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Tactical Digital Information Link-Technical Advice and Lexicon for Enabling Simulation (TADIL-TALES) II: Link 11/11B

Topic: C2 Modeling and Simulation
C2 Analysis
C2 Architecture

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Abstract

Link 11/11B, or otherwise known as TADIL A and TADIL B, has been used by U.S Services and NATO nations for many years. However, the NATO Standard Agreement (STANAG) 5602 Standard Interface for Multiple Platform Link Evaluation (SIMPLE) does not fully describe the radio frequency network environment, which is required to model a more robust Link 11/11B operation. In addition, the IEEE 1278.1a standard does not provide a way to model the Link 11/11B RF network, only send the data as non standard, user defined Signal Protocol Data Unit (PDU). A SISO Link 11/11B Product Development Group (PDG) has been formed, and has started working on a DIS and HLA standard for Link 11/11B transport and network modeling. The Link 11/11B DIS and HLA standard will be developed using many of the Link 16 methods and procedures.

This paper presents a Link 11/11B model approach, including implementation of various Link 11/11B TDL message types (e.g. Roll Call, Net Sync, Short Broadcast). In addition, the first draft of the DIS Signal and Transmitter PDUs, and HLA Link 11/11B BOM will be presented.

1. Introduction

Over the past few years, a protocol for simulating Link 16 in IEEE 1278.1 – 1995, Distributed Interactive Simulation (DIS), and IEEE 1516, High Level Architecture (HLA) has been developed, and recently approved as a Simulation Interoperability Standards Organization (SISO) Standard; SISO-STD-002-2005. It has been recognized that there are requirements for simulating Link 11/11B in DIS and HLA. The DIS simulation protocol for Link 11/11B will develop DIS and HLA definitions, guidance, and standardization. Similarly, Link 11/11B will be described in terms of the established DIS Transmitter and Signal Protocol Data Units (PDUs). There is no change to the IEEE 1278.1 – 1995 standard fields for the Transmitter or Signal PDUs. Link 11/11B specific enumerations will be created to populate the standard fields. The implementation of Link 11/11B will take advantage of the fact that both these PDUs are variable length. In the case of the Transmitter PDUs, this protocol sets forth how the variable length "modulation parameter" fields will be populated. In the case of the Signal PDU, Link 11/11B specific information is relegated to the variable length data fields. Link 11/11B has some similarities to Link 16, but there are some differences, which will be described, along with Link 11/11B terms and definitions.

2. Link 11/11B Description

Link 11/11B encompasses two types of Tactical Digital Information Link (TADIL): Link 11, and Link 11 B, 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 11 B is a full-duplex, two-way, point-to-point link that provides for the serial transfer of data between units of the U.S. Army (USA), U.S. Air Force (USAF), U.S. Marine Corps (USMC), and the United States National Security Agency (NSA). Its participants are referred to as Reporting Units (RUs). Because it is point-to-point, each pair of RUs operates on a separate Link 11 B channel, often referred to as a "B-Link." Data is forwarded among the RU pairs by Forwarding RUs (FRUs). Link 11 B 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 J. TADIL B is not employed directly by Naval or Allied units. Because Link 11 and 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 B are referred to as Link 11/11B operations. These are fully described in MI- STD-6011B [1].

2.1 Link 11/11B Message Structure

The Link 11/11B message consists of 72 bits, consisting of eight groups of 9 bits each. The start and check groups use 18 bits while each of the six data groups uses 1 bit each to precede the 8 information bits. The messages contain 48 bits of tactical information. Each message

The Link 11/11B message structure is shown in Table 1.

Link 11/11B Field	Size, in Bits
Group 1	9
Group 2	9
Group 3	9
Spare	9 (Set to Zero)
Group 4	9
Group 5	9
Group 6	9
Spare	9 (Set to Zero)

Table 1. Link 11/11B Message Structure

The first 4 bits contain the message label, the next 12 bits contain the Track Number (TN), and the next 2 bit contain the identity, however, not all messages contain an identity field. The rest of the bits are defined by size and description fields specific to the message, for a total of 48 bits of tactical information.

There are several M series messages used in Link 11/11B. They are:

M.0 Test message
M.1 Data Reference Position message
M.81 Data Reference Position Amplify message
M.2 Air Track Position message
M.82 Air Position Amplify message
M.3 Surface Track Position message
M.83 Surface Position Amplify message
M.4A ASW Primary message
M.84A ASW Amplify message
M.4B ASW Secondary message
M.4C ASW Primary Acoustic message
M.84C ASW Primary Acoustic Amplify message
M.4D ASW Bearing message
M.84D ASW Bearing Amplify message
M.5 Special Points Position message
M.85 Special Points Amplify message
M.6A ECM Intercept Data message
M.6B Electronic Support Measures Primary message
M.86B Electronic Support Measures Amplify message
M.6C Electronic Support Measures Parametric message
M.86C Electronic Support Measures Parametric Amplify message
M.6D Electronic Warfare Coordination and Control message
M.86D Electronic Warfare Coordination and Control Amplify message
M.9A Management message (Information)
M.9B Management message (Pairing/Association)
M.9C Management message (Pointer)
M.9D Management message (TADIL A Monitor)
M.9E Management message (Supporting Information)
M.9F(0) (ACT=0) Area of Probability Basic message
M.89F(0)(ACT=0) Area of Probability Basic Amplify message
M.9F(1) (ACT=1) Area of Probability Secondary message
M.9G Data Link Reference Point Position message
M.10A Aircraft Control message
M.11B Aircraft Mission Status message
M.11C ASW Aircraft Status message
M.11D IFF/SIF message
M.11M EW/Intelligence message
M.811MEW/Intelligence Amplify message
M.12 National message
M.12.31 Timing message
M.13 Worldwide National message
M.14 Weapon/Engagement Status message
M.15 Command message

These messages correspond to most Link 16 messages.

2.2 Link 11/11B Terms and Definitions

Acknowledge: The act of notifying a unit transmitting a message that the message has been received as a valid message.

Active Status: An interface unit received over Link 11/11B may be considered active if its M.1 has been received within the last 60 seconds. On Link 11B, a directly tied unit is considered active upon proper initialization of a point-to-point link and an M.0 has been received within the last 60 seconds. On Link 11B, a unit that is not directly tied is considered active when an appropriate M.5 has been received.

Inactive Status: A unit received over Link 11 may be considered to be inactive after 60 seconds have gone by without the receipt of an M.1 or if a Drop Track message has been received for that unit. A unit received over Link 11B may be considered inactive if (1) it is a directly tied unit and no M.0 has been received for 60 seconds; (2) a Drop Track message is received for that unit; (3) the unit is being received over a data link for which the directly tied unit goes inactive.

Address: A number applied to a PU or RU to associate information and directives with interface units or tracks for both digital and voice communications.

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.

Data Link Reference Point (DLRP): The DLRP is a fixed geographic reference point, specified by appropriate authority, form which the PU on Link 11/11B can calculate the relative position of ownship and local tracks, and from which all tracks are reported on Link 11/11B.

Force Track Coordinator (FTC): A representative of the AAWC who is repsonsible for management of force tracking

Frame: A 30 bit word consisting of 24 data bits and 6 parity bits.

Lateral Tell: The process of sharing or telling information between the Link 11/11B RADIL System and the Joint Surveillance System.

Link 11/11B: See TADIL

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 NTDS unit operating in a Link 11/11B net in any mode of operation

Picket (PK): A switch setting on the Link 11/11B data terminal set allowing a PU to act as a reporting unit when interrogated by the NCS during roll call.

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.

Tactical Digital Information Link (TADIL) A: 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.

3. Link 11/11B Simulation Standard Using DIS or HLA

The first Link 11 Military Standard, Mil-Std 188-203, was published in 1982, and as such, is considered a legacy tactical data link. Because of this, there has been some discussion of how long Link 11/11B will be used, not only by U.S. Services, but NATO countries as well. The SISO Tactical Data Link (TDL) Study Group (SG) voted to standardize Link 11/11B, and use the same approach as Link 16. However, three options are currently being discussed. They are:

1. Develop a DIS and HLA standard modeling the network as well as message exchange, and developing interoperable levels of fidelity.
2. Develop a DIS and HLA standard with one level of fidelity, which models message exchange only. Design should be capable of adding additional levels of fidelity if required in the future.
3. Do not develop a DIS and HLA standard for Link 11/11B.

Most of the responses support option 2. The following sections define Link 11/11B general requirements; DIS Signal and Transmitter PDUs, and a HLA BOM for one level of fidelity. The design allows for additional fidelity levels if deemed necessary.

3.1 General Requirements

This section describes general requirements for simulation of Link 11/11B independent of the simulation protocol used. These general requirements support basic Link 11/11B operation, and additional requirements may be added from the results of Link 11/11B PDG meetings.

1. All Link 11/1B messages **shall** be bit encoded in accordance with the MIL-STD-6011 Ref [1] Tactical Data Link 11/11B specification. The specification describes the message structure as defined in section 2.1
2. All Transmission modulation parameters **shall** be filled with data described in section 3.2.
3. 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 members.
4. The types of transmissions that **shall** occur during Roll Call are NCS Call Up (Interrogation), Picket Reply, and the NCS report.
5. The Short Broadcast **shall** be a single data transmission to all members of the net by a station that may be acting as a Picket Unit or NCS.
6. The Broadcast net mode **shall** consist of a continuous series of Short Broadcast messages contained in one Signal PDU.
7. To simulate the two frames of dead time required, each Signal PDU **shall** contain the series of Short Broadcast messages, wait for a

period of two updates as defined in Ref [7], then **shall** transmit another Signal PDU containing a series of Short Broadcast messages. For HLA, the message transmission **shall** pause for a time that is defined as dead time.

8. Transmitter/Signal PDU pairs **shall** be sent for Roll Call and Short Broadcast messages. Transmitter PDUs **shall** be required for the first Broadcast Signal PDU. Subsequent Transmitter PDUs from the same PU are not required.
9. All systems should have some representation of periodic clock time.

3.2 Link 11/11B DIS Transmitter PDU Design Approach

The existing Transmitter PDU fields that are Link 11/11B specific are the Radio Entity Type, which **shall** be set to 22 (Proposed Enumeration) for Link 11/11B Radio. The Frequency **shall** be set to 4 MHz, and the Transmit Frequency Bandwidth **shall** be set to 28 MHz for Link 11 HF, 175MHz for Link 11 UHF. The Spread Spectrum field **shall** be set to zero, for no spread spectrum in use. The Modulation parameter fields **shall** be set to 1 for Major Modulation, 11 (proposed) for Dual Side Band, Suppressed Carrier, and 9 (proposed) for system. For the Link 11/11B Transmitter PDU, five modulation fields have been added to the Transmitter PDU. They are: Fidelity Level; Link 11/11B Terminal Mode, Link 11/11B Side Band Select, Data Terminal Set Indicator, and Modes of Operation.

1. **Link 11 Terminal Side Band Select.** The Link 11 Terminal Side Band Select shall indicate whether the terminal is using the lower side band, upper side band, or both, depending on if the Link 11/11B terminal is using High Frequency or Ultra High frequencies.
2. **Data Terminal Set Indicator:** The Data Terminal Set Indicator has seven enumerations that describe the seven Link 11/11B terminal indicators: Transmit, Receive, Net Busy, Transmit Data Error, Receive Data Error, Code Error, and Synchronization Complete.
3. **Modes of Operation:** The modes of operation are Net Sync, Net Test, Roll Call, Short Broadcast, and Broadcast.
4. **Padding:** 24 bits of padding are added so that the modulation parameter fields end on a 64 bit boundary and are a multiple of 8, as required by Ref [7].

The enumerations for some of the fields have not yet been submitted to the DIS EBV Documentation Editor. These fields may change, be deleted, or other fields may be added, depending on subsequent Link 11/11B PDG Discussions. Once these fields have been defined, proposed DIS EBV enumerations will be submitted as required. The first draft of the Link 11/11B Transmitter PDU template is shown in Appendix A.

3.3 Link 11/11B DIS Signal PDU Design Approach

The Signal PDU fields for Link 11/11B are defined with one level of fidelity; with additional padding fields add if additional levels of fidelity are required. For Fidelity Level one, the fields added are the Picket Number, Message Type Identifier, and Net Cycle Time.

1. **Picket Number:** The Picket Number field is a 16 bit enumerated field, and shall identify the Participating Unit Number of any Link 11/11B unit in any mode of operation
2. **Padding:** 40 bits of padding have been added to ensure the Signal PDU Data fields are on a 32 bit boundary. This field can be used if additional levels of fidelity are added.
3. **Message Type Identifier:** The Message Type Identifier field is an 8-bit enumeration and identifies whether message is Net Test, Roll Call, Picket Reply, Short Broadcast, or Broadcast.
4. **Net Cycle Time:** Net cycle time contains the time required for the NCS to complete a polling sequence of all PUs, and shall consist of two 32-bit fields. The first 32-bit field shall be an integer field, and shall be represented in seconds relative to 0h on 1 January 1900 UTC. The second 32-bit field contains fraction part of the time. For Fidelity Level 1, all Fs (4294967295) shall be entered into this field, indicating a wildcard (No Statement).
5. **Message Data:** The Link 11/11B messages are added to the end of the Signal PDU, and shall be read in as 32 bit unsigned integer arrays.

The first draft of the Link 11/11B Signal PDU template is shown in Appendix A.

3.4 Link 11/11B BOM

The Link 11/11B BOM design approach should describe how to implement a simulation of the Link 11/11B Tactical Data Link (TDL) and its associated message set, Link 11/11B, within a High Level Architecture (HLA) simulation. The Link 11/11B

BOM should be designed for integration within the Federation Object Model (FOM) of the HLA federation.

3.4.1 Assumptions

The Link 11/11B BOM assumes that:

1. The parent FOM contains all current DIS Transmitter PDU PDU records (not those associated with the PDU header) in accordance with Ref 1as part of its object class hierarchy.
2. The parent FOM contains all current DIS Signal PDU PDU records (not those associated with the PDU header) in accordance with Ref 1as part of its interaction class hierarchy.

3.4.2 Naming Convention

Conventions within the Link 11/11B BOM in OMT 1.3 format follow those adopted by the RPR FOM versions 1.0 and 2.0. These conventions are intended to address some of the OMT 1.3 format shortcomings, which have been addressed in the IEEE 1516.2 specification. These include:

1. All names have the initial letter of each word capitalized.
2. All enumeration names end in the text "Enum" followed by a number. The number indicates the number of bits in the enumerated value.
3. All complex data type names end in the text "Struct".

3.4.3 Levels of Fidelity

The Link 11/11B BOM initial design should be for one level of fidelity, with the ability to add levels if required.

3.4.4 Protocol Implementation Procedures

The first draft of protocol implementation features was designed in parallel with the existing Link 16 BOM. They should be equivalent to the corresponding details for Link 11/11B DIS implementation.

3.4.4.1 Object Class Data Approach

The Link 11/11B BOM first draft, shown in Appendix C, defines no new object classes. Instead the BOM defines a single complex data type (Link11TransmitterStruct) that corresponds to the modulation parameters in the DIS Transmitter PDU defined in section 3.2. An attribute of this complex data type should be added to the object class in the parent FOM corresponding to the DIS Transmitter PDU, corresponding to assumption 1 in section 3.3.1.

Modulation parameters of the Transmitter PDU, described in section 3.1 and shown in Appendix A, should map to the fields of the Link11TransmitterStruct complex data type attribute.

Parent object class fields should also be modified such that they refer to the corresponding Transmitter PDU fields (see Assumption 1 in section 3.3.1).

NOTE: For a RPR FOM implementation, it is suggested that an attribute of the Link11TransmitterStruct complex data type should be added to the RadioTransmitter object class.

3.4.4.2 Interaction Class Data

The Link 11/11B BOM, first draft, is added to the family of interactions that support TDL implementation of other datalinks. The Link 11/11B interactions are added to the family of interactions that, in which, a hierarchy of the BOM's base class. The interaction is a generic class - the TDLBinaryRadioSignal interaction. This class is an empty class, contains no parameters, and is neither publishable nor subscribable. The specific parameters are properties of the various subclasses of this generic base class, and it is these subclasses that are published and subscribed to.

The Link11RadioSignal interaction, shown in Appendix B, which is a subclass of the TDLBinaryRadioSignal interaction, contains the Link 11/11B Network Header Parameters as defined in section 3.2. The Link11MessageRadioSignal interaction should be designed to contain the Link 11/11B message data. Additional interactions shown in Appendix B define the other types of Link 11/11B messages.

The Link 11/11B BOM design is such that the TDLBinaryRadioSignal interaction becomes a subclass of the parent FOM's equivalent of the DIS Signal PDU (see Assumption 2 in section 3.4.1).

3.4.4.3 Adding the Link 11/11B BOM to the RPR FOM

Adding the Link 11/11B BOM to the RPR FOM consists of three steps: adding the Link 11/11B Radio Signal interaction, adding a Link11TransmitterData structure, and adding the contents of the tables listed in Appendix B. Adding the interaction is the same for both RPR FOM versions 1.0 and 2.0. The

manner of adding the Link11TransmitterData structure should be different between the two RPR FOM versions.

The TDLBinaryRadioSignal class shall be added as a subclass of the RawBinaryRadioSignal interaction class; this is done in order to allow access to the HostRadioIndex parameter in the RawBinaryRadioSignal interaction class. The HostRadioIndex parameter ties the Link 11/11B message to a specific Host and Radio Transmitter.

The `Link11ABRadioSignal` interaction class is added as a subclass of a new interaction class, the `TDLBinaryRadioSignal` interaction, which itself is a subclass of the RPR FOM's `RawBinaryRadioSignal` interaction class, as shown in Appendix B.

The addition of the TDLBinaryRadioSignal interaction class and its associated subclasses, shown in Appendix B were necessary because of the RPR FOM implementation limitations of the DIS Signal PDU. Section 3.2 defines the DIS Signal PDU used for all Link 11/11B messages in a Raw Binary Signal PDU. The RPR FOM equivalent of this PDU type (the RawBinaryRadioSignal interaction class) contains a parameter, called SignalData, containing one or more octets containing the signal data. If the SignalData octet based storage scheme to store Link 11/11B messages was used, then the Link 11/11B message would be lost during byte swapping. The implementation is defined such that the Link 11/11B interaction becomes a subclass of the RawBinaryRadioSignal interaction to ensure the SignalData storage is not used. Data integrity is achieved by moving the Link 11/11B message storage into the lowest level classes (i.e the JTIDSMessageRadioSignal).

Also, DIS to HLA gateways will require modification, but the modifications are well defined. DIS Raw Binary Signal PDUs need to be split into a RawBinaryRadioSignal interaction or the appropriate Link 11/11B interaction class, depending on the TDL type. Conversely, a HLA to DIS gateway must merge both interaction types into a single DIS Signal PDU.

3.4.4.4 Adding the Link 11/11B BOM to the RPR FOM versions 1 and 2

Adding the Link 11/11B BOM to RPR FOM versions 1 and 2 should parallel the Link 16 additions, such that they are consistent and interoperable with each set of BOMs. Appendix B shows all required tables, with some that still require design and enumeration assignments. Subsequent Link 11/11B PDGs shall design and complete these tables.

3.4.5 Existing Link 11/11B BOM

The Naval Aviation Simulation Master Plan (NASMP) Technical working group has created a Link 11/11B Guidance, Rational, and Interoperability Manual (GRIM) [2], written by Mr. Jamie Burns, P-3C TORT Federate Developer. The NASMP Link 11 GRIM provides guidance on how the BOM supports roll call, broadcast, short broadcast, and radio silence modes of the Link-11 tactical data link.

4. Current Status

The first Link 11/11B PDG was conducted at the Fall 2005 SISO SIW. Most discussions were on design approach, levels of fidelity, and officer elections. The elected officers are:

PDG Chair: Joe Sorroche
PDG Vice Chair: Joe Zehnle
PDG Secretary: Dr. Rob Byers

Link 11/11B PDG activities were suspended after the Fall 2005 SIW due to Mr. Sorroche's and Dr. Byers' involvement in completing the Link 16 standard. Once the Link 16 Standard has been formally approved, the Link 11/11B PDG will proceed.

5. Acknowledgements

We thank the DMOC for sponsoring this paper, DMOC's Chief Engineer Mr. Tom Brown, and DMOC's Commander Lt. Col. Gordon "Gordo" Phillips.

6. References

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5. SISO Enumeration and Bit Encoded Values for use with Protocols for Distributed Interactive Simulation, 25 March 2005.

6. SISO Standard for Link 16 Simulation: SISO-STD-002-2005, Draft; 22 December 2005.

7. IEEE 1278.1 – 1995, Distributed Interactive Simulation (DIS)

7. Biography

Mr. SORROCHE is a Senior Systems Engineer with Arctic Slope Regional Corporation Communications (ASRCC), and has 17 years professional experience; 10 years experience in the Modeling and Simulation field. He currently works at the DMOC and has been the Engineering lead for the DMOC for JEFX 06, JEFX 04, Millennium Challenge 02, JEFX 2000, JEFX 99, EFX 98, and many Blue Flag and Virtual Flag exercises. He is the Vice Chair for the Simulation Interoperability Standards Organization (SISO) Tactical Data Links Study Group, the Link 16 Product Development Group Chair, and the SISO Liaison for the NATO Tactical Data Link Interoperability Testing Syndicate. Mr. Sorroche is a co-recipient of the Fall 2002 SIWZIE Award for paper 02F-SIW-119 titled "TADIL TALES." He has Bachelors and Masters of Science Degrees in Electrical Engineering from New Mexico State University. He is a member of Tau Beta Pi and Eta Kappa Nu Honor Societies.

Dr. Byers is a senior engineer with Northrop Grumman Information Technology in Orlando, FL. In As part of the CAF DMO Operations and Integration (O&I) standards development, he is the lead for the CAF DMO Common Models Standard, Tailored DIS Standard and the Reference FOM Standard. He has a Bachelor of Science degree from the United States Miltary Academy, and a Masters Degree and Doctoral Degree in Aerospace Engineering from Texas A&M University.

Neil Barrett is a Senior Computer Scientist at the JITC, and is the Lead Analyst for JTAMD interoperability test events. He has 23 years of engineering and software development experience 15 of which involve the testing of C4I systems

Appendix A: Transmitter PDU for Link 11/11B

Field Size (bits)	Transmitter PDU Fields			Description*
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	
		Padding	16 bits unused	
48	Entity ID	Site	16 bit unsigned integer	
		Application	16 bit unsigned integer	
		Entity	16 bit unsigned integer	
16	Radio ID		16 bit unsigned integer	**Shall** contain the ID of the radio transmitting the signal.
64	Radio Entity Type	Entity Kind	8 bit enumeration	
		Domain	8 bit enumeration	
		Country	16 bit enumeration	
		Category	8 bit enumeration	22 – Proposed for Link 11/11B
		Nomenclature Version	8 bit enumeration	
		Nomenclature	16 bit enumeration	
8	Transmit State		8 bit enumeration	
8	Input Source		8 bit enumeration	8 - Digital Data Device
16	Padding		16 bits unused	
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		16 bit unsigned integer	
64	Frequency		64 bit unsigned integer	4000000
32	Transmit Frequency Bandwidth		32 bit floating point	28000000 for HF, 175000000 for UHF

Appendix A: Transmitter PDU for Link 11/11B

Field Size (bits)	Transmitter PDU Fields			Description*
32	Power		32 bit floating point	Power in dBm
64	Modulation Type	Spread Spectrum	16 bit Boolean array	All bits set to 0 (No modulation in use)
		Major	16 bit enumeration	1 - Amplitude
		Detail	16 bit enumeration	11 – Proposed for Dual Side Band, Suppressed Carrier
		System	16 bit enumeration	9 – Proposed for Link 11/11B
16	Crypto System		16 bit enumeration	0 - Other
16	Crypto Key ID		16 bit unsigned integer	0 - Other
8	Length of Modulation Parameters		8 bit unsigned integer	8= 8 octets
24	Padding		24 bits unused	
8	Modulation Parameter #1	Fidelity Mode	8 bit enumeration	Integer enumeration 0-4. For Link 11/11B, Set to 1.
8	Modulation Parameter #2	Link 11/11B Terminal Mode	8 bit enumeration	Integer Enumeration: 1 - NCS 2 - Participant Unit
8	Modulation Parameter #3	Link 11/11B Terminal Side Band Select	8 bit enumeration	Integer Enumeration: 1 – Lower Side Band 2 – Upper Side Band 3 – Independent Side Band Suppressed Carrier
8	Modulation Parameter #4	Data Terminal Set Indicator	8 bit enumeration	Integer Enumeration: 1- Transmit 2 - Receive 3 - Net Busy 4 - Transmit Data Error 5 - Receive Data Error 6 - Code Error 7 - Synchronization Complete
8	Modulation Parameter #5	Modes of Operation	8 bit enumeration	Integer Enumeration 0 – Net Sync 1 – Net Test 2 – Roll Call 3 – Short Broadcast 4 - Broadcast
24	Padding		24 bits unused	Required for length of modulation parameters to end on 64 bit boundary IAW Ref 7

Appendix A: SIGNAL PDU for Link 11/11B

Field Size (bits)	Signal PDU Fields			Valid Range	Description
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		
		Padding	16 bits unused		
48	Entity ID	Site	16 bit unsigned integer		
		Application	16 bit unsigned integer		
		Entity	16 bit unsigned integer		
16	Radio ID		16 bit unsigned integer		**Shall** contain the ID of the radio transmitting the signal.
16	Encoding Scheme		16 bit enumeration		Bits 0-13 **shall** contain the number of Link 11/11B words. Bits 14-15 **shall** contain the value 1 to indicate an encoding class raw binary data
16	TDL Type		16 bit enumeration		This field **shall** be set to 4 for Link 11 B, and 8 for Link 11.
32	Sample Rate		32 bit integer		This field **shall** be set to 0
16	Data Length		16 bit integer		This field **shall** contain the length of data in bits beginning after the samples field.
16	Samples		16 bit integer		This field **shall** be set to 0
		Picket Number	16 bit unsigned integer	0-511	Participating Unit Number of any Link 11/11B unit in any mode of operation.

Appendix A: SIGNAL PDU for Link 11/11B

Field Size (bits)	Signal PDU Fields				Valid Range	Description
128	**Link 11/11B Signal PDU Fields**	Padding		40 bits unused		Can be used for additional Link 11/11B fields if required. If not, set to zero
		Message Type Identifier		8 bit enumeration		Determines whether message is Net Test, Roll Call, Picket Reply, Short Broadcast, or Broadcast
		Net Cycle Time	Integer Part	32 bit unsigned integer	0-4294967295, 4294967295	Net cycle time contains the time required for the NCS to complete a polling sequence of all PUs. The integer part is in the first 32 bits and the fraction part in the last 32 bits. The precision of this representation is about 200 picoseconds, which should be adequate for Link 11/11B requirements. For Fidelity Level 1, all Fs (4294967295) shall be entered into this field, indicating a wildcard (No Statement).
			Fraction Part	32 bit unsigned integer	0-4294967295, 4294967295	
	Message Data			Array of 32 bit unsigned integers		Each Link 11/11B message is 72 bits in length. Messages shall be read in as 32 bit arrays.
	Padding			Signal PDU C2 Padding to doubleword boundary IAW Ref. 7		Padding (if needed) to increase total PDU size to a multiple of 32 bits.

APPENDIX B: Link 11/11B BOM INTERACTIONS

Link 11/11B BOM Interactions in the RPR-FOM (First Draft)

Interaction 1	**Interaction2**	**Interaction3**	**Interaction4**	**Interaction5**
RadioSignal	ApplicationSpecifcRadioSignal			
	DatabaseIndexRadioSignal			
	EncodedAudioRadioSignal			
	RawBinaryRadioSignal	TDLBinaryRadioSignal	Link11_11B RadioSignal	Net Test
				Roll Call
				Picket Unit Response
				Short Broadcast
				Broadcast

Link 11/11B BOM Complex Datatypes in RPR-FOM 1.0 (TBD)

Complex Datatype	Field Name	Datatype	Cardinality
ModulationStruct	SINCGARModulation[TBD]	SINCGARSModulationStruct	0-1
	Link11_11BTransmitterDataTBD]	Link11_11BTransmitterStruct	0-1

Link 11/11B BOM Enumerated Values in RPR-FOM 1.0 (TBD)

Identifier	Enumerator	Representation
RFModulationSystemTypeEnum16	Other	0
	GENERIC	1
	HQ	2
	HQII	3
	HQIIA	4
	SINCGARS	5
	CCTT_SINCGARS	6
	JTIDS_MIDS	8
	Link11_11B	9 (Proposed)

Link 11/11B BOM Complex Datatypes in RPR-FOM 2.0 (TBD)

Complex Datatype	Field Name	Datatype	Cardinality
SpreadSpectrumStruct	SpreadSpectrumType	SpreadSpectrumEnum16	1
	Padding	Octet	2

	SINCGARModulation[52]	SINCGARSModulationStruct	0-1 (SpreadSpectrumType = SINCGARSFrequencyHop)
	Link11TransmitterData[56]	Link11TransmitterStruct	0-1 (SpreadSpectrumType = Link11_11B_SpectrumType)

Link 11/11B BOM Enumerated Values in RPR-FOM 2.0 (Proposed)

Identifier	Enumerator	Representation
RFModulationSystemTypeEnum16	Other	0
	Generic	1
	HQ	2
	HQII	3
	HQIIA	4
	SINCGARS	5
	CCTT_SINCGARS	6
	JTIDS_MIDS	8
	Link11AB	9
SpreadSpectrumEnum16	None	0
	SINCGARSFrequencyHop	1
	JTIDS_MIDS_SpectrumType	2
	Link11_11B	3

Appendix C: Link 11/11B BOM, First Draft

Link 11/11B Base Object Model Identification Table

Category	Information		
Name	Link 11/11B BOM		
Version	V0.2		
Date	2/2/2006		
Purpose	Link 11/11B Base Object Model (BOM)		
Application Domain	C4ISR & C2 platform simulations		
Sponsor	SISO		
POC (Title, First, Last)	Mr	Joe	Sorroche
POC Organization	ASRC Communications		
POC Telephone	+1 505-853-0372		
POC Email	joe.sorroche@kirtland.af.mil		

Object Class Table: There are no Link 11/11B unique object classes in the Link 11/11B BOM

Object Interaction Table

Interaction1	Interaction2	Interaction3	Interaction4
Parent (N)	TDLBinaryRadioSignal (N)	Link11_11BRadioSignal (R)	NetTest (IR)
			Roll Call (IR)
			Picket Unit Response (IR)
			Short Broadcast (IR)
			Broadcast (IR)

Link 11/11B BOM Attribute Table (First Draft)

Object	Attribute	Datatype	Cardinality	Units	Resolution	Accuracy	Accuracy Condition
Parent	Link11_11BTransmitterData	Link11_11BTransmitterStruct	1	N/A	N/A	N/A	N/A

Link 11/11B BOM Parameter Table (First Draft)

Interaction	Parameter	Datatype	Cardinality	Units	Resolution	Accuracy	Accuracy Condition	Routing Space
NetTest	Link11_11BHeader	Link11_11BHeaderStruct	1	N/A	N/A	N/A	N/A	N/A
	Link11_11BMessage	Link11_11BWordStruct	1	N/A	N/A	N/A	N/A	
RollCall	Link11_11BHeader	Link11_11BHeaderStruct	1	N/A	N/A	N/A	N/A	N/A
	Link11_11BMessage	Link11_11BWordStruct	1	N/A	N/A	N/A	N/A	
PicketResponse	Link11_11BHeader	Link11_11BHeaderStruct	1	N/A	N/A	N/A	N/A	N/A
	Data	octet	29+	N/A	N/A	perfect	always	
ShortBroadcast	Link11_11BHeader	Link11_11BHeaderStruct	1	N/A	N/A	N/A	N/A	N/A
	Data	octet	29+	N/A	N/A	perfect	always	
Broadcast	Link11_11BHeader	Link11_11BHeaderStruct	1	N/A	N/A	N/A	N/A	N/A
	Data	octet	29+	N/A	N/A	perfect	always	
Link11_11BRadioSignal	PicketNumber	unsigned short	1	N/A	N/A	perfect	always	N/A
	MessageTypeIdentifier	octet	1	N/A	N/A	perfect	always	
	NetCycleTime	long long	1	N/A	N/A	perfect	always	

Link 11/11B BOM Enumerated Datatypes Table (Proposed)

Identifier	Enumerator	Representation
TerminalMode	NCS	1
	ParticipantingUnit	2
TerminalSideBandSelect	LowerSide	0
	UpperSide	1
	IndependentSideBandSC	2
DataTerminalSetIndicator	Transmit	0
	Receive	1
	NetBusy	2
	TransmitError	3
	ReceiveError	4
	CodeError	5
	SynchronizationComplete	6

Link 11/11B BOM Complex Datatypes table (Proposed)

Complex Datatype	Field Name	Datatype	Cardinality	Units	Resolution	Accuracy	Accuracy Condition
Link11_11BHeaderStruct	Data	octet	6	N/A	N/A	perfect	always
Link11_11BTransmitterStruct	FidelityMode	FidelityEnum8	1	N/A	N/A	N/A	N/A
	Link11TerminalMode	Link11_11BTerminalModeEnum8	1	N/A	N/A	N/A	N/A
	Link 11_11BTerminal Side Band Select	Link11_11BTerminalSBSelectEnum8	1	N/A	N/A	N/A	N/A
	DataTerminalSetIndicator	DataTerminalSetIndicatorEnum8	1	N/A	N/A	N/A	N/A
	ModesofOperation	ModesofOperationEnum8	1	N/A	N/A	perfect	always