of the Transmitter PDU.
    A. The Link 11 Modulation Parameters field shall consist of a record containing the following fields as detailed in Table 17 below:
        i. *Modulation Parameter 1.* This field shall contain the Participating Unit number of the transmitted information in the simulated system.
        ii. *Modulation Parameter 2.* This field shall contain the Fidelity Level of the Link 11 simulation being used and shall be set IAW section 4.1.2 and Reference 3 [UID 467].
        iii. *Modulation Parameter 3.* This field shall identify the Terminal Mode and shall be set IAW section 4.1.2 and Reference 3 [UID 468].
        iv. *Modulation Parameter 4.* This field is not used for Link 11 and shall be set to 0.
        v. *Modulation Parameter 5.* This field shall contain the Mode of Operation and shall be set IAW section 4.1.2 and Reference 3 [UID 470].
        vi. *Modulation Parameter 6.* This field shall contain the Net Cycle Time. This 16-bit unsigned integer field shall contain the time in seconds required for the NCS to complete a polling sequence of all PUs. This field shall be set IAW section 4.1.2 and 4.1.4.
    B. The Link 11B Modulation Parameters field shall consist of a record containing the following fields as detailed in Table 18 below:
        i. *Modulation Parameter 1.* This field shall contain the Reporting Unit number of the transmitted information in the simulated system.

ii. *Modulation Parameter 2.* This field shall contain the Fidelity Level of the Link 11B simulation being used and shall be set IAW section 4.1.2 and in Reference 3 [UID 467].

iii. *Modulation Parameter 3.* This field is not used for Link 11B and shall be set to 0.

iv. *Modulation Parameter 4.* This field shall contain the Link State and shall be set IAW section 4.1.2 and Reference 3 [UID 737].

v. *Modulation Parameter 5.* This field shall contain the Mode of Operation and shall be set IAW section 4.1.2 and Reference 3 [UID 738].

vi. *Modulation Parameter 6.* This field is not used for Link 11B and shall be set to 0.

Table 16: Transmitter PDU for Link 11/11B

Field Size (bits)	Transmitter PDU Fields			Value
96	PDU Header	Protocol Version	8-bit enumeration	
		Exercise ID	8-bit unsigned integer	
		PDU Type	8-bit enumeration	
		Protocol Family	8-bit enumeration	
		Timestamp	32-bit unsigned integer	
		Length	16-bit unsigned integer	
		PDU Status	8-bit record	
		Padding	8 bits unused	
48	Radio Reference ID	Site Number	16-bit unsigned integer	
		Application Number	16-bit unsigned integer	
		Reference Number	16-bit unsigned integer	
16	Radio Number		16-bit unsigned integer	
64	Radio Type	Entity Kind	8-bit enumeration	
		Domain	8-bit enumeration	
		Country	16-bit enumeration	
		Category	8-bit enumeration	Link 11: 22 (Link 11 Terminal) Link 11B: 23 (Link 11B Terminal)
		Subcategory	8-bit enumeration	
		Specific	8-bit enumeration	
		Extra	8-bit enumeration	

Field Size (bits)	Transmitter PDU Fields			Value
8	Transmit State		8-bit enumeration	
8	Input Source		8-bit enumeration	8 (Digital Data Device)
16	Number of Variable Transmitter Parameters Records (*N*)		16-bit unsigned integer	
192	Antenna Location	X component	64-bit floating point	
		Y component	64-bit floating point	
		Z component	64-bit floating point	
96	Relative Antenna Location	x component	32-bit floating point	
		y component	32-bit floating point	
		z component	32-bit floating point	
16	Antenna Pattern Type		16-bit enumeration	
16	Antenna Pattern Length (*A*)		16-bit unsigned integer	
64	Frequency		64-bit unsigned integer	
32	Transmit Frequency Bandwidth		32-bit floating point	
32	Power		32-bit floating point	
64	Modulation Type	Spread Spectrum	16-bit record	0
		Major Modulation	16-bit enumeration	
		Detail	16-bit enumeration	
		Radio System	16-bit enumeration	Link 11: 9 (Link 11) Link 11B: 10 (Link 11B)
16	Crypto System		16-bit enumeration	[UID 166]
16	Crypto Key ID	Crypto Mode (bit 15) Pseudo Crypto Key (bits 0-14)	16-bit record	Crypto Mode: [UID 449]

Field Size (bits)	Transmitter PDU Fields			Value
8	Length of Modulation Parameters (*M*)		8-bit unsigned integer	8 (8 octets)
8	Padding		8 bits unused	
16	Padding		16 bits unused	
64	Link 11/11B Modulation Parameters			Link 11: see Table 17 Link 11B: see Table 18
8*A*	Antenna Pattern			
As Required	Variable Transmitter Parameters record #1 ... #*N*			
Total Link 11/11B Transmitter PDU size = 896 + 8*A* + 8 Σ *Ki* bits, for *i* = 1 to *N* where *A* is the length of the Antenna Pattern record in octets, which has to be a multiple of 8 *N* is the number of Variable Transmitter Parameters records *Ki* is the total length of the Variable Transmitter Parameters record *i* in octets, including padding required in the Variable Transmitter Parameters record to make its length a multiple of 8 octets				

Table 17: Link 11 Modulation Parameters

Field Size (bits)	Field Name and Data Type			Value
8	Modulation Parameter #1	Participating Unit	8-bit unsigned integer	PU number
8	Modulation Parameter #2	Fidelity Level	8-bit enumeration	[UID 467]
8	Modulation Parameter #3	Terminal Mode	8-bit enumeration	[UID 468]
8	Modulation Parameter #4	Padding	8 bits unused	0
16	Modulation Parameter #5	Mode of Operation	16-bit enumeration	[UID 470]
16	Modulation Parameter #6	Net Cycle Time	16-bit unsigned integer	Units of seconds. Only applicable to the NCS. Set to 0 for Fidelity Level 0 and non-NCS units.

Table 18: Link 11B Modulation Parameters

Field Size (bits)	Field Name and Data Type			Value
8	Modulation Parameter #1	Reporting Unit	8-bit unsigned integer	RU number
8	Modulation Parameter #2	Fidelity Level	8-bit enumeration	[UID 467]
8	Modulation Parameter #3	Padding	8 bits unused	0
8	Modulation Parameter #4	Link State	8-bit enumeration	[UID 737]
16	Modulation Parameter #5	Mode of Operation	16-bit enumeration	[UID 738]
16	Modulation Parameter #6	Padding	16 bits unused	0

4.2.2 Signal PDU Description

Table 19 shows the format and values for the Signal PDU for Link 11/11B simulation.

Signal PDUs used in Link 11/11B simulation shall comply with requirements established in References 4 and 3, and the following requirements:

1. *Encoding scheme*. Bits 0-13 of this field shall contain the number of Link 11/11B tactical information messages. For live encrypted data, bits 0 – 13 shall be set to 0. Bits 14-15 shall contain the value 1 to indicate an Encoding Class of Raw Binary Data IAW Reference 3 [UID 270].
2. *TDL Type*. This field shall specify the TDL type as a 16-bit enumeration field and shall be set to 4 for Link 11B, and 8 for Link 11 IAW Reference 3 [UID 178].
3. *Sample Rate*. This field shall be set to 0 for Link 11 and Link 11B. See Data Signaling Rate in the appropriate Simulation Network Header.
4. *Data Length*. This field shall contain the length of the Data field in bits.
   NOTE: Since all Link 11/11B Message Data formats are 64 bits long, and the Link 11/11B Network Simulation Headers are both 160 bits long, the Data field is always a multiple of 32 bits. Therefore, additional padding after the Data field is never required.
5. *Samples*. This field shall be set to 0.
6. *Data*. For Link 11/11B, the Data field shall consist of two parts, a simulation network header portion and a message data portion as shown in Table 19. The different simulation network headers for Link 11 and Link 11B are described below.
   A. *Link 11 Simulation Network Header*. The Link 11 Simulation Network Header portion of the Signal PDU Data field shall be 160 bits long and shall use the same byte order as the Signal PDU. These fields are shown in Table 20, and shall be set as follows:
      i. *Message Sub Type*. This 8-bit enumeration field specifies the Link 11 Message Sub Type and shall be set IAW section 4.1.2 and Reference 3 [UID 730].
      ii. *Participating Unit Number*. This 8-bit unsigned integer field shall contain the Participating Unit Source Number of the Link 11 unit in any mode of operation. For Interrogation Messages, the PU Number is the identification of the unit being polled. For all other Sub-Types, the PU Number reflects the originating Participating Unit.

iii. *Sequence Number*. This 8-bit unsigned integer field is a PDU counter that each simulated system increments for every Link 11 Signal PDU generated. This field shall start at 0 for each transmission cycle (cycling of the Transmit State). The Sequence Number may be used by the Link 11 simulation application to determine transmit/receive of Link 11 messages and monitor of any missing data. In the event of missing data, the current data shall be delivered as usual. Upon reaching a value of 255, the counter shall roll over back to 0 on the next Signal PDU transmitted.

iv. *Message Type Identifier*. This 8-bit enumeration field shall identify the Link 11 Message Type and shall be set IAW section 4.1.2 and Reference 3 [UID 731].

v. *Data Signaling Rate*. This 8-bit enumeration field shall identify the data signaling rate of the Link 11 transmission and shall be set IAW section 4.1.2 and Reference 3 [UID 732].

vi. *Signal Waveform*. This 8-bit enumeration field shall identify the Link 11 signal waveform and the message format used (see Table 22 and Table 23), and shall be set IAW section 4.1.2 and Reference 3 [UID 734].

vii. *Encryption Flag*. This 8-bit enumeration field shall identify if the Link 11 data is encrypted and shall be set IAW section 4.1.2 and Reference 3 [UID 735].

viii. *Perceived Transmit Time*. The Perceived Transmit Time (in NTP timestamp format) shall indicate the simulation time the first included Link 11 tactical message was sent, in seconds relative to 0 hours on 1 January 1900 Coordinated Universal Time (UTC). It includes a 32-bit unsigned Integer Part field spanning 136 years and a 32-bit Fraction Part field resolving 232 picoseconds. See Reference 12 for detailed format. The Perceived Transmit Time shall be set IAW section 4.1.2 and both fields shall be set to 4 294 967 295 (all bits set to one) to indicate a no statement/wildcard.

B. *Link 11B Simulation Network Header*. The Link 11B Simulation Network Header portion of the Signal PDU Data field shall be 160 bits long and shall use the same byte order as the Signal PDU. These fields are shown in Table 21, and shall be set as follows:

i. *Message Sub Type*. This 8-bit enumeration field specifies the Link 11B Message Sub Type and shall be set IAW section 4.1.2 and Reference 3 [UID 739].

ii. *Reporting Unit Number*. This 8-bit unsigned integer field shall contain the Reporting Unit Source Number of the Link 11B unit in any mode of operation.

iii. *Sequence Number*. This 8-bit unsigned integer field is a PDU counter that each simulated system increments for every Link 11B Signal PDU generated. This field shall start at 0 for each transmission cycle (cycling of the Transmit State). The Sequence Number may be used by the Link 11B simulation to determine transmit/receive of Link 11B messages and monitor of any missing data. In the event of missing data, the current data shall be delivered as usual. Upon reaching a value of 255, the counter shall roll over back to 0 on the next Signal PDU transmitted.

iv. *Data Signaling Rate*. This 8-bit enumeration field shall identify the data signaling rate of the Link 11B transmission and shall be set IAW section 4.1.2 and Reference 3 [UID 740].

v. *Modulation Standard*. This 8-bit enumeration field shall identify the Link 11B modulation standard and shall be set IAW section 4.1.2 and Reference 3 [UID 741].

vi. *Encryption Flag*. This 8-bit enumeration field shall identify if the Link 11B data is encrypted and shall be set IAW section 4.1.2 and Reference 3 [UID 735].

vii. *Perceived Transmit Time*. The Perceived Transmit Time (in NTP timestamp format) shall indicate the simulation time the first included Link 11B tactical message was sent, in seconds relative to 0 hours on 1 January 1900 Coordinated Universal Time (UTC). It includes a 32-bit unsigned Integer Part field spanning 136 years and a 32-bit Fraction Part field resolving 232 picoseconds. See Reference 12 for detailed format. The Perceived

Transmit Time shall be set IAW section 4.1.2 and both fields shall be set to 4 294 967 295 (all bits set to one) to indicate a no statement/wildcard.

C. *Link 11/11B Message Data*. Link 11/11B Message Data portion of the Data field is a bit stream that shall contain the Link 11/11B tactical information message data corresponding to the TDL Type, and for Link 11 to the Signal Waveform, as specified in Table 22, Table 23 and Table 24. Link 11/11B tactical information message data bit orientation shall be accomplished in accordance with paragraph 4.1.1 item 7. Table 25 shows an example of bit ordering for the Link 11 CLEW message format (Table 22). Link 11/11B message formats illustrated in Table 23 and Table 24 have a similar structure.

Table 19: Signal PDU for Link 11/11B

Field Size (bits)	Signal PDU Fields			Value
96	PDU Header	Protocol Version	8-bit enumeration	
		Exercise ID	8-bit unsigned integer	
		PDU Type	8-bit enumeration	
		Protocol Family	8-bit enumeration	
		Timestamp	32-bit unsigned integer	
		Length	16-bit unsigned integer	
		PDU Status	8-bit record	
		Padding	8 bits unused	
48	Radio Reference ID	Site Number	16-bit unsigned integer	
		Application Number	16-bit unsigned integer	
		Reference Number	16-bit unsigned integer	
16	Radio Number		16-bit unsigned integer	
16	Encoding Scheme		16-bit record	Bits 0-13 shall contain the number of Link 11/11B tactical information messages. For live encrypted data, bits 0 – 13 shall be set to 0. Bits 14-15 shall contain the value 1 to indicate an Encoding Class of Raw Binary Data.
16	TDL Type		16-bit enumeration	Link 11: 8 (Link 11 (TADIL A)) Link 11B: 4 (Link 11B (TADIL B))
32	Sample Rate		32-bit integer	0

Field Size (bits)	Signal PDU Fields			Value
16	Data Length (*K*)		16-bit integer	
16	Samples		16-bit integer	0
Start of Data field				
160	Link 11/11B Simulation Network Header			Link 11: see Table 20 Link 11B: see Table 21
K-Varies	Link 11/11B Message Data		Bit stream	Link 11: corresponding to the Signal Waveform as described in Table 22 or Table 23. Link 11B: see Table 24.
End of Data field				
P	Padding		Padding to 32-bit boundary	
Total Link 11/11B Signal PDU size = 256 + *K* + *P* bits where *K* is the length of the Data field in bits *P* is the number of padding bits, which is ⌈*K*/32⌉32 - *K* ⌈x⌉ is the largest integer < x+1 Note: *P* = 0 because the Link 11/11B Message Data field is always a multiple of 64 bits, and thus the Data field is always a multiple of 32 bits.				

Table 20: Link 11 Simulation Network Header

Field Size (bits)	Field Name and Data Type			Value
160	Link 11 Simulation Network Header	Message Sub Type	8-bit enumeration	[UID 730]
		Participating Unit Number	8-bit unsigned integer	
		Sequence Number	8-bit unsigned integer	
		Message Type Identifier	8-bit enumeration	[UID 731]
		Padding	32 bits unused	0
		Data Signaling Rate	8-bit enumeration	[UID 732]
		Padding	8 bits unused	0

Field Size (bits)	Field Name and Data Type			Value
		Signal Waveform	8-bit enumeration	[UID 734]
		Encryption Flag	8-bit enumeration	[UID 735]
		Perceived Transmit Time – Integer Part	32-bit unsigned integer	0-4 294 967 295 [1]
		Perceived Transmit Time – Fraction Part	32-bit unsigned integer	0-4 294 967 295 [1]

Table 21: Link 11B Simulation Network Header

Field Size (bits)	Field Name and Data Type			Value
160	Link 11B Simulation Network Header	Message Sub Type	8-bit enumeration	[UID 739]
		Reporting Unit Number	8-bit unsigned integer	
		Sequence Number	8-bit unsigned integer	
		Padding	8 bits unused	0
		Padding	32 bits unused	0
		Data Signaling Rate	8-bit enumeration	[UID 740]
		Padding	8 bits unused	0
		Modulation Standard	8-bit enumeration	[UID 741]
		Encryption Flag	8-bit enumeration	[UID 735]
		Perceived Transmit Time – Integer Part	32-bit unsigned integer	0-4 294 967 295 [1]
		Perceived Transmit Time – Fraction Part	32-bit unsigned integer	0-4 294 967 295 [1]

[1] All bits for both fields set to one, i.e., both field values being 4 294 967 295, indicates no statement/ wildcard.

Table 22: Link 11 CLEW Message Format

Octet 3								Octet 2								Octet 1								Octet 0							
31	30	29					24	23																							0
Pad.		EDAC						Frame A: 24 Bit Tactical Data																							
Octet 7								Octet 6								Octet 5								Octet 4							
63	62	61					56	55																							32
Pad.		EDAC						Frame B: 24 Bit Tactical Data																							

Table 23: Link 11 SLEW Message Format

Octet 3								Octet 2								Octet 1								Octet 0							
31							24	23																							0
Frame B (bits 0-7)								Frame A: 24 Bit Tactical Data																							
Octet 7								Octet 6								Octet 5								Octet 4							
63			60	59											48	47															32
Padding				CRC												Frame B: 24 Bit Tactical Data (cont'd, bits 8-23)															

Table 24: Link 11B Message Format

Octet 3								Octet 2								Octet 1								Octet 0							
31							24	23							16	15							8	7							0
Data Group 4								Data Group 3								Data Group 2								Data Group 1							
Octet 7								Octet 6								Octet 5								Octet 4							
63							56	55							48	47							40	39							32
Padding								Check Group								Data Group 6								Data Group 5							

Table 25 below depicts the Signal PDU Data field, showing the Link 11 Simulation Network Header in yellow (for DIS versions that use big endian octet ordering) followed by two Link 11 tactical information messages when using the CLEW signal waveform. Note that the displayed octet ordering switches after octet 19 due to the change from octet-oriented data to bit stream data.

Table 25: Signal PDU Data field with Link 11 Simulation Network Header and CLEW Message Format

Octet 0							
7							0
Message Sub Type							

Octet 1							
7							0
Participating Unit Number							

Octet 2							
7							0
Sequence Number							

Octet 35								Octet 34								Octet 33								Octet 32							
		125					120	119																							96
Pad.		EDAC						Tactical Information Message Fields (cont'd) (Frame B)																							

4.3 Link 11/11B Implementation Using HLA

Link 11/11B TDL simulation is typically part of a larger distributed federation, where the HLA implementation of the Link 11/11B protocol will be part of the Federation Object Model (FOM). Such federations are used for many purposes including system development, test and evaluation, and training.

The HLA design for Link 11/11B implementation is defined in a FOM module in the HLA 1516-2010 FOM format [6]. However, not every federation that will use the Link 11/11B FOM module has the same FOM. FOMs that incorporate the Link 11/11B FOM module may already have definitions for basic concepts such as radio transmitters and radio signals, or their equivalents. If these definitions were included in the Link 11/11B FOM module then there would be duplication, and potentially incompatibilities, with existing definitions in the "parent" FOM in which the Link 11/11B module is incorporated. Therefore, the Link 11/11B FOM module does not include definitions for some basic concepts, and relies on the parent FOM to provide suitable definitions. The Link 11/11B FOM module can be considered a "template" for creating a concrete FOM module for inclusion in the parent FOM.

In addition, the Link 11/11B FOM module is designed to build upon existing datatypes and classes in the RPR FOM [1], allowing an integration with the RPR FOM 2.0 without changing any of its existing capabilities. See section 4.3.7 for a detailed description of how to add the Link 11/11B FOM module to the RPR FOM.

4.3.1 The Link 11/11B FOM Module

4.3.1.1 Assumptions

The Link 11/11B FOM module assumes that the parent FOM contains:

1. An object class that represents a radio transmitter with the general transmitter capabilities as described in section 4.1.
2. An interaction class that represents a tactical data link capable radio signal. This class will act as a base class for the TDLBinaryRadioSignal defined in the Link 11/11B FOM module with the general transmission capabilities as described in section 4.1.
3. A mechanism for determining the number of TDL messages contained in the signal interaction.
4. A mechanism for associating any instance of the radio signal interaction class with an instance of the radio transmitter object class that it emanated from.

4.3.1.2 Naming Convention

Conventions within the Link 11/11B FOM module follow those adopted by the RPR FOM version 2.0 [1]. These conventions are described in more detail in the RPR FOM GRIM, section 6.8.1 [2].

4.3.1.3 Representations

The Link 11/11B FOM module file (named Link_11_11B_v1.0.xml and available on the SISO website), in compliance with the HLA Evolved FOM schema, shall be considered normative, while the human-readable tables in Annex A shall be considered informative. If any statement in this document is interpreted to be in conflict with the Link 11/11B FOM module in XML format, the content of the XML file shall take precedence.

4.3.2 Levels of Fidelity

The HLA levels of fidelity are directly equivalent to the corresponding DIS levels of fidelity as defined in sections 4.1.2 and 4.1.3. The requirements for mixed Fidelity Levels as defined in section 4.1.5 also apply to the usage of the Link 11/11B FOM module.

4.3.3 Time Synchronization

For time-managed HLA federations the logical time shall be used as a time source for all time references.

For non-time managed HLA federations, the system time shall be used as a time source for all time references. In this case the HLA time synchronization mechanism is directly equivalent to the corresponding mechanism for DIS as defined in Reference 44.1.3.

A time-managed HLA federation requires a common understanding of logical time by all federates. According to the description of rule 10 in the HLA standard (IEEE Std 1516-2010, section 6.5): “Federation designers will identify their time management approach as part of their implementation design. Federates shall adhere to the time management approach of the federation." Federation designers need to make agreements on the mapping of the HLA logical time to the time value in Link11RadioSignal and Link11BRadioSignal messages, including agreements on the time value that corresponds with the HLA logical time zero (the start time of the federation execution). A federate shall implement these agreements and shall provide the HLA logical time in the RTI time management service calls for which the data in the Link11RadioSignal or Link11BRadioSignal message is valid.

4.3.4 Protocol Implementation Details

This section defines how Link 11/11B FOM module compliant federates shall implement the Link 11/11B protocol. The HLA protocol implementation details are directly equivalent to the corresponding details for DIS as defined in section 4.2.

4.3.4.1 Object Class Data

The Link 11/11B FOM module defines no new object classes. Instead, the FOM module defines two fixed record datatypes (Link11TransmitterStruct and Link11BTransmitterStruct, see section A.10) that correspond to the modulation parameters in the DIS Transmitter PDU defined in section 4.2.1. These datatypes should be added to the parent FOM either directly into the radio transmitter object class or into a suitable subclass of the radio transmitter object class. The datatypes can be added as attributes or into another data structure in an existing attribute.

The modulation parameters requirements as specified under item 6.A in section 4.2.1 also apply to the usage of the Link11TransmitterStruct. Refer to Table 26 for a mapping between the Link11TransmitterStruct fields and the DIS Transmitter PDU fields. The modulation parameters requirements as specified under item 6.B in section 4.2.1 also apply to the usage of the Link11BTransmitterStruct. Refer to Table 27 for a mapping between the Link11BTransmitterStruct fields and the DIS Transmitter PDU fields. All other requirements defined in section 4.2.1 apply to the equivalent attributes of this object class.

Table 26: Link11TransmitterStruct Mapping to DIS Modulation Parameters

Link11TransmitterStruct Field Name	Transmitter PDU Field	
ParticipatingUnit	Modulation Parameter #1	Participating Unit
FidelityLevel	Modulation Parameter #2	Fidelity Level
TerminalMode	Modulation Parameter #3	Terminal Mode
ModeOfOperation	Modulation Parameter #5	Mode of Operation

Link11TransmitterStruct Field Name	Transmitter PDU Field	
NetCycleTime	Modulation Parameter #6	Net Cycle Time

Table 27: Link11BTransmitterStruct Mapping to DIS Modulation Parameters

Link11BTransmitterStruct Field Name	Transmitter PDU Field	
ReportingUnit	Modulation Parameter #1	Reporting Unit
FidelityLevel	Modulation Parameter #2	Fidelity Level
LinkState	Modulation Parameter #4	Link State
ModeOfOperation	Modulation Parameter #5	Mode of Operation

4.3.4.2 Interaction Class Data

The Link 11/11B FOM module includes a family of interactions that have been developed to support other data link implementations. The family of interactions is a hierarchy in which the base class for the Link 11/11B interactions is a generic class, the TDLBinaryRadioSignal interaction. This class is a class without parameters, and this class cannot be published nor subscribed to. The specific parameters are properties of the various subclasses of this generic base class, and these are the subclasses that are published and subscribed to. This hierarchy of interaction classes provides for Declaration Management (DM) filtering, enabling the federate to only receive the data link messages it is interested in.

The Link11RadioSignal interaction, a subclass of the TDLBinaryRadioSignal interaction (see Table A-3), contains the parameters for the Link 11 Simulation Network Header fields (see Table 20) as shown in Table A-4. The field ‘Message Type Identifier’ is represented in the Link 11/11B FOM module by the six subclasses of Link11RadioSignal. These subclasses, Link11NetTestRadioSignal, Link11RollCallRadioSignal, Link11PicketReplyRadioSignal, Link11ShortBroadcastRadioSignal, Link11BroadcastRadioSignal, and Link11NetSyncRadioSignal, are the interactions that shall be published within the HLA federation for Fidelity Level 1 and higher. At Fidelity Level 0, interactions of the class Link11RadioSignal shall be published, in accordance with a ‘Message Type Identifier’ setting of No Statement (0).

The Link11BRadioSignal interaction, also a subclass of the TDLBinaryRadioSignal interaction (see Table A-3), contains the parameters for the Link 11B Simulation Network Header fields (see Table 21) as shown in Table A-4.

It is uncommon in HLA FOMs to use datatypes with sizes other than 8, 16, 32, or 64 bits. Therefore, similar to structures shown in Table 22 and Table 23, the fields EDAC and CRC are defined using one and two octets, respectively, which include padding bits. Note that in case the test pattern is provided when using the CLEW waveform, all 30 bits of a frame are used, i.e., both the TacticalData and the EDAC fields.

The TDLBinaryRadioSignal interaction class (and its child classes) shall be integrated as a subclass of the interaction that represents a tactical data link capable radio signal. All other requirements defined in section 4.2.2 apply to the equivalent parameters, when present, of this interaction class.

4.3.5 FOM Module Definition

The complete Link 11/11B FOM module is defined in Link_11_11B_v1.0.xml and can be downloaded from the SISO website. It is also represented in human-readable form in Annex A.

For the special case where the parent FOM is the RPR FOM version 2.0, a complete set of pre-built FOM modules can be downloaded from the SISO website. The set includes the Link 11/11B capabilities from this standard, as well as the Link 16 capabilities as defined in SISO-STD-002-2021.

4.3.6 Adding the Link 11/11B FOM Module to a Parent FOM

Note: If the parent FOM is the RPR FOM then see section 4.3.7 instead.

Adding the Link 11/11B FOM module to a parent FOM consists of the following steps:

1. Identify the object class representing a radio transmitter.
    A. If the parent FOM does not contain such a class then a Radio Transmitter object class should be added to the parent FOM.
    B. If the parent FOM already contains such a class and is designed to support subscription-based filter using declaration management then it may be desirable to create one or two subclasses to act as a Link 11 and/or Link 11B Radio Transmitter.
2. Add the usage of the Link11TransmitterStruct and Link11BTransmitterstruct structures to the object class(es) identified above.
3. Identify the interaction class representing a radio signal.
    A. If the parent FOM does not contain such a class then a Radio Signal interaction class should be added to the parent FOM.
    B. If the parent FOM does contain a suitable interaction class then add the TDLBinaryRadioSignal as a subclass.
4. Add the datatypes defined in Table A-6 through Table A-10.

4.3.7 Adding the Link 11/11B FOM Module to the RPR FOM

If an unmodified RPR FOM 2.0 [1] for HLA Evolved is being used, then it is recommended that the pre-built RPR FOM with Link 11/11B FOM modules provided are used. However, if the RPR FOM has been modified for some other federation specific reason then it will be necessary to integrate the Link 11/11B FOM module as follows:

Adding the Link 11/11B FOM module to the RPR FOM consists of the following steps:

1. Update the RPR FOM Communication module to add Link 11/11B specific types and extend the RPR FOM SpreadSpectrumVariantStruct variant record to include the Link11TransmitterStruct and Link11BTransmitterstruct structures as alternatives.
2. Update the RPR FOM Enumerations module to add Link 11/11B specific enumerations and the Link11_SpectrumType and Link11B_SpectrumType enumerator values.
3. Update the Link 11/11B FOM module to:
    A. Add the TDLBinaryRadioSignal as a subclass of the RPR FOM RawBinaryRadioSignal. The resulting RadioSignal interaction class hierarchy is shown in Table 28, with the Link 11/11B FOM module classes shaded in yellow.
    B. Remove elements included elsewhere in the modified RPR FOM modules.

Detailed instructions are contained in the following sections.

4.3.7.1 Updating the RPR FOM Communication Module

1. Add the simple datatypes ParticipatingUnitSourceNumber and TimeSecondUnsignedInteger16 from Table A-6.
2. Add the fixed record datatypes Link11TransmitterStruct and Link11BTransmitterstruct from Table A-9.
3. Add an alternative for enumerator Link11_SpectrumType, using the Link11TransmitterStruct, and an alternative for enumerator Link11B_SpectrumType, using the Link11BTransmitterStruct, to the variant record datatype SpreadSpectrumVariantStruct, as shown in yellow in Table 30.

4. Update the modelIdentification name, version, modificationDate, and description, and add a useHistory as appropriate.

The RawBinaryRadioSignal parameter SignalData shall not be used to publish the Link 11/11B messages. Consequently, the RawBinaryRadioSignal parameter SignalDataLength shall either not be published or shall be set to 0. As per the DIS requirement in section 4.2.2 item 3, the RawBinaryRadioSignal parameter DataRate shall be set to 0.

NOTE: DIS to HLA gateways respecting this standard cannot simply forward Signal PDUs as corresponding RPR FOM RadioSignal based interactions based on the Encoding Class, copying 'Raw Binary Data' into the SignalData parameter of a RawBinaryRadioSignal interaction. See Annex B for a detailed guide for DIS-HLA gateway implementation.

4.3.7.2 Updating the RPR FOM Enumerations Module

The Enumerations module (RPR-Enumerations_v2.0.xml) can be used as provided with SISO-REF-010 from version 30 onwards. If for any reason you cannot use this module, then:

1. Add the following enumerated datatypes from Table A-7:
   A. Link1111BEncryptionFlagEnum8
   B. Link1111BFidelityLevelEnum8
   C. Link11BDataSignalingRateEnum8
   D. Link11BLinkStateEnum8
   E. Link11BMessageSubTypeEnum8
   F. Link11BModeOfOperationEnum16
   G. Link11BModulationStandardEnum8
   H. Link11DataSignalingRateEnum8
   I. Link11MessageSubTypeEnum8
   J. Link11ModeOfOperationEnum16
   K. Link11SignalWaveformEnum8
   L. Link11TerminalModeEnum8
2. Add the enumerators Link11_SpectrumType (value 3) and Link11B_SpectrumType (value 4) to the enumerated datatype SpreadSpectrumEnum16 as shown in yellow in Table 29.
3. Update the modelIdentification name, version, modificationDate, and description, and add a useHistory as appropriate.

4.3.7.3 Updating the Link 11/11B FOM Module

1. Remove the object class RadioTransmitter.
2. Replace the interaction class Parent by scaffolding classes for HLAinteractionRoot.RadioSignal.RawBinaryRadioSignal, i.e. replace:

```
<interactions>
  <interactionClass notes="Link11_11B_2">
    <name>Parent</name>
      <sharing>PublishSubscribe</sharing>
      <transportation>HLAbestEffort</transportation>
      <order>Receive</order>
      <interactionClass>
          <name>TDLBinaryRadioSignal</name>
          ...
```



```
        </interactionClass>
      </interactionClass>
    </interactions>
```

With the following:

```
    <interactions>
      <interactionClass>
        <name>HLAinteractionRoot</name>
        <interactionClass>
          <name>RadioSignal</name>
          <interactionClass>
            <name>RawBinaryRadioSignal</name>
            <interactionClass>
              <name>TDLBinaryRadioSignal</name>
              ...
            </interactionClass>
          </interactionClass>
        </interactionClass>
      </interactionClass>
    </interactions>
```

3. Delete the RPR FOM datatypes RPRunsignedInteger16BE, RPRunsignedInteger32BE, RPRunsignedInteger8BE, Octet, UnsignedInteger32, UnsignedInteger8, OctetArray2, and OctetArray3 (it is assumed that these datatypes have not been modified in the base RPR FOM Foundation and Base modules).
4. Delete the datatypes added to the Enumerations and Communication modules:
   A. ParticipatingUnitSourceNumber
   B. TimeSecondUnsignedInteger16
   C. Link1111BEncryptionFlagEnum8
   D. Link1111BFidelityLevelEnum8
   E. Link11BDataSignalingRateEnum8
   F. Link11BLinkStateEnum8
   G. Link11BMessageSubTypeEnum8
   H. Link11BModeOfOperationEnum16
   I. Link11BModulationStandardEnum8
   J. Link11DataSignalingRateEnum8
   K. Link11MessageSubTypeEnum8
   L. Link11ModeOfOperationEnum16
   M. Link11SignalWaveformEnum8
   N. Link11TerminalModeEnum8
   O. SpreadSpectrumEnum16
   P. Link11TransmitterStruct
   Q. Link11BTransmitterStruct
5. Delete the notes Link11_11B_1 and Link11_11B_2.
6. Add a Dependency to the Real-time Platform Reference Communication FOM module in the modelIdentification.

7. Update the modelIdentification name, version, modificationDate, and description, and add a useHistory as appropriate.

Table 28: RPR FOM Link 11/11B FOM Module Interactions Class Structure Table

RadioSignal (N)	ApplicationSpecificRadioSignal (PS)			
	DatabaseIndexRadioSignal (PS)			
	EncodedAudioRadioSignal (PS)			
	RawBinaryRadioSignal (PS)	TDLBinaryRadioSignal (N)	Link11RadioSignal (PS)	Link11NetTestRadioSignal (PS)
				Link11RollCallRadioSignal (PS)
				Link11PicketReplyRadioSignal (PS)
				Link11ShortBroadcastRadioSignal (PS)
				Link11BroadcastRadioSignal (PS)
				Link11NetSyncRadioSignal (PS)
			Link11BRadioSignal (PS)	

Table 29: SpreadSpectrumEnum16 with Link 11/11B FOM Module Modifications

Name	Representation	Enumerator	Values	Semantics
SpreadSpectrumEnum16	RPRunsignedInteger16BE	None	0	The type of spread spectrum characteristics employed by a transmitter.
		SINCGARSFrequencyHop	1	
		Link11_SpectrumType	3	
		Link11B_SpectrumType	4	

Table 30: SpreadSpectrumVariantStruct with Link 11/11B FOM Module Modifications

Record name	Discriminant			Alternative			Encoding	Semantics
	Name	Type	Enumerator	Name	Type	Semantics		
SpreadSpectrumVariantStruct	SpreadSpectrumType	SpreadSpectrumEnum16	SINCGARSFrequencyHop	SINCGARSModulation	SINCGARSModulationStruct	Modulation parameters for SINCGARS radio system.	HLAvariantRecord	Identifies the actual spread spectrum technique in use.
			Link11_SpectrumType	Link11TransmitterData	Link11TransmitterStruct	Modulation parameters for Link 11 radio system according to SISO-STD-005.		
			Link11B_SpectrumType	Link11BTransmitterData	Link11BTransmitterStruct	Modulation parameters for Link 11B radio system according to SISO-STD-005.		

Annex A Link 11/11B FOM Module (Informative)

A.1 Object Model Identification Table

General introduction: *The purpose of this table is to document certain key identifying information within the object model description.*

For detailed information on the table format, see Reference 6.

Table A-1: Object Model Identification

Category	Information
Name	SISO-STD-005-2023 - Link 11/11B Simulation FOM module
Type	FOM
Version	1.0
Modification Date	2023-06-15
Security Classification	Unclassified
Purpose	Defines the Link 11/11B model in an HLA federation
Application Domain	C4ISR & C2 platform simulations
Description	This module provides the full definition of the SISO-STD-005 Standard for Link 11/11B Simulation for implementation using HLA. Note that this Link 11/11B FOM module relies upon a parent FOM to provide suitable class definitions for radio transmitters and radio signals. Typically, it cannot be directly used within a federation. This module can be considered as a template for creating a concrete FOM module for inclusion in the parent FOM. See SISO-STD-005-2023 section 4.3 for more information. Note also that for HLA Evolved a pre-built RPR FOM 2.0 with Link 11/11B FOM modules can be downloaded from the SISO website.

Category	Information
POC	
POC Type	Primary author
POC Name	TADIL TALES Product Development Group and Product Support Group
POC Organization	SISO - Simulation Interoperability Standards Organization
POC Telephone	+1 (407) 882-1348
POC Email	siso-help@sisostds.org
References	
Type	Text Document
Identification	SISO-STD-005-2023 Standard for Link 11/11B Simulation Version 1.0 15 June 2023
Type	Text Document
Identification	SISO-STD-001-2015 Standard for Guidance, Rationale, and Interoperability Modalities for the Real-time Platform Reference Federation Object Model Version 2.0 10 August 2015
Type	Text Document
Identification	SISO-STD-001.1-2015 Standard for Real-time Platform Reference Federation Object Model Version 2.0 10 August 2015
Type	Text Document
Identification	SISO-REF-010-2023 Reference for Enumerations for Simulation Interoperability Version 31 08 October 2022

Category	Information
Other	

A.2 Object Class Structure Table

General introduction: *The object class structure of an object model is defined by a set of relations among classes of objects from the simulation or federation domain. The object class structure table represents the class-subclass hierarchy of object classes. It is populated from the most general object classes in the left-most column, followed by all of their immediate subclasses in the next column, and then further levels of subclasses, as required. Finally, the most specific object classes are specified in the right-most column.*

Each object class in the object class structure table is followed by information on publication and subscription capabilities enclosed in parentheses:

- *P (Publish): At least one federate is capable of publishing at least one attribute of the object class.*
- *S (Subscribe): At least one federate is capable of subscribing to at least one attribute of the object class.*
- *PS (PublishSubscribe): At least one federate is capable of publishing at least one attribute and at least one federate is capable of subscribing to at least one attribute of the object class.*
- *N (Neither): No federate is capable of either publishing or subscribing to any attributes of the object class.*

Explanatory information with individual table entries may be included by using a notes pointer. Pointers to notes consist of a uniquely identifying note label (or a series of comma-separated labels) preceded by an asterisk and enclosed by brackets. The notes themselves are included in the notes table.

For detailed information on the table format, see Reference 6.

There are no Link 11/11B unique object classes in the Link 11/11B FOM module. The RadioTransmitter object shown in Table A-2 is a scaffolding class to hold note Link11_11B_1. Refer to this note (see Table A-11) for information on the integration of datatypes Link11TransmitterStruct and Link11BTransmitterStruct.

Table A-2: RadioTransmitter Object

RadioTransmitter (PS) *[Link11_11B_1]

A.3 Interaction Class Structure Table

General introduction: *The interaction class structure of an object model is defined by a set of relations among classes of interactions from the simulation or federation domain. The interaction class structure table represents the class-subclass hierarchy of interaction classes, in much the same way that objects are described in the object class structure table.*

Each interaction class in the interaction class structure table is followed by information on publishing and subscribing capabilities enclosed in parentheses:

- *P (Publish): At least one federate is capable of publishing the interaction class.*
- *S (Subscribe): At least one federate is capable of subscribing to the interaction class.*
- *PS (PublishSubscribe): At least one federate is capable of publishing and at least one federate is capable of subscribing to the interaction class.*
- *N (Neither): No federate is capable of either publishing or subscribing to the interaction class.*

Pointers to notes may be included, in the same way as described for the object class structure table.

For detailed information on the table format, see Reference 6.

Refer to note Link11_11B_2 (see Table A-11) for information on the interpretation of the Parent class.

Table A-3: Interaction Class Structure Table

Parent (PS) *[Link11_11B_2]	TDLBinaryRadioSignal (N)	Link11RadioSignal (PS)	Link11NetTestRadioSignal (PS)
			Link11RollCallRadioSignal (PS)
			Link11PicketReplyRadioSignal (PS)
			Link11ShortBroadcastRadioSignal (PS)
			Link11BroadcastRadioSignal (PS)
			Link11NetSyncRadioSignal (PS)
		Link11BRadioSignal (PS)	

A.4 Attribute Table

General introduction: *Each class of simulation domain objects is characterized by a fixed set of attribute types. These attributes are named portions of their object's state whose values can change over time. The attribute table describes all object attributes represented in a federation.*

For detailed information on the table format, see Reference 6.

There are no Link 11/11B unique object classes in the Link 11/11B FOM module. Refer to note Link11_11B_1 (see Table A-11).

A.5 Parameter Table

General introduction: *Most interaction classes are characterized according to a list of one or more interaction parameters. Interaction parameters are used to associate relevant and useful information with classes of interactions. The parameter table describes all interaction parameters that may be represented in a federation.*

For detailed information on the table format, see Reference 6.

Table A-4: Parameter Table

Interaction	Parameter	Datatype	Available Dimensions	Transportation	Order
Link11BRadioSignal	MessageSubType	Link11BMessageSubTypeEnum8	NA	HLAbestEffort	Receive
	ReportingUnitNumber	ParticipatingUnitSourceNumber			
	SequenceNumber	UnsignedInteger8			
	DataSignalingRate	Link11BDataSignalingRateEnum8			
	ModulationStandard	Link11BModulationStandardEnum8			
	EncryptionFlag	Link1111BEncryptionFlagEnum8			
	PerceivedTransmitTime	NTPTimestampStruct			
	MessageData	Link11BMessageStructArray			
Link11RadioSignal	MessageSubType	Link11MessageSubTypeEnum8	NA	HLAbestEffort	Receive
	ParticipatingUnitNumber	ParticipatingUnitSourceNumber			
	SequenceNumber	UnsignedInteger8			
	DataSignalingRate	Link11DataSignalingRateEnum8			
	EncryptionFlag	Link1111BEncryptionFlagEnum8			
	PerceivedTransmitTime	NTPTimestampStruct			
	MessageData	Link11MessageVariantStruct			

A.6 Basic Data Representation Table

General introduction: *Basic data representation is the underpinning of all OMT datatypes. These basic data representations cannot be directly used as a named datatype in any OMT datatype table, but rather are the basis upon which named datatypes are built.*

For detailed information on the table format, see Reference 6.

NOTE – Cells that are shaded in blue are defined in RPR FOM 2.0.

Table A-5: Basic Data Representation Table

Name	Size in bits	Interpretation	Endian	Encoding
RPRunsignedInteger16BE	16	Integer in the range [0, 2^16-1]	Big	16-bit unsigned integer.
RPRunsignedInteger32BE	32	Integer in the range [0, 2^32-1]	Big	32-bit unsigned integer.
RPRunsignedInteger8BE	8	Integer in the range [0, 2^8-1]	Big	8-bit unsigned integer.

A.7 Simple Datatype Table

General introduction: *The simple datatype table describes simple, scalar data items.*

For detailed information on the table format, see Reference 6.

NOTE – Cells that are shaded in blue are defined in RPR FOM 2.0.

Table A-6: Simple Datatype Table

Name	Representation	Units	Resolution	Accuracy	Semantics
Octet	HLAoctet	NA	1	perfect	Uninterpreted 8-bit value.
ParticipatingUnitSourceNumber	RPRunsignedInteger8BE	NA	NA	NA	PU number. Valid range [1,76] octal ([1,62] decimal).
TimeSecondUnsignedInteger16	RPRunsignedInteger16BE	second (s)	1	perfect	Time, based on SI base unit second, unit symbol s.
UnsignedInteger32	RPRunsignedInteger32BE	NA	1	perfect	Integer in the range [0, 2^32-1].
UnsignedInteger8	RPRunsignedInteger8BE	NA	1	perfect	Integer in the range [0, 2^8-1].

A.8 Enumerated Datatype Table

General introduction: *The enumerated datatype table describes data elements that can take on a finite discrete set of possible values.*

For detailed information on the table format, see Reference 6.

NOTE – Cells that are shaded in blue are defined in RPR FOM 2.0.

Table A-7: Enumerated Datatype Table

Name	Representation	Enumerator	Values	Semantics
Link1111BEncryptionFlagEnum8	HLAoctet	NoEncryptionUsed	0	Link 11/11B Encryption Flag [UID 735].
		EncryptionUsed	1	
Link1111BFidelityLevelEnum8	HLAoctet	FidelityLevel0	0	Link 11/11B Fidelity Level [UID 467].
		FidelityLevel1	1	
		FidelityLevel2	2	
Link11BDataSignalingRateEnum8	HLAoctet	NoStatement	0	Link 11B Data Signaling Rate [UID 740].
		_1200Bps	3	
		_2400Bps	4	
		_600Bps	5	
Link11BLinkStateEnum8	HLAoctet	NoStatement	0	Link 11B Link State [UID 737].
		Inactive	1	
		Ready	2	
		Active	3	
		Operational	4	
Link11BMessageSubTypeEnum8	HLAoctet	NoStatement	0	Link 11B Message Sub Type [UID 739].
		TransmissionFrame	1	
		StandbySignal	2	
Link11BModeOfOperationEnum16	RPRunsignedInteger16BE	NoStatement	0	Link 11B Mode of Operation [UID 738].
		FullTransmissionOfData	1	
		LimitedTransmissionOfData	2	
		ReceiveOnly	3	
Link11BModulationStandardEnum8	HLAoctet	NoStatement	0	Link 11B Modulation Standard [UID 741].
		CCITTV_23	1	

Name	Representation	Enumerator	Values	Semantics
Link11DataSignalingRateEnum8	HLAoctet	NoStatement	0	Link 11 Data Signaling Rate [UID 732].
		_1364Bps	1	
		_2250Bps	2	
Link11MessageSubTypeEnum8	HLAoctet	NoStatement	0	Link 11 Message Sub Type [UID 730].
		Interrogation	1	
		DataStart	2	
		Data	3	
		DataStop	4	
Link11ModeOfOperationEnum16	RPRunsignedInteger16BE	NoStatement	0	Link 11 Mode of Operation [UID 470].
		NetSync	1	
		NetTest	2	
		RollCall	3	
		ShortBroadcast	4	
		Broadcast	5	
Link11SignalWaveformEnum8	HLAoctet	NoStatement-CLEWFormat	0	Link 11 Signal Waveform [UID 734].
		ConventionalLinkElevenWaveform_CLEW_	1	
		SingleToneLinkElevenWaveform_SLEW_	2	
Link11TerminalModeEnum8	HLAoctet	NoStatement	0	Link 11 Terminal Mode [UID 468].
		NetworkControlStation	1	
		Picket	2	
SpreadSpectrumEnum16	RPRunsignedInteger16BE	Link11_SpectrumType	3	The type of spread spectrum characteristics employed by a transmitter.
		Link11B_SpectrumType	4	

A.9 Array Datatype Table

General introduction: *The array datatype table describes indexed homogenous collections of datatypes; these constructs are also known as arrays or sequences.*

For detailed information on the table format, see Reference 6.

NOTE – Cells that are shaded in blue are defined in RPR FOM 2.0.

Table A-8: Array Datatype Table

Name	Element type	Cardinality	Encoding	Semantics
Link11BMessageStructArray	Link11BMessageStruct	Dynamic	HLAvariableArray	Array of Link 11B messages, encoded with the number of array elements (equals the number of 48-bit TDS words).
Link11CLEWMessageStructArray	Link11CLEWMessageStruct	Dynamic	HLAvariableArray	Array of Link 11 messages in CLEW format, encoded with the number of array elements (equals the number of 48-bit TDS words).
Link11SLEWMessageStructArray	Link11SLEWMessageStruct	Dynamic	HLAvariableArray	Array of Link 11 messages in SLEW format, encoded with the number of array elements (equals the number of 48-bit TDS words).
OctetArray2	Octet	2	HLAfixedArray	Generic array of two Octet elements.
OctetArray3	Octet	3	HLAfixedArray	Generic array of three Octet elements.
OctetArray6	Octet	6	HLAfixedArray	Array of 6 octets.

A.10 Fixed Record Datatype Table

General introduction: *The fixed record datatype table shall be used to describe heterogeneous collections of types; these constructs are also known as records or structures. Each entry in the fixed record datatype table may contain fields that are of other types, such as simple datatypes, fixed records, arrays, enumerations, or variant records. This enables building "structures of data structures".*

For detailed information on the table format, see Reference 6.

Table A-9: Fixed Record Datatype Table

Record name	Field			Encoding	Semantics
	Name	Type	Semantics		
Link11BMessageStruct	Data	OctetArray6	Data group 1 to 6 (excluding each group's first mark bit from the original transmission frame).	HLAfixedRecord	Link 11B message consisting of six data groups and a check group of 8 bits each (the start group and the mark bits are not included). Padded with 8 bits, resulting in a total structure size of 64 bits.
	Check	Octet	Check group (excluding the first mark bit from the original transmission frame).		
	Padding	Octet	Padding, set to 0.		
Link11BTransmitterStruct	ReportingUnit	ParticipatingUnitSourceNumber	Reporting Unit (RU) number.	HLAfixedRecord	Contains specific information about the Link 11B transmitter system.
	FidelityLevel	Link1111BFidelityLevelEnum8	Fidelity level of the Link 11B simulation.		
	LinkState	Link11BLinkStateEnum8	The state the Link 11B terminal is currently in.		
	ModeOfOperation	Link11BModeOfOperationEnum16	Link 11B terminal operation mode.		
Link11CLEWFrameStruct	TacticalData	OctetArray3	Tactical data.	HLAfixedRecord	Link 11 30-bit frame consisting of 24 bits of tactical information and 6 Hamming Error Detection And Correction (EDAC) bits. The EDAC field is padded to 8 bits.
	EDAC	Octet	In total 8 bits, with the following fields: Bits 0-5: Error Detection And Correction. Bits 6-7: Padding, set to 0.		

Record name	Field			Encoding	Semantics
	Name	Type	Semantics		
Link11CLEWMessageStruct	FrameA	Link11CLEWFrameStruct	First frame in the message.	HLAfixedRecord	Link 11 message in CLEW format, consisting of two 30-bit frames. Each frame is padded with 2 bits, resulting in a total structure size of 64 bits.
	FrameB	Link11CLEWFrameStruct	Second frame in the message.		
Link11SLEWMessageStruct	FirstBlock	OctetArray3	First frame in the message.	HLAfixedRecord	Link 11 message in SLEW format, consisting of two 24-bit TDS data blocks and 12 CRC error detection bits. The CRC field is padded with 4 bits, resulting in a total structure size of 64 bits.
	SecondBlock	OctetArray3	Second frame in the message.		
	CRC	OctetArray2	In total 16 bits, with the following fields: Bits 0-11: CRC error detection. Bits 12-15: Padding, set to 0.		
Link11TransmitterStruct	ParticipatingUnit	ParticipatingUnitSourceNumber	Participating Unit (PU) number.	HLAfixedRecord	Contains specific information about the Link 11 transmitter system.
	FidelityLevel	Link1111BFidelityLevelEnum8	Fidelity Level of the Link 11 simulation.		
	TerminalMode	Link11TerminalModeEnum8	Mode of the Link 11 terminal.		
	ModeOfOperation	Link11ModeOfOperationEnum16	Link 11 terminal operation mode.		
	NetCycleTime	TimeSecondUnsignedInteger16	The time in seconds required for the NCS to complete a polling sequence of all PUs. Not applicable to non-NCS PUs.		

Record name	Field			Encoding	Semantics
	Name	Type	Semantics		
NTPTimestampStruct	Seconds	UnsignedInteger32	Number of seconds since 0 h 1 January 1900 UTC.	HLAfixedRecord	64-bit timestamp format according to RFC 5905. All bits set to one in both fields indicate a no statement/wildcard.
	Fraction	UnsignedInteger32	Fraction of a second, in 1/(2^32) resolution (232 picoseconds).		

A.11 Variant Record Datatype Table

General introduction: *The variant record datatype table shall describe discriminated unions of types; these constructs are also known as variant or choice records.*

For detailed information on the table format, see Reference 6.

Table A-10: Variant Record Datatype Table

Record name	Discriminant			Alternative			Encoding	Semantics
	Name	Type	Enumerator	Name	Type	Semantics		
Link11MessageVariantStruct	SignalWaveform	Link11SignalWaveformEnum8	NoStatement-CLEWFormat, ConventionalLinkElevenWaveform_CLEW_	CLEWMessage	Link11CLEWMessageStructArray	Link 11 messages in CLEW format.	HLAvariantRecord	Variant record for the different message formats in Link 11 signals.
			SingleToneLinkElevenWaveform_SLEW_	SLEWMessage	Link11SLEWMessageStructArray	Link 11 messages in SLEW format.		

A.12 Notes Table

General introduction: *Any entry within any of the OMT tables may be annotated with additional descriptive information outside of the immediate table structure. The mechanism for attaching one or more notes to an OMT table entry is to include a notes pointer in the appropriate table cell. The notes themselves are associated with the note label and included in the notes table. A single note may be referenced numerous times in OMT tables*

For detailed information on the table format, see Reference 6.

Table A-11: Notes Table

ID	Text
Link11_11B_1	The RadioTransmitter class is a scaffolding class, i.e. it refers to a class (structure) in which the Link 11/11B FOM module is integrated. This class is to represent all capabilities as provided with the DIS Transmitter PDU, in accordance with IEEE Std 1278.1(tm)-2012, and contains an attribute using the Link11TransmitterStruct and Link11BTransmitterStruct.
Link11_11B_2	The Parent class is a scaffolding class, i.e. it refers to an interaction class (structure) in which the Link 11/11B FOM module is integrated. The TDLBinaryRadioSignal class (and its children classes) is to be integrated as a subclass of an interaction class providing the DIS Signal PDU capabilities, in accordance with IEEE Std 1278.1(tm)-2012.

A.13 Object Class Definition Table

General introduction: *The lexicon tables provides a means to define all object classes, interaction classes, object class attributes, and interaction parameters to achieve a common understanding of the semantics of the data. The object class definition table describes the object classes.*

For detailed information on the table format, see Reference 6.

There are no Link 11/11B unique object classes in the Link 11/11B FOM module.

A.14 Interaction Class Definition Table

General introduction: *The lexicon tables provides a means to define all object classes, interaction classes, object class attributes, and interaction parameters to achieve a common understanding of the semantics of the data. The interaction class definition table describes the interactions.*

For detailed information on the table format, see Reference 6.

Table A-12: Interaction Class Definition Table

Class	Definition
Link11BRadioSignal	Link 11B signal.
Link11BroadcastRadioSignal	Link 11 radio signal from a PU without having been explicitly interrogated, containing one or more PU data messages (when the MessageSubType is set to Data). Used in Broadcast Mode of Operation.
Link11NetSyncRadioSignal	Link 11 radio signal from a PU for the purpose of establishing a universal timing reference in all PUs. This signal does not contain data (i.e. the CLEWMessage or SLEWMessage array indicates 0 elements).
Link11NetTestRadioSignal	Link 11 radio signal from the DNCS, optionally containing a test pattern.

Class	Definition
Link11PicketReplyRadioSignal	Link 11 radio signal from a (non-NCS) PU in reply to a roll-call interrogation, containing one or more PU data messages (when the MessageSubType is set to Data).
Link11RadioSignal	Link 11 radio signal common base class.
Link11RollCallRadioSignal	Link 11 radio signal from the NCS to interrogate a specific PU (when the MessageSubType is set to Interrogation) or containing one or more NCS data messages (when the MessageSubType is set to Data).
Link11ShortBroadcastRadioSignal	Link 11 radio signal from a PU without having been explicitly interrogated, containing one or more PU data messages (when the MessageSubType is set to Data). Used in Short Broadcast / Silence Mode of Operation.
TDLBinaryRadioSignal	Parent class for all TDL radio signals.

A.15 Attribute Definition Table

General introduction: *The lexicon tables provides a means to define all object classes, interaction classes, object class attributes, and interaction parameters to achieve a common understanding of the semantics of the data. The attribute definition table describes the attributes that characterize object classes.*

For detailed information on the table format, see Reference 6.

There are no Link 11/11B unique object classes in the Link 11/11B FOM module.

A.16 Parameter Definition Table

General introduction: *The lexicon tables provides a means to define all object classes, interaction classes, object class attributes, and interaction parameters to achieve a common understanding of the semantics of the data. The parameter definition table describes the parameters that are associated with interaction classes.*

For detailed information on the table format, see Reference 6.

Table A-13: Parameter Definition Table

Class	Parameter	Definition
Link11BRadioSignal	MessageSubType	The Link 11B Message Sub Type.
	ReportingUnitNumber	The Reporting Unit Source Number of the Link 11B unit in any mode of operation.
	SequenceNumber	A counter that each simulated system increments for every Link11BRadioSignal generated. This parameter starts at 0 for each transmission cycle (cycling of the Transmit State).

Class	Parameter	Definition
	DataSignalingRate	The data signaling rate of the Link 11B transmission.
	ModulationStandard	The Link 11B modulation standard.
	EncryptionFlag	Identifies if the Link 11B data is encrypted.
	PerceivedTransmitTime	The simulation time at which the radio signal is transmitted. Optional for Fidelity Levels 0 and 1; default value: all bits set to one (no statement/wildcard).
	MessageData	Link 11B message data.
Link11RadioSignal	MessageSubType	The Link 11 Message Sub Type.
	ParticipatingUnitNumber	The Participating Unit Source Number of the Link 11 unit in any mode of operation. For Interrogation Messages, the PU Number is the identification of the unit being polled. For all other Sub-Types, the PU Number reflects the originating Participating Unit
	SequenceNumber	A counter that each simulated system increments for every Link11RadioSignal generated. This parameter starts at 0 for each transmission cycle (cycling of the Transmit State).
	DataSignalingRate	The data signaling rate of the Link 11 transmission.
	EncryptionFlag	Identifies if the Link 11 data is encrypted.
	PerceivedTransmitTime	The simulation time at which the radio signal is transmitted. Optional for Fidelity Levels 0 and 1; default value: all bits set to one (no statement/wildcard).
	MessageData	Link 11 message data.

Annex B DIS to HLA Translations (Informative)

B.1 RPR FOM RadioTransmitter Object versus DIS Transmitter PDU

See the RPR FOM GRIM [2], sections 7.10.1.1 and 9.6.1, for the cross references between the RPR FOM 2.0 RadioTransmitter object class attributes and the DIS Transmitter PDU fields.

B.2 RPR FOM RadioSignal Based Interactions versus DIS Signal PDU

The RPR FOM defines four interaction classes, one for each of the encoding classes, as subclasses of the common parent class RadioSignal. Since the encoding class for the Link 11/11B DIS Signal PDU messages are set to Raw Binary Data, RawBinaryRadioSignal interactions are used in HLA federations based on the RPR FOM.

B.2.1 Link 11

Compliance to the Link 11/11B FOM module requires the Link 11 messages to be sent using the Link11RadioSignal or one of its subclasses, as per the Link 11 Message Type Identifier. Table B-1 shows the interaction class to be generated for each of the allowed values of the Message Type Identifier field [UID 731]. See Table B-3 in the next section for the location of the Message Type Identifier field, bits 24-31 (octet #3) of the Signal PDU Data field. Note that the Link 11 Message Data is always included in the Link11RadioSignal parameter MessageData. In the Link 11/11B FOM module no parameters are defined for the subclasses.

Table B-1: Link 11 Message Type to HLA Interaction Class Mapping

Message Type Identifier		HLA Interaction Class
Description	Value	
No Statement	0	Link11RadioSignal
Net Test	1	Link11NetTestRadioSignal
Roll Call	2	Link11RollCallRadioSignal
Picket Reply	3	Link11PicketReplyRadioSignal
Short Broadcast	4	Link11ShortBroadcastRadioSignal
Broadcast	5	Link11BroadcastRadioSignal
Net Sync	6	Link11NetSyncRadioSignal

The following sections describe the translations of the DIS Signal PDU fields to the interaction class parameters. The first section covers the data irrespective of the Link 11 Signal Waveform. The subsequent sections describe the details for the message data in the CLEW and the SLEW format.

The same tables can be used for the reverse translation from an HLA interaction to a DIS Signal PDU. Translating from HLA to DIS does not require selection of the appropriate PDU as it will always be to the Signal PDU. For fields not mapped (shown as N/A in the tables), see the requirements from section 4.2.2 and the DIS standard for the values to be set.

B.2.1.1 Link 11 Common Data

Table B-2 shows the translations of the DIS Signal PDU fields to the corresponding RPR FOM and Link 11/11B FOM module interaction class parameters independent of the message data format used. Most of the mapping of the Signal PDU fields to the RawBinaryRadioSignal parameters is as per the RPR FOM standard. The Data field however is not published in the parameter SignalData. Instead, the content of the Data field is to be extracted and published in parameters of the Link 11/11B FOM module interaction

classes. The first 160 bits of the Data field, the Link 11 Simulation Network Header, is split into individual parameters of the Link11RadioSignal class. The subsequent Signal Waveform-specific content of the Data field is covered in the next sections.

Table B-2: Link 11 Common Signal PDU to HLA Interaction Mapping

Signal PDU fields					HLA interaction	
Size (bits)					**Class**	**Parameter**
96		PDU Header			*N/A*	
48		Radio Reference ID			RawBinaryRadioSignal	HostRadioIndex
16		Radio Number				
16		Encoding Scheme				Bits 0-13: TDLMessageCount
16		TDL Type				TacticalDataLinkType
32		Sample Rate				DataRate
16		Data Length			*N/A* [2]	
16		Samples			*N/A*	
160	8	Data	Link 11 Simulation Network Header	Message Sub Type	Link11RadioSignal	MessageSubType
	8			Participating Unit Number		ParticipatingUnitNumber
	8			Sequence Number		SequenceNumber
	8			Message Type Identifier	*See section B.2.1*	
	32			Padding	*N/A*	
	8			Data Signaling Rate	Link11RadioSignal	DataSignalingRate
	8			Padding	*N/A*	
	8			Signal Waveform	Link11RadioSignal	MessageData. SignalWaveform [3]
	8			Encryption Flag		EncryptionFlag
	64			Perceived Transmit Time		PerceivedTransmitTime
≥ 0			Link 11 Message Data		*See sections B.2.1.2 and B.2.1.3*	

Table B-3 provides another perspective of the fields of the Link 11 Simulation Network Header in the Signal PDU Data field. The Link 11 Simulation Network Header occupies the first 160 bits, 20 octets, of the Data field. The lines below the DIS Data display the mapping of these bits/octets to the Link11RadioSignal interaction parameters. Note that, in accordance with IEEE Std 1278.1™-2012 [4] section 6.1.2, the Data

[2] Data Length is NOT mapped to SignalDataLength as the RawBinaryRadioSignal parameter SignalData is not used; see section 4.3.7.1.
[3] See Table B-5 and Table B-7 for the location of the discriminant SignalWaveform within the variant record datatype used for the parameter MessageData.

octet ordering is not strictly from right to left, but follows the big endian scheme. Since also the Link 11/11B FOM module basic datatypes are defined as big endian, it would be possible for DIS to HLA gateways to perform a datatype agnostic memory or buffer copy. However, care must be taken to check the endianness of future DIS versions or modifications to the RPR FOM basic datatypes in Link 11/11B parent FOMs.

Table B-3: Link 11 Simulation Network Header Data

Bit #	7	6	5	4	3	2	1	0
	Message Sub Type							
Bit #	7	6	5	4	3	2	1	0
DIS	Data octet #0							
Bit #	7	6	5	4	3	2	1	0
HLA	MessageSubType							

Bit #	7	6	5	4	3	2	1	0
	Participating Unit Number							
Bit #	15	14	13	12	11	10	9	8
DIS	Data octet #1							
Bit #	7	6	5	4	3	2	1	0
HLA	ParticipatingUnitNumber							

Bit #	7	6	5	4	3	2	1	0
	Sequence Number							
Bit #	23	22	21	20	19	18	17	16
DIS	Data octet #2							
Bit #	7	6	5	4	3	2	1	0
HLA	SequenceNumber							

Bit #	7	6	5	4	3	2	1	0
	Message Type Identifier							
Bit #	31	30	29	28	27	26	25	24
DIS	Data octet #3							
Bit #								
HLA								

Bit #																																
	Padding																															
Bit #	39	38	37	36	35	34	33	32	47	46	45	44	43	42	41	40	55	54	53	52	51	50	49	48	63	62	61	60	59	58	57	56
DIS	Data octet #4								Data octet #5								Data octet #6								Data octet #7							
Bit #																																
HLA																																

Bit #	7	6	5	4	3	2	1	0
	Data Signaling Rate							
Bit #	71	70	69	68	67	66	65	64
DIS	Data octet #8							
Bit #	7	6	5	4	3	2	1	0
HLA	DataSignalingRate							

Bit #								
	Padding							
Bit #	79	78	77	76	75	74	73	72
DIS	Data octet #9							
Bit #								
HLA								

Bit #	7	6	5	4	3	2	1	0
	Signal Waveform							
Bit #	87	86	85	84	83	82	81	80
DIS	Data octet #10							
Bit #	7	6	5	4	3	2	1	0
HLA	MessageData. SignalWaveform							

Bit #	7	6	5	4	3	2	1	0
	Encryption Flag							
Bit #	95	94	93	92	91	90	89	88
DIS	Data octet #11							
Bit #	7	6	5	4	3	2	1	0
HLA	EncryptionFlag							

Bit #	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Perceived Transmit Time - Integer Part																															
Bit #	103	102	101	100	99	98	97	96	111	110	109	108	107	106	105	104	119	118	117	116	115	114	113	112	127	126	125	124	123	122	121	120
DIS	Data octet #12								Data octet #13								Data octet #14								Data octet #15							
Bit #	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
HLA	PerceivedTransmitTime.Seconds																															

Bit #	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
	Perceived Transmit Time - Fraction Part																															
Bit #	135	134	133	132	131	130	129	128	143	142	141	140	139	138	137	136	151	150	149	148	147	146	145	144	159	158	157	156	155	154	153	152
DIS	Data octet #16								Data octet #17								Data octet #18								Data octet #19							
Bit #	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
HLA	PerceivedTransmitTime.Fraction																															

B.2.1.2 Link 11 CLEW Message Format

Table B-4 shows the translation of the Link 11 Message Data of the DIS Signal PDU Data field to the Link11RadioSignal parameter MessageData when the Signal Waveform field is set to Conventional Link Eleven Waveform (CLEW) (1). As the enumerator description indicates, this message format is also used when the Signal Waveform field is set to No Statement - CLEW Format (0).

Note that Table B-4 provides a generic example of a series of Link 11 data messages. The M-series messages are specified in the Link 11/11B standards [7, 8]. The example shows that each frame consists of 24 bits of tactical data followed by 6 EDAC bits, each message consists of 2 frames (i.e., 48 bits of tactical data), and that each frame is padded to 32 bits.

Table B-4: Link 11 CLEW Message Format to Link11RadioSignal Mapping

Signal PDU fields						HLA interaction	
Size (bits)						Class	Parameter
160		Data	Link 11 Simulation Network Header			*See section B.2.1.1*	
64	24	Data	Link 11 Message Data	Frame A	Tactical Data	Link11RadioSignal	MessageData. CLEWMessage
	6				EDAC		
	2			Padding			
	24			Frame B	Tactical Data		
	6				EDAC		
	2			Padding			
64	30			Frame A	Data, EDAC		
	2			Padding			
	30			Frame B	Data, EDAC		
	2			Padding			
⋮				⋮			
64	30			Frame A			
	2			Padding			
	30			Frame B			
	2			Padding			

Table B-5 provides another perspective of the Link 11 Message Data in CLEW format in the Signal PDU Data field and Link11RadioSignal parameter MessageData. Table B-5 illustrates the mapping between the

content of the real Link 11 data, the DIS Signal PDU Data field, and the equivalent HLA interaction parameter fields. This example contains two generic M-series messages, with the two frames split into tactical data and the EDAC fields. As per the Link 11/11B standards, the tactical data bits are numbered consecutively from 0 to 48 with the first four bits containing the message number.

As the Link11RadioSignal parameter MessageData datatype is a variant record, it starts with the discriminant, named SignalWaveform. As indicated in Table B-3, this maps to the Data octet #10. As per the HLA standard HLAvariantRecord encoding [6], the discriminant is followed by padding to align the alternative to a 32-bit boundary. When the discriminant indicates No_Statement_CLEW_format (0) or Conventional_Link_Eleven_Waveform_CLEW_ (1), the alternative field is named CLEWMessage, which is an array of Link11CLEWMessageStruct elements. As this array is defined according to the HLA standard HLAvariableArray encoding [6], it starts with the number of elements in a (signed) 32-bit integer (in this example, the content would be 2). Following these HLA variant and array datatype encoding ‘prefixes’, the actual message data content on HLA is equal to the remainder of the DIS Signal PDU Data field.

As the Link 11 Message Data follows the Link 11 Simulation Network Header, the Signal PDU Data starts at bit #160 (octet #20). The lines below the DIS Data display the mapping of these bits/octets to the fields of the HLA datatype Link11CLEWFrameStruct. This datatype is used for both fields of the datatype Link11CLEWMessageStruct: FrameA and FrameB. The bottom row of the HLA section shows the index of the message in the CLEWMessage array of the MessageData interaction parameter.

Table B-5: Link 11 Message Data in CLEW Message Format

Bit #																															
Bit #																													87	86	85	84	83	82	81	80
DIS																													Data octet #10							
Bit #																													7	6	5	4	3	2	1	0
HLA	Padding																												SignalWaveform							
	MessageData																																			

Bit #																															
Bit #																															
DIS																															
Bit #	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
HLA	*number_of_elements*																															
	CLEWMessage																															
	MessageData																															

Bit #			5	4	3	2	1	0	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Padd'g		EDAC						M-series message fields																				Message Nr.			
	Frame A																															

Bit #	191	190	189	188	187	186	185	184	183	182	181	180	179	178	177	176	175	174	173	172	171	170	169	168	167	166	165	164	163	162	161	160
DIS	Data octet #23								Data octet #22								Data octet #21								Data octet #20							

Bit #	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
HLA	EDAC								TacticalData[2]								TacticalData[1]								TacticalData[0]							
	Padd'g																															
	FrameA																															
	MessageData.CLEWMessage[0]																															

Bit #			5	4	3	2	1	0	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24
	Padd'g		EDAC						M-series message fields (cont'd)																							
	Frame B																															

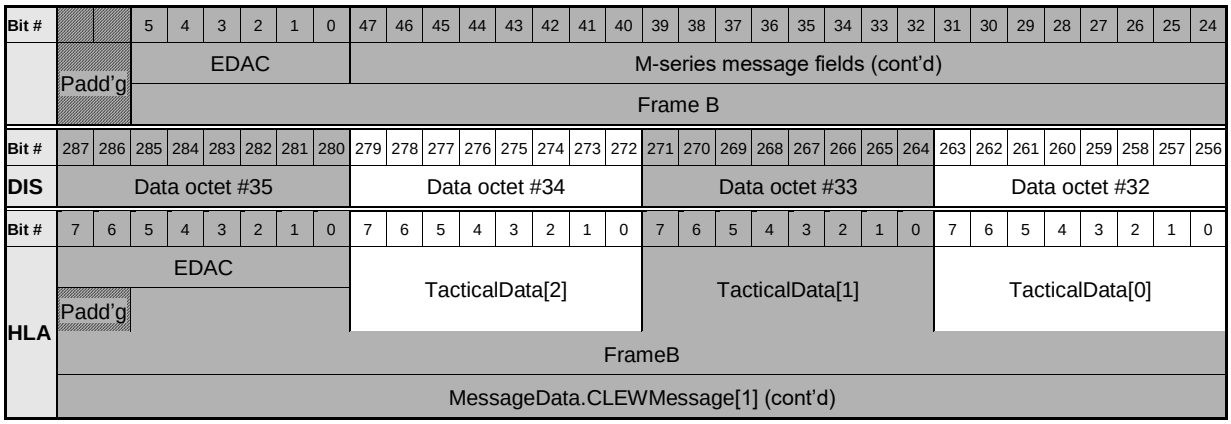
Bit #	223	222	221	220	219	218	217	216	215	214	213	212	211	210	209	208	207	206	205	204	203	202	201	200	199	198	197	196	195	194	193	192
DIS	Data octet #27								Data octet #26								Data octet #25								Data octet #24							

Bit #	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
HLA	EDAC								TacticalData[2]								TacticalData[1]								TacticalData[0]							
	Padd'g																															
	FrameB																															
	MessageData.CLEWMessage[0] (cont'd)																															

Bit #			5	4	3	2	1	0	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Padd'g		EDAC						M-series message fields																				Message Nr.			
	Frame A																															

Bit #	255	254	253	252	251	250	249	248	247	246	245	244	243	242	241	240	239	238	237	236	235	234	233	232	231	230	229	228	227	226	225	224
DIS	Data octet #31								Data octet #30								Data octet #29								Data octet #28							

Bit #	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
HLA	EDAC								TacticalData[2]								TacticalData[1]								TacticalData[0]							
	Padd'g																															
	FrameA																															
	MessageData.CLEWMessage[1]																															



B.2.1.3 Link 11 SLEW Message Format

Table B-6 shows the translation of the Link 11 Message Data of the DIS Signal PDU Data field to the Link11RadioSignal parameter MessageData when the Signal Waveform field is set to Single Tone Link Eleven Waveform (SLEW) (2).

Note that Table B-6 provides a generic example of a series of Link 11 data messages. The M-series messages are specified in the Link 11/11B standards [7, 8]. The example shows that two frames of each 24 bits of tactical data are followed by 12 CRC bits, and that each message is padded to 64 bits.

Table B-6: Link 11 SLEW Message Format to Link11RadioSignal Mapping

Signal PDU fields						HLA interaction	
Size (bits)						Class	Parameter
160		Data	Link 11 Simulation Network Header			*See section B.2.1.1*	
64	24		Link 11 Message Data	Frame A	Tactical Data	Link11RadioSignal	MessageData. SLEWMessage
	24			Frame B			
	12			CRC			
	4			Padding			
64	24			Frame A	Tactical Data		
	24			Frame B			
	12			CRC			
	4			Padding			
⋮				⋮			
64	24			Frame A			
	24			Frame B			
	12			CRC			
	4			Padding			

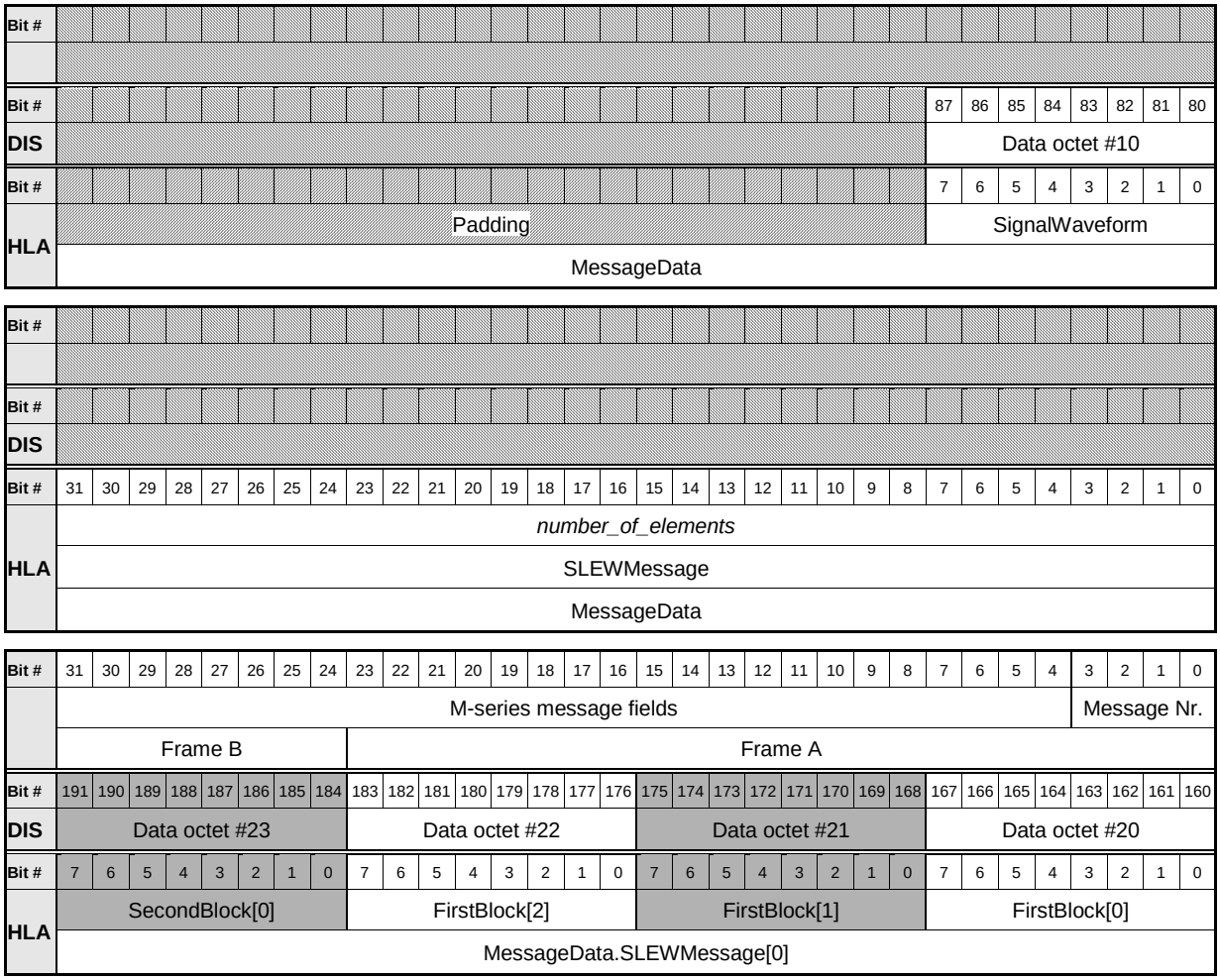
Table B-7 provides another perspective of the Link 11 Message Data in SLEW format in the Signal PDU Data field and Link11RadioSignal parameter MessageData. This example contains two generic M-series messages, with the two frames of tactical data and the CRC field. As per the Link 11/11B standards, the

tactical data bits are numbered consecutively from 0 to 48 with the first four bits containing the message number.

As the Link11RadioSignal parameter MessageData datatype is a variant record, it starts with the discriminant, named SignalWaveform. As indicated in Table B-3, this maps to the Data octet #10. As per the HLA standard HLAvariantRecord encoding [6], the discriminant is followed by padding to align the alternative to a 32-bit boundary. When the discriminant indicates Single_Tone_Link_Eleven_Waveform_SLEW_ (2), the alternative field is named SLEWMessage, which is an array of Link11SLEWMessageStruct elements. As this array is defined according to the HLA standard HLAvariableArray encoding [6], it starts with the number of elements in a (signed) 32-bit integer (in this example, the content would be 2). Following these HLA variant and array datatype encoding 'prefixes', the actual message data content on HLA is equal to the remainder of the DIS Signal PDU Data field.

As the Link 11 Message Data follows the Link 11 Simulation Network Header, the Signal PDU Data starts at bit #160 (octet #20). The lines below the DIS Data display the mapping of these bits/octets to the fields of the HLA datatype Link11SLEWMessageStruct. The bottom row of the HLA section shows the index of the message in the SLEWMessage array of the MessageData interaction parameter.

Table B-7: Link 11 Message Data in SLEW Message Format



Bit #					11	10	9	8	7	6	5	4	3	2	1	0	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
	Padding				CRC												M-series message fields (cont'd)																
																	Frame B (cont'd)															
Bit #	223	222	221	220	219	218	217	216	215	214	213	212	211	210	209	208	207	206	205	204	203	202	201	200	199	198	197	196	195	194	193	192
DIS	Data octet #27								Data octet #26								Data octet #25								Data octet #24							
Bit #	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
HLA	CRC[1]								CRC[0]								SecondBlock[2]								SecondBlock[1]							
	Padding																															
	MessageData.SLEWMessage[0] (cont'd)																															

Bit #	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	M-series message fields																												Message Nr.			
	Frame B								Frame A																							
Bit #	255	254	253	252	251	250	249	248	247	246	245	244	243	242	241	240	239	238	237	236	235	234	233	232	231	230	229	228	227	226	225	224
DIS	Data octet #31								Data octet #30								Data octet #29								Data octet #28							
Bit #	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
HLA	SecondBlock[0]								FirstBlock[2]								FirstBlock[1]								FirstBlock[0]							
	MessageData.SLEWMessage[1]																															

Bit #					11	10	9	8	7	6	5	4	3	2	1	0	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
	Padding				CRC												M-series message fields (cont'd)																
																	Frame B (cont'd)															
Bit #	287	286	285	284	283	282	281	280	279	278	277	276	275	274	273	272	271	270	269	268	267	266	265	264	263	262	261	260	259	258	257	256
DIS	Data octet #35								Data octet #34								Data octet #33								Data octet #32							
Bit #	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
HLA	CRC[1]								CRC[0]								SecondBlock[2]								SecondBlock[1]							
	Padding																															
	MessageData.SLEWMessage[1] (cont'd)																															

B.2.2 Link 11B

Compliance to the Link 11/11B FOM module requires the Link 11B messages to be sent using the Link11BRadioSignal. The following sections describe the translations of the DIS Signal PDU fields to the interaction class parameters. In alignment with the split between the header and the data in section B.2.1, the description is split into two subsections.

The same tables can be used for the reverse translation from an HLA interaction to a DIS Signal PDU. Translating from HLA to DIS does not require selection of the appropriate PDU as it will always be to the Signal PDU. For fields not mapped (shown as N/A in the tables), see the requirements from section 4.2.2 and the DIS standard for the values to be set.

B.2.2.1 Link 11B Common Data

Table B-8 shows the translations of the DIS Signal PDU fields to the corresponding RPR FOM and Link 11/11B FOM module interaction class parameters unrelated to the Link 11B M-series messages. Most of the mapping of the Signal PDU fields to the RawBinaryRadioSignal parameters is as per the RPR FOM standard. The Data field however is not published in the parameter SignalData. Instead, the content of the Data field is to be extracted and published in parameters of the Link 11/11B FOM module interaction classes.

The first 160 bits of the Data field, the Link 11B Simulation Network Header, is split into individual parameters of the Link11BRadioSignal class. The subsequent message data within the Data field is covered in the next section.

Table B-8: Link 11B Common Signal PDU to HLA Interaction Mapping

Signal PDU fields					HLA interaction	
Size (bits)					Class	Parameter
96				PDU Header	*N/A*	
48				Radio Reference ID	RawBinaryRadioSignal	HostRadioIndex
16				Radio Number		
16				Encoding Scheme		Bits 0-13: TDLMessageCount
16				TDL Type		TacticalDataLinkType
32				Sample Rate		DataRate
16				Data Length	*N/A* [4]	
16				Samples	*N/A*	
160	8	Data	Link 11B Simulation Network Header	Message Sub Type	Link11BRadioSignal	MessageSubType
	8			Reporting Unit Number		ReportingUnitNumber
	8			Sequence Number		SequenceNumber
	8			Padding	*N/A*	
	32			Padding	*N/A*	
	8			Data Signaling Rate	Link11BRadioSignal	DataSignalingRate
	8			Padding	*N/A*	
	8			Modulation Standard	Link11BRadioSignal	ModulationStandard
	8			Encryption Flag		EncryptionFlag
	64			Perceived Transmit Time		PerceivedTransmitTime
≥ 0			Link 11B Message Data		*See section B.2.2.2*	

Table B-9 provides another perspective of the fields of the Link 11B Simulation Network Header in the Signal PDU Data field. The Link 11B Simulation Network Header occupies the first 160 bits, 20 octets, of the Data field. The lines below the DIS Data display the mapping of these bits/octets to the Link11BRadioSignal interaction parameters. Note that, in accordance with IEEE Std 1278.1™-2012 [4] section 6.1.2, the Data octet ordering is not strictly from right to left, but follows the big endian scheme. Since also the Link 11/11B FOM module basic datatypes are defined as big endian, it would be possible for DIS to HLA gateways to perform a datatype agnostic memory or buffer copy. However, care must be

[4] Data Length is NOT mapped to SignalDataLength as the RawBinaryRadioSignal parameter SignalData is not used; see section 4.3.7.1.

taken to check the endianness of future DIS versions or modifications to the RPR FOM basic datatypes in Link 11/11B parent FOMs.

Table B-9: Link 11B Simulation Network Header Data

Bit #	7	6	5	4	3	2	1	0
	Message Sub Type							
Bit #	7	6	5	4	3	2	1	0
DIS	Data octet #0							
Bit #	7	6	5	4	3	2	1	0
HLA	MessageSubType							

Bit #	7	6	5	4	3	2	1	0
	Reporting Unit Number							
Bit #	15	14	13	12	11	10	9	8
DIS	Data octet #1							
Bit #	7	6	5	4	3	2	1	0
HLA	ReportingUnitNumber							

Bit #	7	6	5	4	3	2	1	0
	Sequence Number							
Bit #	23	22	21	20	19	18	17	16
DIS	Data octet #2							
Bit #	7	6	5	4	3	2	1	0
HLA	SequenceNumber							

Bit #								
	Padding							
Bit #	31	30	29	28	27	26	25	24
DIS	Data octet #3							
Bit #								
HLA								

Bit #																																
	Padding																															
Bit #	39	38	37	36	35	34	33	32	47	46	45	44	43	42	41	40	55	54	53	52	51	50	49	48	63	62	61	60	59	58	57	56
DIS	Data octet #4								Data octet #5								Data octet #6								Data octet #7							
Bit #																																
HLA																																

Bit #	7	6	5	4	3	2	1	0
	Data Signaling Rate							
Bit #	71	70	69	68	67	66	65	64
DIS	Data octet #8							
Bit #	7	6	5	4	3	2	1	0
HLA	DataSignalingRate							

Bit #								
	Padding							
Bit #	79	78	77	76	75	74	73	72
DIS	Data octet #9							
Bit #								
HLA								

Bit #	7	6	5	4	3	2	1	0
	Modulation Standard							
Bit #	87	86	85	84	83	82	81	80
DIS	Data octet #10							
Bit #	7	6	5	4	3	2	1	0
HLA	ModulationStandard							

Bit #	7	6	5	4	3	2	1	0
	Encryption Flag							
Bit #	95	94	93	92	91	90	89	88
DIS	Data octet #11							
Bit #	7	6	5	4	3	2	1	0
HLA	EncryptionFlag							

Bit #	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Perceived Transmit Time - Integer Part																															
Bit #	103	102	101	100	99	98	97	96	111	110	109	108	107	106	105	104	119	118	117	116	115	114	113	112	127	126	125	124	123	122	121	120
DIS	Data octet #12								Data octet #13								Data octet #14								Data octet #15							
Bit #	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
HLA	PerceivedTransmitTime.Seconds																															

Bit #	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
	Perceived Transmit Time - Fraction Part																															
Bit #	135	134	133	132	131	130	129	128	143	142	141	140	139	138	137	136	151	150	149	148	147	146	145	144	159	158	157	156	155	154	153	152
DIS	Data octet #16								Data octet #17								Data octet #18								Data octet #19							
Bit #	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
HLA	PerceivedTransmitTime.Fraction																															

B.2.2.2 Link 11B Message Format

Table B-10 shows the translation of the Link 11B Message Data of the DIS Signal PDU Data field to the Link11BRadioSignal parameter MessageData.

Note that Table B-10 provides a generic example of a series of Link 11 data messages. The M-series messages are specified in the Link 11/11B standards [7, 8]. The example shows that six data groups of eight information bits (i.e., excluding the 'mark' bit) compose 48 bits of tactical data, that is followed by an 8-bit check group (also excluding the 'mark' bit). The message is padded to 64 bits.

Table B-10: Link 11B Message Format to Link11BRadioSignal Mapping

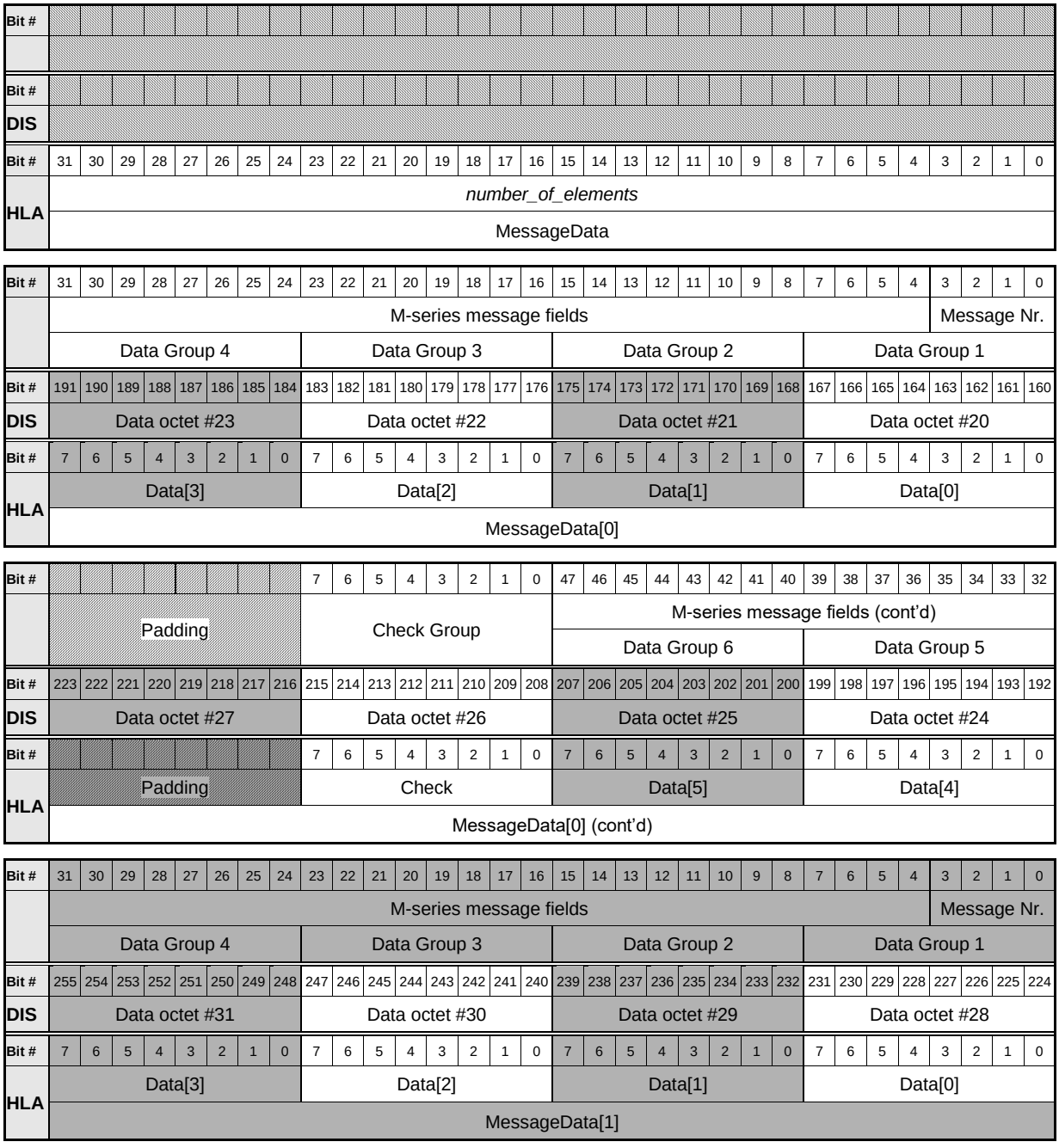
<table>
<tr><th colspan="6">Signal PDU fields</th><th colspan="2">HLA interaction</th></tr>
<tr><th colspan="2">Size (bits)</th><th colspan="4"></th><th>Class</th><th>Parameter</th></tr>
<tr><td colspan="2">160</td><td rowspan="20">Data</td><td colspan="3">Link 11B Simulation Network Header</td><td colspan="2">See section B.2.2.1</td></tr>
<tr><td rowspan="8">64</td><td>8</td><td rowspan="19">Link 11B Message Data</td><td>Data Group 1</td><td rowspan="6">Tactical Data</td><td rowspan="19">Link11BRadioSignal</td><td rowspan="19">MessageData</td></tr>
<tr><td>8</td><td>Data Group 2</td></tr>
<tr><td>8</td><td>Data Group 3</td></tr>
<tr><td>8</td><td>Data Group 4</td></tr>
<tr><td>8</td><td>Data Group 5</td></tr>
<tr><td>8</td><td>Data Group 6</td></tr>
<tr><td>8</td><td colspan="2">Check Group</td></tr>
<tr><td>8</td><td colspan="2">Padding</td></tr>
<tr><td rowspan="3">64</td><td>48</td><td>Data Groups 1-6</td><td>Tactical Data</td></tr>
<tr><td>8</td><td colspan="2">Check Group</td></tr>
<tr><td>8</td><td colspan="2">Padding</td></tr>
<tr><td colspan="2">⋮</td><td colspan="2">⋮</td></tr>
<tr><td rowspan="3">64</td><td>48</td><td colspan="2">Data Groups 1-6</td></tr>
<tr><td>8</td><td colspan="2">Check Group</td></tr>
<tr><td>8</td><td colspan="2">Padding</td></tr>
</table>

Table B-11 provides another perspective of the Link 11B Message Data in the Signal PDU Data field and Link11BRadioSignal parameter MessageData. This example contains two generic M-series messages, with the tactical data in six data groups and the check group field. As per the Link 11/11B standards, the tactical data bits are numbered consecutively from 0 to 48 with the first four bits containing the message number.

The Link11BRadioSignal parameter MessageData datatype is an array of Link11BMessageStruct elements. As this array is defined according to the HLA standard HLAvariableArray encoding [6], it starts with the number of elements in a (signed) 32-bit integer (in this example, the content would be 2). The actual message data content follows and is equal to the remainder of the DIS Signal PDU Data field.

As the Link 11B Message Data follows the Link 11B Simulation Network Header, the Signal PDU Data starts at bit #160 (octet #20). The lines below the DIS Data display the mapping of these bits/octets to the fields of the HLA datatype Link11BMessageStruct. The bottom row of the HLA section shows the index of the message in the MessageData interaction parameter.

Table B-11: Link 11B Message Data



Bit #									7	6	5	4	3	2	1	0	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
	Padding								Check Group								M-series message fields (cont'd)															
																	Data Group 6								Data Group 5							
Bit #	287	286	285	284	283	282	281	280	279	278	277	276	275	274	273	272	271	270	269	268	267	266	265	264	263	262	261	260	259	258	257	256
DIS	Data octet #35								Data octet #34								Data octet #33								Data octet #32							
Bit #									7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
HLA	Padding								Check								Data[5]								Data[4]							
	MessageData[1] (cont'd)																															