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29 September 2005
SUPERSEDING
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DEPARTMENT OF DEFENSE
INTERFACE STANDARD

DIGITAL MESSAGE TRANSFER DEVICE SUBSYSTEMS

AMSC N/A   AREA TCSS

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited

FOREWORD

This military standard (MIL-STD) is approved for use by all Departments and Agencies of the Department of Defense (DoD). It applies to all inter- and intra-Department of Defense (DoD) Digital Message Transfer Devices (DMTDs) and Command, Control, Communications, Computers and Intelligence (C^4I) systems that exchange information with DMTDs.

This standard contains technical parameters for the data communications protocols that support DMTD interoperability. It provides mandatory system standards for planning, engineering, procuring, and using DMTDs in tactical digital communications systems. This standard specifies the lower layer (Physical through Intranet) protocol for interoperability of C^4I systems over combat net radio (CNR) on the battlefield. This standard provides the information required to pass digital data via CNR on the battlefield.

The Preparing Activity (PA) for this standard is USA C-E LCMC, ATTN: AMSEL-SE-CD (Mr. S. Turczyn), Fort Monmouth, NJ 07703. The custodians for the document are identified in the Defense Standardization Program, "Standardization Directory (SD1)" under Standardization Area Telecommunications Systems Standards (TCSS).

Beneficial comments (recommendations, additions, deletions) and any pertinent data that may be of use in improving this MIL-STD should be addressed to the PA at the above address by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

Comments, suggestions, or questions on this document should be addressed to CDR, USA C-E LCMC, ATTN: AMSEL-SE-CD (Mr. Stephen Turczyn), Building 1209, Fort Monmouth, NJ 07703 or emailed to stephen.turczyn@us.army.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at http://assist.daps.dla.mil.

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1 SCOPE

1.1 Purpose.

This document promulgates the minimum essential technical parameters in the form of mandatory system standards and optional design objectives for interoperability and compatibility among DMTDs, and between DMTDs and applicable C^4I systems. These technical parameters are based on the data communications protocol standards specified herein to ensure interoperability.

1.2 Scope.

This document identifies the procedures, protocols, and parameters to be applied in specifications for DMTDs and C^4I systems that exchange information with DMTDs. This document addresses the communications protocols and procedures for the exchange of information among DMTDs, among C^4I systems, and between DMTDs and C^4I systems participating in inter- and intra-Service tactical networks.

1.3 Application guidance.

This document applies to the design and development of new equipment and systems, and to the retrofit of existing equipment and systems.

1.4 Version interoperability.

MIL-STD-188-220D is not fully interoperable with MIL-STD-188-220C, as they can not be used on the same network simultaneously in all cases. This is due to MIL-STD-188-220D supporting IPv6, Intranet Fragmentation, Six Octets Link Layer Addressing, the MIL-STD-188-220 Version subfield replacing the Topology Update ID in the Transmission Information field subfield, as well as some other implementation details. Systems requiring interoperability between multiple versions of the standard must require their supplier to implement as a dual stack.

1.5 Clarification of examples.

Throughout this standard, many examples are provided as guidance only. In the event that an example is inconsistent with the text and DSPICS of the standard, the text description/DSPICS takes precedence over the example. Should a user detect any inconsistent examples, they should notify the CNRWG so that the example can be updated for a future release of the standard. It should also be noted that while all examples should be accurate in relation to the feature they are explaining, some of the examples provided may not reflect changes made to unrelated sections of the standard (e.g. examples to illustrate the use of XNP reflect the current version of XNP, but may not reflect the current version of the Intranet Header).

2 APPLICABLE DOCUMENTS

2.1 General.

The documents listed in this section are specified in sections 3, 4, and 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3, 4, and 5 of this standard, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks.

The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the current issue of the DoD Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.2).

DEPARTMENT OF DEFENSE STANDARDS

FEDERAL

FED-STD-1037	Glossary of Telecommunication Terms

MILITARY

MIL-STD-2045-47001	DoD Interface Standard, Connectionless Data Transfer -- Application Layer Standard

[Unless otherwise indicated, copies of federal and MIL-STDs are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.] Department of Defense Standards documents are available at the ASSIST website: http://assist.daps.dla.mil.

2.2.2 Other Government documents, drawings, and publications.

The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

JIEO Specification 9120A	Technical Interface Specification for UHF SATURN/HAVEQUICK Waveforms (U)

Approved Standard Change Catalog (SCC) modifications to this document form a part of this document as of the SCC approval date. Approved SCCs are posted to the "Documents" section of the CNRWG web page, http://cnrwg.disa.mil.

2.3 Non-Government publications.
The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents that are DoD- adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 6.2).

2.3.1 International Organization for Standardization (ISO).

ISO 3309	Information Processing Systems -- Data Communication -- High-level Data Link Control Procedures -- Frame Structure
ISO 7498-1	Information Processing Systems -- Open Systems Interconnection -- Basic Reference Model
ISO 8802-2	Information Processing Systems -- Local Area Networks -- Part 2: Logical Link Control

[ISO standards are available from the American National Standards Institute, Inc., 25 West 43rd Street, Fourth Floor, New York, NY 10036.] The ISO website is http://www.iso.org

2.3.2 International Telecommunications Union (ITU).
Formerly known as International Telephone and Telegraph Consultative Committee (CCITT)

CCITT V.33	14,400 Bits Per Second Modem Standardized for Use on Point-to-Point 4-wire Leased Telephone-Type Circuits.
CCITT V.36	Modems for Synchronous Data Transmission Using 60-108 KHz Group Band Circuits.

[ITU-T/CCITT standards are available from Omnicom, 115 Park Street, South East, Vienna, VA 22180]

The ITU website is http://www.itu.int

2.3.3 Internet Architecture Board (IAB) standards.

RFC 768	User Datagram Protocol (UDP)
RFC 793	Transmission Control Protocol (TCP)

RFC 826	An Ethernet Address Resolution Protocol (ARP) -- or -- Converting Network Protocol Addresses to 48-bit Ethernet Addresses for Transmission on Ethernet Hardware
RFC 791	Internet Protocol DARPA Internet Program Protocol Specification
RFC 1770	IPv4 Option for Sender Directed Multi-Destination Delivery
RFC 2328	OSPF Version 2
RFC 2460	Internet Protocol Version 6 (IPv6)
RFC 2461	Neighbor Discovery for IP Version 6 (IPv6)
RFC 2463	Internet Control Message Protocol (ICMPv6) for the Internet Protocol Version 6 (IPv6) Specification
RFC 2474	Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers
RFC 2475	An Architecture for Differentiated Services

The IAB website is http://www.iab.org

Request for comments (RFCs) are available from Network Information Center, 14200 Park Meadow Drive, Suite 200, Chantilly, VA 22021. The Network Information Center (NIC) can be reached, by phone, Monday through Friday, 7 AM through 7 PM, Eastern Standard time: 1-800-365-3642 and 1-703-802-4535. RFCs may also be obtained from the DS.INTERNIC.NET via FTP, WAIS, and electronic mail. Through FTP, RFCs are stored as rfc/rfcnnnn.txt or rfc/rfcnnnn.ps where 'nnnn' is the RFC number, 'txt' is a text file and 'ps' is a postscript file. Login as "anonymous" and provide your e-mail address as the password. Through WAIS, you may use either your local WAIS client or TELNET to DS.INTERNIC.NET and login as "wais" (no password required). Through electronic mail send a message to mailserv@ds.internic.net and include the following commands in the message body document -by-name RFC#### where #### is the RFC number without leading zeros or file /ftp/rfc/rfc####.yyy where 'yyy' is 'ps' or 'txt'. To obtain the complete RFC index, the subject line of your message should read "RFC index."]

2.3.4 Other.
Parameters and parameter values for the data link and the Network Timing Model, described in APPENDIX C, are provided in a separate document entitled "MIL-STD-188-220 Parameter Table". It is important, to insure interoperability, that all systems participating in a network use the same parameter values. These parameters and values should be utilized by all systems. Project Managers and implementers should note that the MIL-STD-188-220 Parameter Table is likely to change more frequently than the parent document. As these values should be used by

all systems, it is advisable that systems are built in such a way that they can be easily updated. The actual parameter values will determine the efficiency and effectiveness of the network. A bad choice of parameter values can degrade the network performance and can lead to a breakdown of the network precluding interoperability. The parameters and parameter values are available via the CNR Implementation Working Group World Wide Web page: http://cnrwg.disa.mil.

2.4 Order of precedence.
In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3 DEFINITIONS

3.1 Definitions of terms.

Definitions of terms used in this document are specified in FED-STD-1037.

3.2 Abbreviations and acronyms.

Abbreviations and acronyms used in this MIL-STD are defined below. In addition, those listed in the current edition of FED-STD-1037 have been included for the convenience of the reader.

ABM	Asynchronous Balanced Mode
ACK	Acknowledgment
ADM	Asynchronous Disconnected Mode
ADMC_N	Analog Data Mode Control_Not
ARP	Address Resolution Protocol
ASD	Adverse State Detector
ASK	Amplitude Shift Keying
B	Network Busy Sensing Time
BCH	Bose-Chaudhuri-Hocquenghem
BER	Bit Error Rate
bps	bit(s) per second
C/R	command/response
C^4I	Command, Control, Communications, Computers, and Intelligence
CCITT	International Telephone and Telegraph Consultative Committee
CDP	Conditioned Diphase
CNR	Combat Net Radio
COMSEC	Communications Security
CSMA	Carrier Sense Multiple Access
DAP-NAD	Deterministic Adaptive Prioritized - Network Access Delay
DARPA	Defense Advanced Research Projects Agency
DATA	Data Transmission Time
DAV-NAD	Data And Voice-Network Access Delay
dB	decibel
DC	Direct Current
DCE	Data Circuit-terminating Equipment
DDCO	Digital Data Clock Out
Dec	Decimal
DES	Destination
DIA	Decoupled Information Acknowledgment
DISC	Disconnect
DL	Data Link Layer
DM	Disconnect Mode
DMTD	Digital Message Transfer Device
DoD	Department Of Defense
DoDISS	Department Of Defense Index Of Specifications and Standards
DPSK	Differential Phase-Shift Keying

DPTT	Delayed Push-to-Talk
DRA	Data Rate Adapter
DRNR	Decoupled Receive Not Ready
DRR	Decoupled Receive Ready
DSPICS	DoD Standard Profile Implementation Conformance Statements
DTE	Data Terminal Equipment
DTEACK	DTE ACK preparation time
DTEPROC	DTE Processing time
DTETURN	DTE Turnaround time
ECP	Emergency Command Precedence
EDC	Error Detection and Correction
EDM	Enhanced Data Mode
ELAG	Equipment Lag time
EPRE	Equipment Preamble time
ETE	End-to-End
EUI	Extended Unique Identifier
FCS	Frame Check Sequence
FEC	Forward Error Correction
FED-STD	Federal Standard
FH	Frequency Hopping
FIFO	First-In First-Out
FLOAD	Load Factor
FOAR	Frequency of Access Ranking
FPI	Field Presence Indicator
FRMR	Frame Reject
FSK	Frequency-Shift Keying
FSN	First Station Number
FSNIN	First Station Number Increment Number
GPI	Group Presence Indicator
GRI	Group Repeat Indicator
H-NAD	Hybrid - Network Access Delay
HDLC	High-level Data Link Control
Hex	Hexadecimal
HF	High Frequency
HLEN	Header Length
HRT	Hop Recovery Time
Hz	Hertz
I PDU	Information frame PDU
IAB	Internet Architecture Board
ICOM	Integrated COMSEC
IHL	Internet Header Length
IL	Intranet Layer
IP	Internet Protocol
ip	Intranet Protocol

ISO	International Organization for Standardization
ITU	International Telecommunications Union
JIEO	Joint Information Engineering Organization
JRT	Join Response Timer
JRTTL	Join Request Time To Live
kbps	kilobit(s) per second
KG	Key Generator
KHz	Kilohertz
LOS	Line-of-Sight
LSB	Least Significant Bit
MI	Message Indicator
MIL-STD	Military Standard
MSB	Most Significant Bit
MTT	Maximum Transmit Time
MTU	Maximum Transmission Unit
N(R)	Receive sequence number
N(S)	Send sequence number
NAC	Network Access Control
NAD	Network Access Delay
NATO	North Atlantic Treaty Organization
NBDT	Network Busy Detect Time
NBT	Net Busy Timeout
NETCON	Network Control
NIC	Network Information Center
NP	Network Precedence
NRZ	Non-Return-to-Zero
NS	Number of Stations
OPS	Operational Parameter Sets
OSI	Open Systems Interconnection
OSPF	Open Shortest Path First
OTAR	Over-The-Air rekeying
OUI	Organizational Unique Identifier
P/F	Poll/Final
P-NAD	Priority - Network Access Delay
PDU	Protocol Data Unit
PHB	Per Hop Behavior
PHASING	PHASING transmission time
PL	Physical Layer
PN	Pseudo-Noise
PSK	Phase-Shift Keying
PTT	Push to Talk
R-NAD	Random Network Access Delay
RCP	Robust Communications Protocol
RE-NAD	Radio Embedded - Network Access Delay

REJ	Reject
REL	Relay
RF	Radio Frequency
RFC	Request For Comments
RHD	Response Hold Delay
RNR	Receive Not Ready
RR	Receive Ready
RSET	Reset
RTURN	Receiver Turnaround Time
R/T	Receiver/Transmitter
S	Coupled Acknowledgment transmission time
S/N	Signal-to-Noise ratio
S PDU	Supervisory frame PDU
SABME	Set Asynchronous Balanced Mode Extended
SALT	Smallest Actual Lag Time
SATCOM	Satellite Communications
SC	Single Channel
SDM	Standard Data Mode
SINCGARS	Single Channel Ground and Airborne Radio System
SIP	System Improvement Program
SNDCF	Subnetwork Dependent Convergence Function
SOM	Start Of Message
SOP	Start Of Packet
SP	Station Precedence
SREJ	Selective Reject
TBD	To Be Determined
Tc	Continuous Scheduler Inteval Timer
TCP	Transmission Control Protocol
TCSS	Telecommunications System Standards
TDC	Time-Dispersive Coding
TOD	Time of Day
TOL	Tolerance time
TOS	Type Of Service
TP	Timeout Period
TRANSEC	Transmission Security
TTTL	TEST Time To Live
TTURN	Transmitter Turnaround time
TURN	Turnaround time
TWC	Transmission Word Count
U PDU	Unnumbered frame PDU
UA	Unnumbered Acknowledgment
UDP	User Datagram Protocol
UI	Unnumbered Information
URNR	Unnumbered Receive Not Ready

URR	Unnumbered Receive Ready
V(R)	Receive-state Variable
V(S)	Send-state Variable
VMF	Variable Message Format
XNP	Exchange Network Parameters

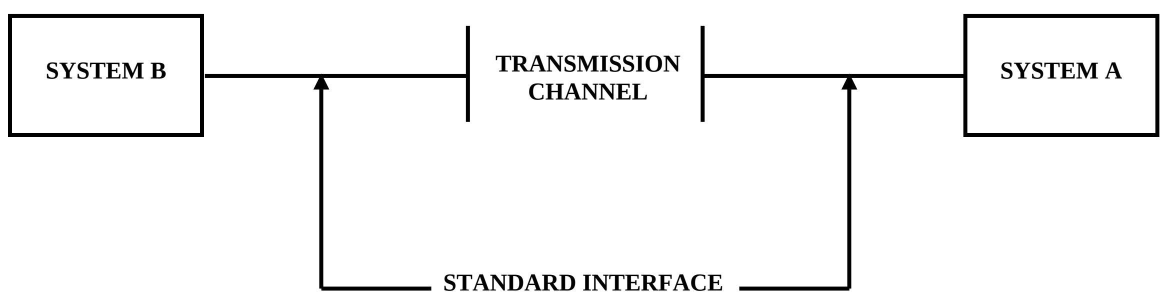
4 GENERAL REQUIREMENTS

4.1 Digital message transfer device (DTMD).

A DMTD is a portable data terminal device with limited message generation and processing capability. DMTDs are used for remote access to automated C^4I systems and to other DMTDs. The environment encompasses point-to-point, point-to-multipoint, relay and broadcast transfer of information over data communications links.

4.2 Interoperability.

Interoperability of DMTDs and associated C^4I systems shall be achieved by implementing the standard interface for DMTD subsystems (see FIGURE 1) specified in this document. This standard defines the layered protocols for the transmission of single or multiple segment messages over broadcast radio subnetworks and point-to-point links. It provides the minimum essential data communications parameters and protocol stack required to communicate with other data terminal devices. These communications parameters and protocols will facilitate functional interoperability among DMTDs, and between DMTDs and applicable C^4I systems within the layered framework described below. Electrical and mechanical design parameters are design-dependent and are outside the scope of this document. Interoperability considerations for terminal designers and systems engineers are addressed in 6.3 and APPENDIX B.



NOTES:

1. System A and System B (where either system, or both, can be a DMTD or a C^4I system) may include modems, line drivers, error control algorithms, encryption devices, control units, and other devices as required to comply with this standard.

2. The transmission channel may include single and multichannel transmission equipment.

FIGURE 1. Standard interface for DMTD subsystems.

4.3 Framework.
The communications and procedural protocols used in DMTD equipment shall support the layers of the functional reference model depicted in FIGURE 2. The DMTD functional reference model in FIGURE 2 is based on the ISO 7498 OSI seven-layer model and is for reference only. FIGURE 2 contains the framework that is used in this document for defining the protocols required to exchange information among DMTD subsystems, and between DMTD subsystems and applicable C^4I systems. FIGURE 3 illustrates a representative time epoch of the basic frame structure supported by the DMTD subsystem. This standard describes the protocols at the following OSI layers:

a. Physical Layer

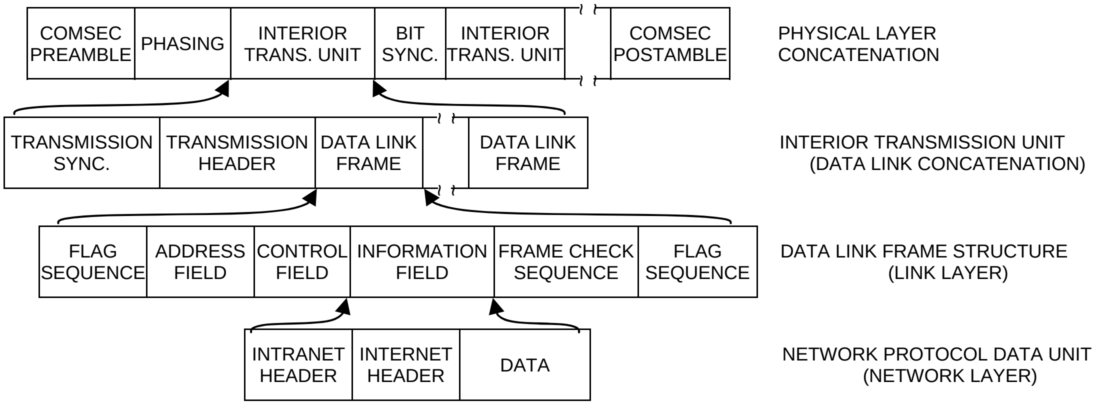
b. Data Link Layer
   1. Network Access Control
   2. Link Level Control

c. Network Layer (Intranet Layer)

Application Layer *
Presentation Layer *
Session Layer *
Transport Layer *
Network Layer
Data Link Layer
Physical Layer

* NOTE: These layers are not defined in this standard.

FIGURE 2. DMTD functional reference model



NOTES: Phasing if required, is applied before the first Interior Transmission Unit.

Bit Synchronization is applied between physically concatenated Interior Transmission Units.

The Network Protocol Data Unit may include an Internet header in addition to the required Intranet header.

This standard does not specify requirements for the Internet header.

FIGURE 3. Basic structure of DMTD protocol data units at the standard interface.

4.4 DMTD capabilities.

The waveform and the protocols necessary to ensure End-to-End (ETE) interoperability at the interface shall support the following capabilities:

a. Transmission in a half-duplex mode over radio, wireline, and satellite links.

b. Link encryption.

c. Point-to-point, multipoint, relay or broadcast connectivity between stations.

d. Asynchronous Balanced Mode (ABM) of operation between two or more stations.

e. Network access control for network access management and collision avoidance.

f. Transport of bit-oriented or free-text (character-oriented) messages for information exchange in a Variable Message Format (VMF) over the link.

g. User data exchange using single or multiple frame packets.

h. Addressing conventions that support single, multiple, and global station broadcast addressing, as well as routing and relay.

i. Error control, for maintaining data integrity over the link, including Frame Check Sequence, Forward Error Correction, and Time-Dispersal Coding.

j. Data scrambling to combat radio Direct Current (DC) bias.

k. Data link frame acknowledgment, intranet frame acknowledgment and ETE, segment acknowledgment at the transport layer.

l. Intranet relay at the network layer.

m. Topology update capability for the intranet.

4.5 System standards and design.
The parameters and other requirements specified in this document are mandatory system standards if the word *shall* or *will* are used in connection with the parameter value or requirement under consideration. Non-mandatory design objectives are indicated in parentheses after a standardized parameter value or by the words *should*, *can* or *may* in connection with the parameter value or requirement under consideration. APPENDIX B also indicates whether specific parameters or other requirements are mandatory or optional. All users of this document shall take into consideration all parts of the document before making decisions to define, procure or implement systems. In the event that there is an apparent conflict between the main volume and APPENDIX B, then one of the following actions shall be taken:

a. The “mandatory” option shall be selected over the “optional” one.

b. The matter shall be referred to the Combat Network Radio Working Group (CNRWG) for adjudication.

This document contains numerous essential technical parameters in the form of mandatory and optional design objectives in which, in some situations, the parent capability is optional but the value is mandatory if the optional capability is elected. Even though the child value is mandatory, it does not mean the parent capability is mandatory.

Example: The Synchronous capability is a mandatory requirement that all systems must implement. The Asynchronous capability is an optional requirement, but if elected then the Frame Synchronization field is mandatory. The fact that the Frame Synchronization field is mandatory if the Asynchronous process is selected does not mean that the Asynchronous process is a mandatory requirement.

Unless stated otherwise, the following convention is used in the figures of MIL-STD-188-220: Least Significant Bit (LSB) is always shown to the RIGHT, and Most Significant Bit (MSB) is always shown to the LEFT.

5 DETAILED REQUIREMENTS

5.1 Physical layer.

The physical layer (PL) shall provide the control functions required to activate, maintain, and deactivate the connections between communications systems. This standard does not address the electrical or mechanical functions normally associated with PL protocols.

5.1.1 Transmission channel interfaces.

Transmission channel interfaces should be implemented as dictated by the communication device (e.g., radio) to which the system will be connected. The transmission channel interfaces, specified in APPENDIX L, define the transmission envelope characteristics (signal waveform, transmission rates, and operating mode) authorized at the standard interface between a DMTD and the transmission channel. The transmission channel may consist of wireline, satellite, or radio links. The specific details of the physical interface for connecting DMTDs to the equipment that implements the transmission channel are beyond the scope of this document. The actual physical connections will depend on the interface characteristics required by the particular transmission equipment. These unique physical interface characteristics may be defined in the equipment specifications or in technical interface specifications. Therefore, the requirements for the electrical features (such as data, clock, and control) and mechanical features (such as connectors, pin assignments, and cable) of the connection between the DMTD and the associated transmission channel equipment are left to the equipment designer.

5.2 Physical-layer protocol.

5.2.1 Physical-layer Protocol Data Unit (PDU).

The transmission frame shall be the basic PDU of the PL and shall be as shown in FIGURE 4. FIGURE 4a presents the transmission frame structure for traditional communication security (COMSEC) (backward-compatible mode). Traditional COMSEC is used in this document to denote systems with the COMSEC equipment placed external to the C4I system. FIGURE 4b presents the transmission frame structure with COMSEC embedded in the C4I system (embedded mode). FIGURE 4c presents the transmission frame structure without COMSEC. This standard defines the following modes of transmission:

a. Synchronous Mode
b. Asynchronous Mode
c. Packet Mode

DMTD subsystems or applicable C4I systems shall support the Synchronous Mode of transmission as a minimum for joint interoperability purposes. DMTD subsystems or applicable C4I systems may support the Asynchronous Mode of transmission and/or Packet Mode of transmission. Note that the Synchronous mode includes both Standard Data Mode (SDM) and Enhanced Data Mode (EDM). For EDM, available in some radios, FEC and TDC are provided by the radio. SDM typically requires FEC and TDC to be applied by the DTE.

Notes:
Synchronous mode is used with Data Circuit-terminating Equipment (DCE) that present a clock and data interface. Packet mode is used with DCEs that require no frame synchronization. Asynchronous mode is used with DCEs that present modulated data without a clock.

COMSEC PREAMBLE	PHASING	TRANSMISSION SYNCHRONIZATION	DATA FIELD	COMSEC POSTAMBLE

Figure 4a. Transmission frame structure with external COMSEC.

PHASING	TRANSMISSION SYNCHRONIZATION WITH COMSEC MESSAGE INDICATOR	DATA FIELD	COMSEC POSTAMBLE

Figure 4b. Transmission frame structure with embedded COMSEC.

PHASING	TRANSMISSION SYNCHRONIZATION	DATA FIELD

Figure 4c. Transmission frame structure with no COMSEC.

FIGURE 4. Transmission frame structure.

5.2.1.1 Communications security preamble and postamble.
These fields are present when link encryption is used. The COMSEC preamble field shall be used to achieve cryptographic synchronization over the link. The COMSEC postamble field shall be used to provide an end-of-transmission flag to the COMSEC equipment at the receiving station. These fields and the COMSEC synchronization process are described in APPENDIX D (D.5.1.1 and D.5.1.5, respectively).

5.2.1.2 Phasing.
Phasing shall be a string of alternating ones and zeros, beginning with a one, sent by the DTE. For Packet Mode interfaces, the length of this field shall be 0. Phasing is described in C.3.2.2.

5.2.1.3 Transmission synchronization field.
The structure of the transmission synchronization field is dependent on the mode of transmission. The structures for Asynchronous and Synchronous modes are shown in FIGURE 5. FIGURE 5a presents the transmission synchronization field with either external or no COMSEC. FIGURE 5b presents the transmission synchronization field with embedded COMSEC. The structure for the Packet Mode is described in 5.2.1.3.3. The Asynchronous and Synchronous modes include both Standard Frame Synchronization (SFS) and Robust Frame Synchronization (RFS). The SFS shall be used to achieve synchronization when implementing the mandatory Synchronous Mode of Transmission and the optional Asynchronous Mode of Transmission. The RFS is used only when implementing the Robust Communication Protocol

(RCP) described in APPENDIX J for both the Asynchronous and Synchronous modes. The RCP, available in some radios, is optional for both the Asynchronous and Synchronous modes.

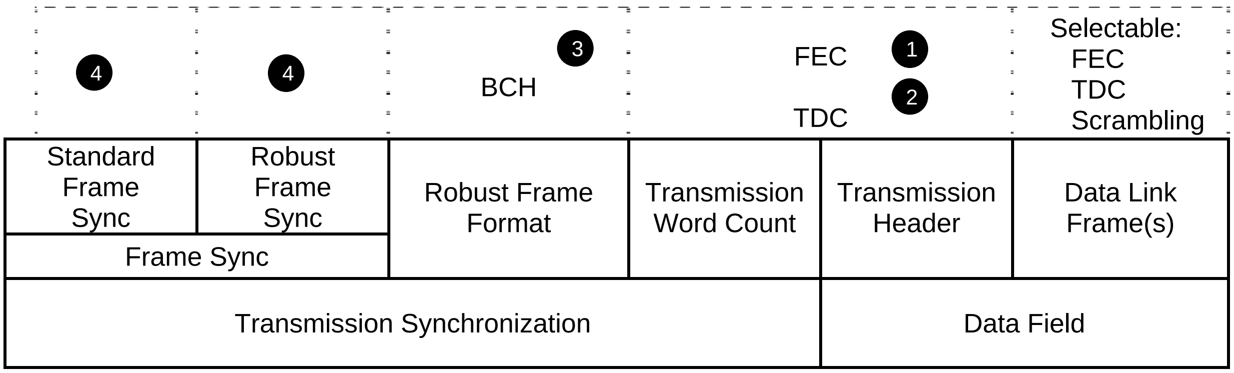


Figure 5a. With external COMSEC or No COMSEC.

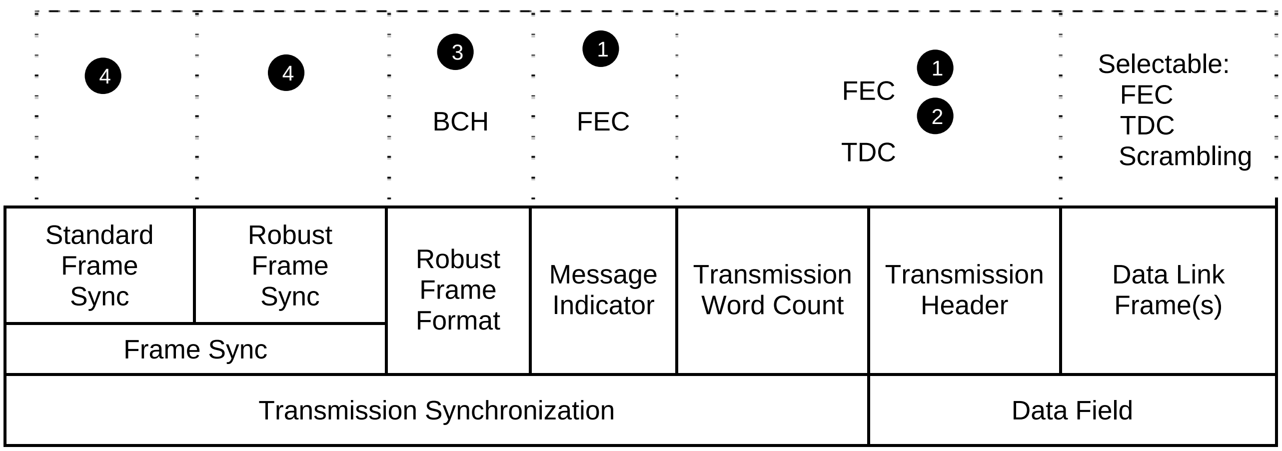


Figure 5b. With Embedded COMSEC.

Notes:

❶ Golay FEC is applied to the Transmission Word Count, message Indicator and Transmission Header fields in Asynchronous and Synchronous Modes. (The Transmission Header is the leading portion of the Data Field as described in 5.3.1.)

❷ TDC is applied to the Transmission Word Count and Transmission Header fields in Asynchronous and Synchronous Modes. (The Transmission header is the leading portion of the Data Field as described in 5.3.1.)

❸ The Robust Frame Format (RFF) subfield is used only when implementing the RCP described in APPENDIX J. BCH is applied to the RFF in Asynchronous and Synchronous Modes.

❹ The Standard Frame Synchronization and Robust Frame Synchronization are mutually exclusive.

FIGURE 5. Transmission synchronization field.
(Synchronous and Asynchronous Mode)

5.2.1.3.1 Synchronous mode transmission synchronization field.
The Synchronous ModeTransmission Synchronization field shall be composed of the following:

a. Frame Synchronization
   - Standard Frame Synchronization
   - Robust Frame Synchronization

b. Robust Frame Format (RCP only)

c. Message Indicator (MI) (embedded COMSEC only)

d. Transmission Word Count

5.2.1.3.1.1 Frame synchronization subfield.
This subfield shall consist of the fixed 64-bit synchronization pattern shown in FIGURE 6 for Standard Frame Synchronization or FIGURE 7 for Robust Frame Synchronization. The receiver shall correlate for the frame synchronization pattern. A pattern shall be detected if 13 or fewer bits are in error with non-inverted or inverted data. If the correlation detects an inverted synchronization pattern, all received data shall be inverted before any other receive processing is performed. If the frame synchronization subfield shown in FIGURE 6 is detected before the robust frame synchronization subfield shown in FIGURE 7, the receiver shall assume the processing of optional Robust Communication Protocol (RCP) is not requested for this transmission.

MSB	LSB
1001101110110101011110100000100101101001010011110100111100100110	

FIGURE 6. Frame synchronization subfield.

If the robust frame synchronization pattern shown in FIGURE 7 is detected, the receiver shall assume the processing of optional Robust Communication Protocol (RCP) described in 5.2.1.3.4 is requested for this transmission. The Robust Frame Format subfield shall be used to determine what physical level processing is required for data reception. If the robust frame synchronization pattern shown in FIGURE 7 is used, the frame synchronization pattern shown in FIGURE 6 shall not be used.

MSB	LSB
0001110001111010101101100100000011111101101101110011001110010010	

FIGURE 7. Robust frame synchronization subfield.

5.2.1.3.1.2 Robust frame format subfield.
The robust frame format subfield shall be used only with the robust frame synchronization subfield shown in FIGURE 7 for RCP processing. The robust frame format subfield is a seven-bit field, which specifies the format of the transmitted frame. Three selectable processes: convolutional coding, data scrambling and packetizing shall be used to construct the transmission frame. The bits are defined in TABLE I and TABLE II. Note that the packetizing scheme is the Multi-Dwell Protocol (MDP) as defined in APPENDIX J. TABLE III is applied only when Multi-Dwell Flag is set to one (1). The robust frame format subfield shall be formatted with multi-dwell majority vote 3 out of 5 Bose-Chaudhuri-Hocquenghem (BCH) (15,7) coding with no scrambling and no convolutional encoding.

TABLE I. Robust frame format.

Bit(s)	Fields
0 (LSB)	Multi-Dwell Flag
1	Scrambling Flag
2, 3, 4	Multi-Dwell Transmission Format
5,6	Convolutional Coding Constraint Length

TABLE II. Multi-dwell transmission format.
(The Most Significant Bit is shown on the Left)

000	Single BCH(15,7) word 32 Bit SOP, 11 64-bit segments per packet
001	Majority Vote 2 out of 3 BCH(15,7) word 64 Bit SOP, 13 64-bit segments per packet
010	Majority Vote 3 out of 5 BCH(15,7) word 64 Bit SOP, 13 64-bit segments per packet
011	Majority Vote 3 out of 5 BCH(15,7) word 64 Bit SOP, 6 64-bit segments per packet

TABLE III. Convolutional coding constraint length codes.
(The Most Significant Bit is shown on the Left)

00	Constraint Length 3
01	Constraint Length 5
10	Constraint Length 7
11	Convolutional Coding Disabled

5.2.1.3.1.3 Message Indicator (MI).
The MI field is contained within the transmission synchronization field only when COMSEC is embedded in the host. The MI field is defined in APPENDIX D (D.5.1.1.3 and D.5.2.4). Golay FEC is applied to the Transmission Word Count (TWC), MI (with embedded COMSEC) and Transmission Header in Asynchronous and Synchronous Modes.

5.2.1.3.1.4 Transmission Word Count (TWC) subfield.
The TWC is a 12-bit value calculated by the transmitting station to inform the receiving station of the number of 16-bit words (after any appropriate FEC encoding, TDC fill or zero bit insertion) contained in the transmission. The TWC calculation shall include the length of the TWC and data field (see 5.2.1.4). The maximum TWC is 4095 (2^{12}-1). The value provided by the 12 information bits is binary-encoded. The maximum number of words is dependent on the maximum number of bits allowed in the data field of a transmission frame. It is possible that the number of bits in the data field will not be evenly divisible by 16. In that case, the word count shall be rounded to the next higher integer and a variable number of zeros, 0 to 15, shall be appended after the final link layer frame in order to make the Transmission Unit an integral number of 16-bit words. These zeros shall not be subject to FEC or TDC (see G.3.7.1.3). TDC is applied to the TWC and Transmission Header in Asynchronous and Synchronous Modes. Golay FEC is applied to the TWC, MI (with embedded COMSEC) and Transmission Header in Asynchronous and Synchronous Modes.

5.2.1.3.2 Asynchronous mode Transmission Synchronization field.
The Asynchronous Transmission Synchronization field shall be composed of the following:

a. Frame Synchronization

  - Standard Frame Synchronization
  - Robust Frame Synchronization

b. Robust Frame Format (RCP only)

c. Message Indicator (MI) (embedded COMSEC only)

d. Word Count

5.2.1.3.2.1 Frame synchronization subfield.
The Asynchronous Mode Frame Synchronization subfield is the same as the Synchronous Mode Frame Synchronization subfield defined in 5.2.1.3.1.1 and shown in FIGURE 6 and FIGURE 7.

5.2.1.3.2.2 Robust Frame Format subfield.
The Asynchronous Mode Robust Frame Format subfield is the same as the Synchronous Mode Robust Frame Format subfield defined in 5.2.1.3.1.2.

5.2.1.3.2.3 Message Indicator.
The format of the Asynchronous Mode MI field is the same as for the Synchronous Mode MI field defined in 5.2.1.3.1.3.

5.2.1.3.2.4 Transmission Word Count subfield.
The Aynchronous Mode TWC format is the same as the Synchronous Mode TWC defined in 5.2.1.3.1.4.

5.2.1.3.3 Packet mode transmission synchronization field.
This field consists of at least one HDLC flag corresponding to the flag bit pattern shown in FIGURE 8. When a DTE has data to send to the radio (DCE) it shall transmit flags on the 'T' lead until flags are received from the radio (DCE) on the 'R' lead, then data shall be sent to the radio (DCE) on the 'T' lead. A variable number (at least one) of lead flags shall be transmitted prior to the actual data. On the receive side, the radio (DCE) shall send at least one flag prior to the data it sends to the DTE.

MSB	LSB
01111110	

FIGURE 8. Packet mode transmission synchronization field.

5.2.1.3.4 Robust Communications Protocol (RCP).
The RCP provides the additional processing to aid the transfer of secure and non-secure digital data when combined with the link processing of the MIL-STD-188-220 protocol. The RCP and its sub components are described in detail in APPENDIX J.

5.2.1.4 Data field.
The data field shall contain the string of bits, comprising the Transmission Header and concatenated data link frames, created by the data link layer following the procedures for framing, zero bit insertion, concatenation, FEC, TDC, and scrambling. FEC, TDC and Scrambling are not applied when Packet Mode is used.

5.2.1.5 Bit synchronization field.
This field shall be used to provide the receiver a signal for re-establishing bit synchronization. Bit synchronization is used only between physically concatenated frames in Asynchronous Mode. The bit synchronization field shall be a 64-bit pattern that consists of alternating ones and zeros, beginning with a one.

5.2.2 Network Access Control (NAC) related indications.

a. The net busy information is conveyed to the upper layer protocol (data link) through a status indication. Upon detection of a net busy, the net busy indicator shall be set. The net busy sensing indicator shall be reset when neither digital data nor voice is detected by the net busy sensing function. APPENDIX C (C.4.1) describes the net busy sensing function.

b. The NAC algorithm described in APPENDIX C needs the transmitter to know when the last bit of data is transmitted, and the receiver to know when the last bit of data is received.

5.2.3 Physical-layer to upper-layer interactions.
At least three primitives are used to pass information for the sending and receiving of data across the upper layer boundary.

a. Requests for transmission of data are sent by the upper layer, using the PL Unitdata Request primitive with the following parameter:

- PL-Unitdata Request
  - Data/Data length
  - FEC/TDC/Scrambling
    - No FEC, No TDC, No Scrambling
    - No FEC, No TDC, Scrambling
    - FEC, No TDC, No Scrambling
    - FEC, No TDC, Scrambling
    - FEC, TDC, No Scrambling
    - FEC, TDC, Scrambling
  - Multi-dwell transmission format segment count
    - 6 segments per packet
    - 11 segments per packet
    - 13 segments per packet
  - PL Scrambling
    - No PL Scrambling
    - PL Scrambling

Convolutional coding constraint length
- Constraint length 3
- Constraint length 5
- Constraint length 7

b. Indication of data received is provided to the upper layer through the Unitdata Indication primitive with the following parameter:

PL-Unitdata Indication
- Data/Data length
- FEC/TDC/Scrambling
  - No FEC, No TDC, No Scrambling
  - No FEC, No TDC, Scrambling
  - FEC, No TDC, No Scrambling
  - FEC, No TDC, Scrambling
  - FEC, TDC, No Scrambling
  - FEC, TDC, Scrambling
- Multi-dwell transmission format segment count
  - 6 segments per packet
  - 11 segments per packet
  - 13 segments per packet
- PL Scrambling
  - No PL Scrambling
  - PL Scrambling
- Convolutional coding constraint length
  - Constraint length 3
  - Constraint length 5
  - Constraint length 7

c. Net activity status information is provided to the upper layer through a Status Indication with the following parameters:

PL-Status Indication
- Net activity
  - net clear
  - net busy
  - busy with/data
  - busy with/voice
- Transmission Status
  - transmit complete/idle
  - in-process
  - transmit aborted

5.3 Data Link layer.

The Data Link layer shall provide the control functions to ensure the transfer of information over established physical paths, to provide framing requirements for data, and to provide for error control. Zero bit insertion is applied to the Transmission Header and Data Link Frame.

5.3.1 Transmission Header.

The Transmission Header is the leading portion of the Data Field transmission (see 5.2.1.4). The Transmission Header consists of a two-octet Transmission Information field, a 32-bit FCS, in accordance with 5.3.4.2.5, and is bounded by Flags in accordance with 5.3.4.2.1. The Transmission Information field contains Selection bits and a Transmission Queue field which indicates the transmitting station queue length. The Transmission Header format is shown in FIGURE 9. Golay FEC and TDC are applied to the entire Transmission Header (except when the Packet Mode Interface described in L.4.1.6 is used at the PL), including leading and trailing flags, MI (with embedded COMSEC) and TWC. The TWC, MI and Transmission Header shall have Golay FEC applied when operating in the Asynchronous and Synchronous modes. TDC (7x24) bit interleaving shall be applied in unison with the FEC on the TWC and Transmission Header. The data shall be formatted into a TDC block composed of seven (7) 24-bit Golay (24,12) codewords in a manner analogous to 5.3.14.3. There are 168 FEC-encoded bits with this TDC.

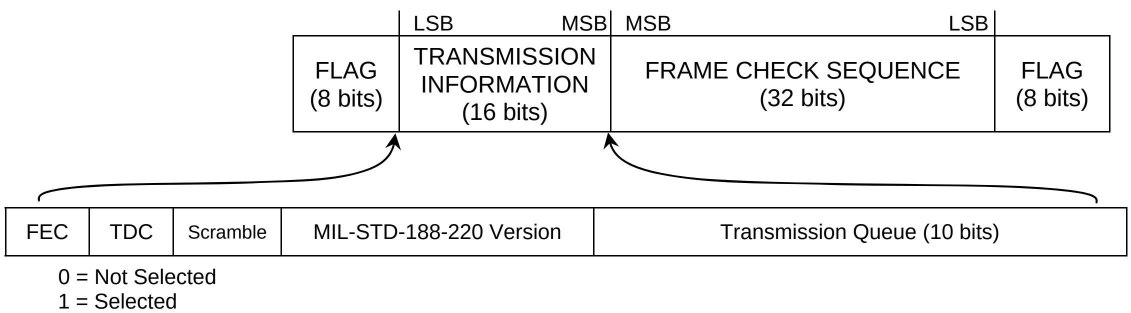


FIGURE 9. Transmission header.

5.3.1.1 Selection bits.

The first three bits of the Transmission Information field selects FEC, TDC and Scrambling, respectively, on or off for the remainder of the PL data field. A zero indicates "off" and a one indicates "on" in these bit positions. Regardless of the setting of these three bits, Golay FEC/TDC is applied and Scrambling is not applied to the entire Transmission Header. Scrambling, if used, shall be applied before any FEC and TDC is applied. FEC, TDC and scrambling are not applied when the Packet Mode Interface described in L.4.1.6 is used at the PL. In addition, FEC/TDC is not applied when the SINCGARS Synchronous mode is selected utilizing the EDM available in the SIP and ASIP radio.

5.3.1.2 MIL-STD-188-220 Version.
This subfield shall identify the MIL-STD-188-220 Version used to generate this message.

Value	MIL-STD-188-220 Version
0	Reserved
1	MIL-STD-188-220 Version D
2-7	Undefined

FIGURE 10. MIL-STD-188-220 Version

MIL-STD-188-220D compliant systems shall use the value "1" for all transmitted messages. If a station supporting only MIL-STD-188-220D is connected to a network containing stations supporting a different version (later version) of the MIL-STD it is possible that a DL PDU with a MIL-STD-188-220 Version field value other than 1 will be received by the station supporting MIL-STD-188-220D. Received DL PDUs with a MIL-STD-188-220 Version field value that is not equal to 1 shall be discarded by stations that implement only MIL-STD-188-220D and a DL-Error Indication shall be generated indicating that an unsupported MIL-STD-188-220 Version field value was received.

5.3.1.3 Transmission Queue field.
This field is used to support the radio embedded network access delay (RE-NAD) process and the deterministic adaptable priority network access delay (DAP-NAD) process and the data and voice network access delay (DAV-NAD) process. The entire field is 10-bits long with the first two bits ('T'-bits) indicating how the rest of the 8-bits long subfield is interpreted. The format of the transmission queue field is shown in FIGURE 11.

5.3.1.3.1 T-bits.
The two left-most bits in the transmission queue field are the T-bits. The bit sequence interpretations are indicated in FIGURE 11. The transmission queue subfield has a variable format depending on which of the following uses are intended:

	T-bits LSB	T-bits MSB	
a.	0	0	The transmission queue subfield does not contain information and is ignored.
b.	0	1	The transmission queue subfield is used in conjunction with RE-NAD. This subfield contains queue precedence (in bit positions 2-3) and queue length (bit positions 4-7). Bit positions 8 and 9 are spare and ignored.
c.	1	0	The transmission queue subfield is used in conjunction with DAP-NAD and DAV-NAD. This subfield contains Data Link Precedence (in bit positions 2 and 3) and First Station Number (FSN) (in bit positions 4-9).
d.	1	1	This bit sequence is INVALID and shall be ignored. Data link frame(s) after this header shall be processed normally.

LSB MSB
T-Bits

<table>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td>0</td><td>0</td><td colspan="8">Transmission Queue Subfield Ignored</td></tr>
<tr><td>0</td><td>1</td><td colspan="2">Queue Prec.</td><td colspan="4">Queue Length</td><td colspan="2">Spare</td></tr>
<tr><td>1</td><td>0</td><td colspan="2">Data Link Prec.</td><td colspan="6">First Station Number</td></tr>
<tr><td>1</td><td>1</td><td colspan="8">Invalid/Ignored</td></tr>
</table>

FIGURE 11. Transmission queue field formats.

5.3.1.3.2 Queue precedence.
The queue precedence component indicates the highest precedence level of information type frames in the queue.

The precedence levels and bit sequences are:

Precedence	Bit 2	Bit 3	Value
Urgent	0	0	0
Priority	1	0	1
Routine	0	1	2
Reserved	1	1	3

5.3.1.3.3 Queue Length.
The Queue Length component indicates the number of concatenated frame sequences required to transmit all of the highest precedence messages in the transmission queue at the time the transmission was created. This number may be used by receiving station to calculate the average network member's queue length. This average is used in calculation of the continuous scheduler for the Radio Embedded channel access procedure (C.4.4.4).

5.3.1.3.4 Data Link Precedence.
This subfield consists of two bits and contains a value that indicates the highest precedence of any message that is contained in the physical frame. It shall contain the value 0 if an urgent message is in the frame, 1 if a priority but no urgent message is in the frame and 2 if neither an urgent nor priority message is in the frame. The variable NP in the equations defined in APPENDIX C (C.4.4.5.2) is set equal to the contents of the highest precedence Data Link Precedence field in any (possibly concatenated) physical frame contained in the most recent reception.

The precedence levels and bit sequences for the Data Link Precedence field are:

Precedence	Bit 2	Bit 3	Value
Urgent	0	0	0
Priority	1	0	1
Routine	0	1	2
Undefined	1	1	3

Undefined precedence values shall be handled as routine.

5.3.1.3.5 First Station Number (FSN).
This subfield consists of 6 bits and designates the number of the station that is to have the first net access opportunity at the next net access period (the one immediately following this transmission). The number of the station that has the first net access opportunity is the variable FSN in the equations defined in APPENDIX C (C.4.4.5.2).

Bit coding for FSN is:

1st Station #	Bit: 4--->9
Illegal	000000
1	100000
2	010000
.	..
.	..
.	..
63	111111

5.3.2 Network access control.
The presence of multiple stations on a single communications net requires a method of controlling the transmission opportunities for each station. To minimize conflicts, the net busy sensing function and NAC procedures regulate transmission opportunities for all participants on the net. Random - Network Access Delay (R-NAD), Hybrid - Network Access Delay (H-NAD), Prioritized - Network Access Delay (P-NAD), Radio Embedded - Network Access Delay (RE-NAD), Data And Voice – Network Access Delay (DAV-NAD) and Deterministic Adaptable Priority - Network Access Delay (DAP-NAD) are the authorized NAC procedures at this interface. APPENDIX C defines the NAC parameters for R-NAD, H-NAD, P-NAD, DAP-NAD, DAV-NAD, and RE-NAD. As a minimum, DAP-NAD and R-NAD shall be available to regulate transmission opportunities for all participants when the network is operating in Synchronous Mode.

5.3.2.1 Scheduler.
When the net access is embedded in the radio, a scheduler may be implemented in the DTE or communications processor to organize radio access throughout the network. The scheduler is used to provide a random distribution of timing for channel requests. When a station has data to transmit, it shall calculate the scheduler timer as indicated in APPENDIX C (C.4.4.4.1). When

this timer expires, the link layer shall first determine that the previous frame concatenation was transmitted by the PL. If the frame concatenation was not transmitted, the link layer shall request its transmission. If a higher precedence individual frame becomes available for transmission, the concatenated frames shall be re-built to include the higher precedence frame. If the previous frame concatenation was transmitted, the link layer shall build a new frame concatenation. This frame concatenation shall then be passed to the PL for transmission. Both randomized and immediate scheduler modes are specified in APPENDIX C (C.4.4.4.1.1, C.4.4.4.1.5, and C.4.4.4.1.6, respectively).

5.3.3 Types of operation.
Four types of operation for data communication between systems are defined to provide basic connectionless and connection mode operations:

Type 1 - Unacknowledged Connectionless Operation
Type 2 - Connection-mode Operation
Type 3 - Acknowledged Connectionless Operation
Type 4 - Decoupled Acknowledged Connectionless Operation

Types and services 1 through 3 are based on ISO 8802-2. The Type 1 and Type 3 connectionless operations are mandatory for implementation in all systems. The Type 2 connection mode and the Type 4 connectionless mode (decoupled ACK) are optional.

5.3.3.1 Type 1 operation.
For the purpose of this protocol, Type 1 operation will designate the ISO 8802-2 unacknowledged connectionless operation.

5.3.3.2 Type 2 operation.
With Type 2 operation, a data link connection shall be established between two systems prior to any exchange of information bearing PDUs. For efficiency at system startup, connections may be assumed to exist with all other stations in the network; and the system may depend on information transfer phase procedures to resolve error conditions. To guarantee a reliable (i.e., no loss) service, connections should be explicitly established, not assumed to exist. The connection normally shall remain open until a station leaves the net. The normal communications cycle between Type 2 systems shall consist of transferring PDUs from the source to the destination, and acknowledging receipt of these PDUs in the opposite direction.

5.3.3.3 Type 3 operation.
For the purpose of this protocol, Type 3 operation will designate the ISO 8802-2 acknowledged connectionless operation.

5.3.3.4 Type 4 operation.
With Type 4 operation, acknowledgments are decoupled from the original Decoupled Information Acknowledgment (DIA) PDU, and DIA PDUs contain a non-modulus identification number assigned by the originator.

5.3.3.5 Station class.
Four station classes define the data link procedures supported by a system:

Station Class A - Supports Types 1 and 3; not Types 2 and 4
Station Class B - Supports Types 1, 2 and 3; not Type 4
Station Class C - Supports Types 1, 3 and 4; not Type 2
Station Class D - Supports Types 1, 2, 3 and 4.

5.3.4 Data Link frame.
The Data Link frame shall be the basic PDU of the link layer. The Transmission Header is not a PDU.

5.3.4.1 Types of frames.
Three types of frames convey data over the Data Link: an unnumbered frame (U PDUs), an information frame (I PDUs) and a supervisory frame (S PDUs).

5.3.4.1.1 Unnumbered frame.
The U PDUs shall be used for Type 1, Type 2, Type 3, and Type 4 operations. They provide connectionless information transfer for Types 1,3 and 4 operations. U PDUs provide acknowledgment for Type 3, and station identification/status information for Types 1 and 3 operations. They also provide data link control functions for Type 1 through 4 operations.

5.3.4.1.2 Information frame.
The I PDUs are used for information transfer in Type 2 operations only. They convey user data or message traffic across a link. The I PDUs are not used in Type 1, Type 3, or Type 4 operations.

5.3.4.1.3 Supervisory frame.
The S PDUs are used for data link supervisory control functions and to acknowledge received I PDUs in Type 2 operations. Additionally, the Type 4 Decoupled Receive Ready (DRR) response S PDU is used to acknowledge Type 4 DIA PDUs. The S PDUs are not used in Type 1 or Type 3 operations.

5.3.4.2 Data Link frame structure.
The basic elements of the Data Link frame shall be the opening flag sequence, the address field, the control field, the information field, the FCS, and the closing flag sequence. Each Type 1, Type 2, Type 3, and Type 4 Data Link frame shall be structured as shown in the Data Link frame portion of FIGURE 12.

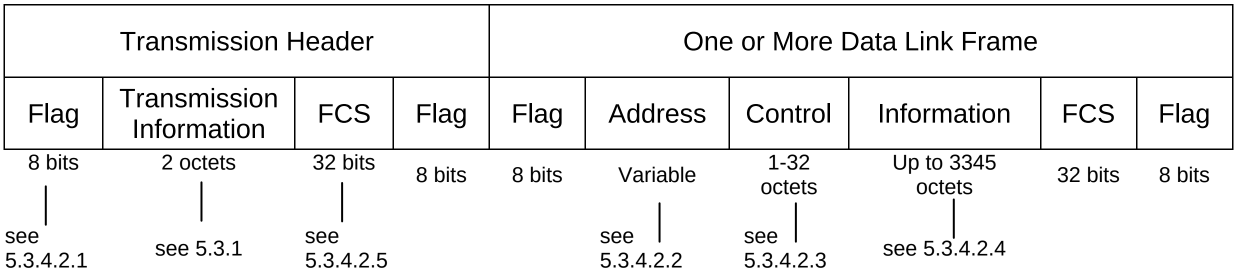


FIGURE 12. Data Link frame structure and placement

5.3.4.2.1 Flag sequence.
All frames shall start and end with the 8-bit flag sequence of one 0 bit, six 1 bits, and one 0 bit (01111110). The flag shall be used for Data Link frame synchronization.

5.3.4.2.2 Address fields.
These fields shall identify the link addresses of the source and destinations. The size of this field will vary depending on the addressing mode used for the transmission:

Single Octet Addressing:	2-17 octets
Four Octet Addressing:	6-85 octets
Six Octet Addressing:	8-119 octets

5.3.4.2.2.1 Address format.
Three Data Link address formats are supported: single octet, four octet, and six octet. Single octet addressing shall be mandatory for any system using IPv4 or N-Layer Pass-Through at the Network Layer for synchronous, asynchronous, and packet modes of operation. Four octet and six octet addressing shall be optional for any system using IPv4 or N-Layer Pass-Through at the Network Layer for synchronous, asynchronous, and packet modes of operation. Six octet addressing shall be mandatory for any system using IPv6 at the Network Layer for synchronous, asynchronous, and packet modes of operation. Any system transmitting messages using IPv6 at the Network Layer shall only use six octets addressing at the Data Link Layer for Individual Addresses. Six Octet Individual Addresses at the Data Link Layer permit the use of ICMPv6 Autoconfiguration and Neighbor Discovery on IPv6 networks. Single octet, four octet, and six octet addressing for individual addresses (see paragraph 5.3.4.2.2.2.2.5) shall not be mixed in the same net. However, four octet or six octet individual addresses can be mixed with single octet Special Addresses, as described in paragraph 5.3.4.2.2.2.2.7.

5.3.4.2.2.1.1 Single octet addressing.
Each address in the address fields shall consist of a single octet. The source address octet shall consist of a command/response (C/R) designation bit (the LSB) followed by a 7-bit address representing the source. Each destination octet shall consist of an extension bit (the LSB) followed by the 7-bit destination address. The destination address uses a modification of the High-Level Data Link Control (HDLC) extended addressing format. The destination address shall be extended by setting the extension bit of a destination address octet to 0, indicating that the following octet is another destination address. The destination address field shall be

terminated by an octet that has the extension bit set to 1. The destination address field shall be extendible from 1 address octet to 16 address octets. The format of the address fields shall be as shown in FIGURE 13.

5.3.4.2.2.1.2 Four octets addressing.
Each address in the address fields shall consist of four octets, except for special, global multicast and group multicast addresses which are a single octet. The four octets of address space shall be preceded by a single octet 32-bit marker subfield. This field, containing a fixed value of 126, is used to indicate that the next four octets contain the actual link layer address. In the source address field the 32-bit marker subfield shall consist of a command/response (C/R) designation bit (the LSB) followed by a 7-bit value=126. In the destination address field the 32-bit marker subfield shall consist of an extension bit (the LSB) followed by the 7-bit value=126. If the destination address field is extended, it shall be indicated by setting the extension bit of the 32-bit marker subfield of a destination address octet to 0. This subsequent address may be formatted in either four octets or a single octet (i.e. special, group multicast or global multicast). The destination address field shall be terminated by an octet (either a valid address or the 32-bit marker subfield) that has the extension bit set to 1. The destination address field shall be extendible from 1 address to 16 addresses.

5.3.4.2.2.1.3 Six octets addressing.
Each address in the address fields shall consist of six octets, except for special, global multicast and group multicast addresses which are a single octet. The six octets of address space shall be preceded by a single octet 48-bit marker subfield. This field, containing a fixed value of 125, is used to indicate that the next six octets contain the actual link layer address. In the source address field the 48-bit marker subfield shall consist of a command/response (C/R) designation bit (the LSB) followed by a 7-bit value=125. In the destination address field the 48-bit marker subfield shall consist of an extension bit (the LSB) followed by the 7-bit value=125. If the destination address field is extended, it shall be indicated by setting the extension bit of the 48-bit marker subfield of a destination address octet to 0. This subsequent address may be formatted in either six octets or a single octet (i.e. special, group multicast or global multicast). The destination address field shall be terminated by an octet (either a valid address or the 48-bit marker subfield) that has the extension bit set to 1. The destination address field shall be extendible from 1 address to 16 addresses.

5.3.4.2.2.1.3.1 Guaranteed uniqueness of six octet address when using IPv6.
Systems using IPv6 at the Network Layer shall only use six octet addressing and shall ensure that they have a universally unique six octet Data Link Layer address. This universally unique six octet Data Link Layer address shall be static and shall not change while a system is an active participant on an IPv6 network. This condition is critical to allow ICMPv6 Autoconfiguration and Neighbor Discovery to function properly. If a system implementing IPv6 at the Network Layer does not have a static universally unique six octet Data Link Layer address, correct participation on an IPv6 network can not be guaranteed. A recommended strategy for implementing this requirement is provided in section 6.3.3.1.

5.3.4.2.2.2 Addressing convention.

The following addressing conventions shall be implemented in the 7 address bits of each address octet, 32-bit marker octet, or 48-bit marker octet. Address allocations, as shown in FIGURE 14, are divided among seven address types: individual, group, global, 32-bit marker, 48-bit marker, special, and reserved.

NOTE: Data link addresses are assigned by an administrative authority.

5.3.4.2.2.2.1 Source and destination.

5.3.4.2.2.2.1.1 Source address.

The source address is either an individual or special (Net Control or Net Entry) address and is always the first address. Either single octet, four octets, or six octets formatting may be used. Its legal values range from 1 to 95, excluding 3 for single octet format. In four octets format legal values range from 0 to 2^{32}-1 (0.0.0.0 – 255.255.255.255 in dot notation). In six octets format legal values range from 0 to 2^{48}-1 (00-00-00-00-00-00 to FF-FF-FF-FF-FF-FF in hex notation as per RFC 2464). If IPv6 is used at the Network Layer, the Source Address shall be six octets. The first octet of the source address has two parts: the C/R designation bit (bit 1, LSB) and the actual 7-bit address value. The C/R designation bit shall be set to 0 for commands and 1 for responses.

MSB							LSB	
8	7	6	5	4	3	2	1	
X	X	X	X	X	X	X	0/1	SOURCE Octet (1 = response; 0 = command)
X	X	X	X	X	X	X	0	DESTINATION 1 Octet
						..	.	
						..	.	
						..	.	
X	X	X	X	X	X	X	1	DESTINATION M Octet where M ≤ 16

Note: In four octets addressing the 32-bit marker octet is followed by the actual four octet address. In six octets addressing the 48-bit marker octet is followed by the actual six octet address.

FIGURE 13. Extended address field format.

MSB							LSB		
1	1	1	1	1	1	1	1	127	Global Multicast Address
1	1	1	1	1	1	0	X	126	32-bit Marker (4 octet addressing)
1	1	1	1	1	0	1	X	125	48-bit Marker (6 octet addressing)
1	1	X	X	X	X	X	X	96-124	Group Multicast Addresses
X	X	X	X	X	X	X	X	4-95	Individual Addresses (Single Octet)
0	0	0	0	0	1	1	X	3	Special (Immediate Retransmission)
0	0	0	0	0	1	0	X	2	Special (Net Control) Address
0	0	0	0	0	0	1	X	1	Special (Net Entry) Address
0	0	0	0	0	0	0	X	0	Reserved Address

FIGURE 14. Address allocation.

5.3.4.2.2.2.1.2 Destination address(es).
The second through seventeenth addresses are labeled destination addresses, which may be global, group, individual, or special addresses. Each destination address may be formatted as a single octet, four octets, or six octets. The first octet of each destination address (an actual address or the 32-bit or 48-bit marker) has two parts: the extension bit (bit 1, LSB) and the actual 7-bit value. An extension bit set to 0 indicates that 1 or more addresses (of either single octet, four octets, or six octets formats) follow. An extension bit set to 1 indicates the last address of the address string has been reached.

5.3.4.2.2.2.2 Types of addresses.
The following paragraphs describe the six types of addresses octets and how they shall be used.

5.3.4.2.2.2.2.1 Reserved address.
Address 0 is labeled a reserved address. A station receiving a value of 0 in the destination address field shall ignore the address and continue processing any remaining addresses.

5.3.4.2.2.2.2.2 Special addresses.
Addresses 1, 2 and 3 are labeled special addresses. Addresses 1 and 2 are provided as network control (NETCON) and unit entry addresses for units entering a new network without knowledge of actual addresses being used. These special addresses are used as described in APPENDIX E (E.5.1). The special address 3 is used for Type 3 transmissions which require an immediate retransmission capability.

5.3.4.2.2.2.2.3 32-bit marker subfield.
The 32-bit marker subfield is used to indicate the four octets immediately following it represent a four octet individual address. This subfield has a value=126.

5.3.4.2.2.2.2.4 48-bit marker subfield.
The 48-bit marker subfield is used to indicate the six octets immediately following it represent a six octet individual address. This subfield has a value=125.

5.3.4.2.2.2.2.5 Individual addresses.
Individual addresses uniquely identify a single station on a broadcast subnetwork. Individual addresses may be a single octet, four octets, or six octets in length. Individual single octet addresses shall be assigned within the address range 4 to 95. Individual four octets addresses shall be assigned within the address range 0.0.0.0 to 255.255.255.255 in dot notation. Individual six octet address shall be assigned within the address range 0 to 2^{48}-1 (00-00-00-00-00-00 to FF-FF-FF-FF-FF-FF in hex notation). If IPv6 is used at the Network Layer, Individual Addresses shall be six octets. Stations shall be capable of sending and receiving 1 to 16 individual destination addresses in a single data link frame. Sending stations shall use any individual address just once in a data link frame. When individual address(es) are present, a receiving station shall receive all addresses, search for its unique individual address, and follow the media access procedures described in APPENDIX C.

5.3.4.2.2.2.2.6 Group multicast addresses.
Group multicast addressing, used when broadcasting messages to multiple (but not all) stations on a broadcast subnetwork, may be implemented. The valid address range shall be 96 to 124. Assignment of membership to (or deletion from) a group is outside the scope of this protocol. While the use of link group multicast addresses is optional, all stations shall be capable of recognizing received group addresses. If a receiving station does not implement group addressing procedures, it shall still process all received addresses, but ignore the group addresses (that is, recognize range 96 to 124 as group addresses). When group addressing is implemented, a station shall be capable of sending and receiving 1 to 16 destination group addresses. Coupled data link acknowledgment of group multicast addresses using the F-bit shall not be allowed. An uncoupled TEST response PDU with its F-bit set to zero shall be sent in response to a TEST command PDU addressed to a group multicast address when the receiving station is a member of the specified group.

5.3.4.2.2.2.2.7 Individual, special and multicast addresses mixed.
All stations shall be capable of sending and receiving Special, Individual, and optionally Multicast (group and global) addresses "mixed" in a destination address subfield. The reception and acknowledgment procedures stated in this paragraph shall be for all stations even those that do not implement group multicast addressing procedures.

a. The total number of destination addresses shall not exceed 16.

b. All individual and special addresses shall precede multicast addresses.

c. The special address 3, if used, shall follow all individual, reserved, and other special addresses but shall precede multicast addresses.

d. Individual addresses occurring after the special address 3 shall be ignored by receiving stations. Specifically, the receiving stations whose individual address is listed after special address 3 shall not generate a Type 3 acknowledgment in response to receipt of the Type 3 frame, and other receiving stations shall not reserve an acknowledgment time slot for stations matching these individual addresses to send acknowledgments.

e. Only one type of multicast address (group or global) shall be mixed in a destination address subfield.

f. If multicast, special and individual addresses are mixed, only the individual and special addresses shall be acknowledged when indicated.

g. Multicast addresses shall not be acknowledged but a data link response (using a TEST Response PDU) is allowed in the case where a TEST message is received with a multicast address in the destination field and the poll bit is set to 0.

h. A station that optionally implements multicast (group and global) addressing shall also be capable of sending and receiving multicast, special and individual addresses "mixed" in a destination subfield.

i. Stations shall treat single, four, and six octet addresses as separate and distinct addresses, e.g. address "3" with no 32-bit or 48-bit marker preceding it is different than address "0.0.0.3" preceded by the 32-bit marker "126", which is different than address "0-0-0-0-0-3" preceded by the 48-bit marker "125".

j. Reserved, Special, Group and Global Multicast Addresses, and the 32-bit and 48-bit Markers shall always be single octet addresses. Only single octet addresses shall represent Reserved, Special, Group and Global Multicast Addresses, and the 32-bit and 48-bit Makers.

k. The address types enumerated in "5.3.4.2.2.2.2.7.j" above can be mixed with four or six octet Individual Addresses. Therefore, a station could receive the following in the Destination Address field:

126	0	0	0	3	3

Indicating that the message has one four octet destination address ('0.0.0.3') and is using Immediate Retransmission (Special Address '3').

5.3.4.2.2.2.2.8 Global multicast addressing.
Global multicast addressing, used when broadcasting messages to all systems on a broadcast subnetwork, shall be implemented through the unique bit pattern 1111111 (127). This global multicast address shall be used to indicate broadcasting at the Data Link Layer, independent of the Upper Layer Protocol addressing mechanism being used to request the Global Multicast. If the global address is used, it shall be the only multicast destination address, but individual

addresses are allowed with the global address. All broadcast stations shall be capable of receiving and sending this address, and all stations will process the information contained within the frame. Data link acknowledgment of the global address shall not be allowed, although the TEST response PDU is allowed in the case where a TEST message is received with the global address in the destination field and the poll bit is set to 0. Coupled data link acknowledgment of the global address using the F-bit shall not be allowed. An uncoupled TEST response PDU with its F-bit set to zero shall be sent in response to a TEST command PDU addressed to the global address.

5.3.4.2.2.3 Mapping.
A data link address is a point of attachment to a broadcast network. The upper-layer protocol is responsible for mapping one or more upper-layer addresses to a data link address. Multiple upper-layer addresses may map to one or more group or individual addresses.

5.3.4.2.3 Control field.
The control field indicates the type of PDU and the response requirements and connection information about the PDU being transmitted over the data link. A summary of the formats and bit patterns (showing MSB as the left most bit) for Types 1, 2, 3 and 4 is shown in TABLE IV, TABLE V, TABLE VI, and TABLE VII, respectively. FIGURE 15 illustrates the data link PDU control field formats.

TABLE IV. Type 1 PDU formats.

COMMANDS/ RESPONSES	ADDRESS FIELD	CONTROL FIELD The left-most bit is the most significant bit.	INFORMATION FIELD
U PDUs UNNUMBERED INFORMATION (UI) COMMAND	Contains the source address and up to 16 individual, special, group or global addresses for which the message is intended.	Bit pattern = 00000011 identifies this frame as a UI PDU not requiring acknowledgment.	Contains data from the upper protocol layer.

TABLE IV. Type 1 PDU formats-Continued

COMMANDS/ RESPONSES	ADDRESS FIELD	CONTROL FIELD The left-most bit is the most significant bit.	INFORMATION FIELD
U PDUs UNNUMBERED RECEIVE READY (URR) COMMAND	Contains the source address, and up to 16 individual, group or global addresses to indicate that the sending station is ready to receive I, DIA and UI PDUs.	Bit pattern = 00100011 indicating receive ready command.	No information field allowed.
UNNUMBERED RECEIVE NOT READY (URNR) COMMAND	Contains the source address and up to 16 individual, group or global addresses to indicate that the sending station is busy and can not receive I, DIA and UI PDUs.	Bit pattern = 00001011 indicating receive not ready command.	No information field allowed.
TOPOLOGY UPDATE ID INDICATION	Contains the full 8-bit Topology Update ID used in the most recent Topology Update message (see 5.4.1.2). If no Topology Updates have been issued, this PDU will not be used.	Bit pattern = 10000011 indicating the most recently generated Topology Update ID.	Bit pattern= TTTTTTTT
VERSION CANTPRO INDICATION	Contains the received Version Number that is not implemented and the preferred Version Number for future communications.	Bit pattern = 11000011 indicating the “CANTPRO” Version Number and the “Preferred” Version Number.	Bit pattern= 0CCC0PPP.
TEST COMMAND	Contains the source address and up to 16 individual, group or global addresses that are to respond.	Bit pattern = 11100011 indicating test command.	Information field optional.
TEST RESPONSE	Contains the source address and the destination address to which this response is being sent.	Bit pattern = 11100011 indicating test response.	Information field optional.

TABLE V. Type 2 PDU formats.

COMMANDS/ RESPONSES	ADDRESS FIELD	CONTROL FIELD The left-most bit is the most significant bit.	INFORMATION FIELD
U PDUs			
SET ASYNCHRONOUS BALANCED MODE EXTENDED (SABME) COMMAND	Contains the source address and up to 16 individual addresses of stations to receive this PDU.	Bit pattern = 001X1111	No information field allowed.
DISCONNECT (DISC) COMMAND	Contains the source address and up to 16 individual addresses of stations to receive this PDU.	Bit pattern = 010X0011	No information field allowed.
RESET (RSET) COMMAND	Contains the source address and up to 16 individual addresses of stations to receive this PDU.	Bit pattern = 100X1111	No information field allowed.
UNNUMBERED ACKNOWLEDGMENT (UA) RESPONSE	Contains the source address and up to 16 individual addresses of stations to receive this PDU.	Bit pattern = 011X0011	No information field allowed.
DISCONNECT MODE (DM) RESPONSE	Contains the source address and up to 16 individual addresses of stations to receive this PDU.	Bit pattern = 000X1111	No information field allowed.
FRAME REJECT (FRMR) RESPONSE	Contains the source address and up to 16 individual addresses of stations to receive this PDU.	Bit pattern = 100X0111	See FIGURE 19.
I PDU			
ACKNOWLEDGMENT OR OTHER APPROPRIATE RESPONSE REQUIRED	Contains the source address and up to 16 individual, group or global addresses for which the message is intended.	Bit pattern = RRRRRRRXSSSSSSS0. Identifies this frame as an I PDU.	Contains data from the upper protocol layer.

TABLE V. Type 2 PDU formats-Continued

COMMANDS/ RESPONSES	ADDRESS FIELD	CONTROL FIELD The left-most bit is the most significant bit.	INFORMATION FIELD
S PDUs			
RECEIVE READY (RR) COMMAND	Contains the source address and up to 16 individual, group or global addresses of stations to receive this PDU.	Bit pattern = RRRRRRRX00000001, indicating receive ready command.	No information field allowed.
RECEIVE READY (RR) RESPONSE	Contains the source address and up to 16 individual addresses of stations to receive this PDU.	Bit pattern = RRRRRRRX00000001, indicating last I PDU is acknowledged.	No information field allowed.
RECEIVE NOT READY (RNR) COMMAND	Contains the source address and up to 16 individual, group or global addresses of stations to receive this PDU.	Bit pattern = RRRRRRRX00000101, indicating receive not ready command.	No information field allowed.
RECEIVE NOT READY (RNR) RESPONSE	Contains the source address and up to 16 individual addresses of stations to receive this PDU.	Bit pattern = RRRRRRRX00000101, indicating receive not ready response.	No information field allowed.
SELECTIVE REJECT (SREJ) COMMAND	Contains the source address and up to 16 individual addresses of stations to receive this PDU.	Bit pattern = RRRRRRRX00001101 indicating selective reject command.	No information field allowed.
SELECTIVE REJECT (SREJ) RESPONSE	Contains the source address and up to 16 individual addresses of stations to receive this PDU.	Bit pattern = RRRRRRRX00001101 indicating selective reject response.	No information field allowed.

TABLE V. Type 2 PDU formats-Continued

COMMANDS/ RESPONSES	ADDRESS FIELD	CONTROL FIELD The left-most bit is the most significant bit.	INFORMATION FIELD
S PDUs			
REJECT (REJ) COMMAND	Contains the source address and up to 16 individual addresses of stations to receive this PDU.	Bit pattern = RRRRRRRX00001001 indicating reject command.	No information field allowed.
REJECT (REJ) RESPONSE	Contains the source address and up to 16 individual addresses of stations to receive this PDU.	Bit pattern = RRRRRRRX00001001 indicating reject response.	No information field allowed.

(X represents the P/F bit setting, S represents send sequence number, and R represents receive sequence number.)

TABLE VI. Type 3 PDU Formats.

COMMANDS/ RESPONSES	ADDRESS FIELD	CONTROL FIELD The left-most bit is the most significant bit.	INFORMATION FIELD
U PDUs			
UNNUMBERED INFORMATION (UI) COMMAND ACKNOWLEDGMENT REQUIRED	Contains the source address and up to 16 individual, special, group or global addresses that are to respond.	Bit pattern = 00010011 identifies this frame as a UI PDU requiring acknowledgment.	Contains data from the upper protocol layer.
UNNUMBERED RECEIVE READY (URR) RESPONSE	Contains the source address and the destination address of a received UI PDU, to which this frame acknowledges.	Bit pattern = 00110011 indicating last UI PDU is acknowledged.	No information field allowed.
UNNUMBERED RECEIVE NOT READY (URNR) RESPONSE	Contains the source address and the destination address to which this response is being sent.	Bit pattern = 00011011 indicating receive not ready response.	No information field allowed.
TEST COMMAND	Contains the source address and up to 16 individual, group or global addresses that are to respond.	Bit pattern = 11110011 indicating test command.	Information field optional.

TABLE VI. Type 3 PDU Formats-Continued

COMMANDS/ RESPONSES	ADDRESS FIELD	CONTROL FIELD The left-most bit is the most significant bit.	INFORMATION FIELD
U PDUs TEST RESPONSE	Contains the source address and the destination address to which this response is being sent.	Bit pattern = 11110011 indicating test command.	Information field optional.

TABLE VII. Type 4 PDU formats.

COMMANDS/ RESPONSES	ADDRESS FIELD	CONTROL FIELD The left-most bit is the most significant bit.	INFORMATION FIELD
U PDU DECOUPLED INFORMATION ACKNOWLEDGMENT (DIA)	Contains the source address and up to 16 individual, group or global addresses for which the message is intended.	Bit pattern = <ID #->LL101011 L-bits are used to indicate PDU precedence.	Contains data from the upper protocol layer.
S PDUs DECOUPLED RECEIVE READY (DRR) COMMAND	Contains the source address and up to 16 individual, group or global address.	Bit pattern = 00000000LL010001 indicates a station is ready to receive DIA PDUs.	No information field allowed.
DECOUPLED RECEIVE READY (DRR) RESPONSE	Contains the source address and individual address for the originator of the DIA PDU which this PDU ACKs.	Bit pattern = <ID #->LL010001 L-bits are used to indicate precedence of PDU being acknowledged. The ID no. is that of the DIA PDU being acknowledged.	No information field allowed.
DECOUPLED RECEIVE NOT READY (DRNR) COMMAND	Contains the source address and up to 16 individual, group or global address.	Bit pattern = 00000000LL010101 indicates a station is not ready to receive DIA PDUs due to a busy condition.	No information field allowed.

TABLE VII. Type 4 PDU formats-Continued

COMMANDS/ RESPONSES	ADDRESS FIELD	CONTROL FIELD The left-most bit is the most significant bit.	INFORMATION FIELD
S PDUs DECOUPLED RECEIVE NOT READY (DRNR) RESPONSE	Contains the source address and individual address for the originator of the DIA PDU which this PDU ACKs.	Bit pattern = <ID #->LL010101 L-bits used to indicate precedence of PDU being acknowledged. The ID no. is that of the DIA PDU being acknowledged. PDU indicates a station is not ready to receive DIA PDUs due to a busy condition.	No information field allowed.

	MSB 16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	LSB 1
INFORMATION TRANSFER Type 2	N(R)							P/F	N(S)							0
SUPERVISORY COMMANDS/RESPONSES (S PDUs) Type 2	N(R)							P/F	Z	Z	Z	Z	S	S	0	1
Type 4	ID Number								L	L	0	1	S	S	0	1
UNNUMBERED COMMANDS/RESPONSES (U PDUs) Types 1, 2 & 3									M	M	M	P/F	M	M	1	1
Type 4	ID Number								L	L	1	0	1	0	1	1
Type 1 Topology Update ID Indication	Topology Update ID								1	0	0	0	0	0	1	1
Type 1 CANTPRO Indication	0	C	C	C	0	P	P	P	1	1	0	0	0	0	1	1

FIGURE 15. Data link PDU control field formats.

Notes:

The LSB is the first bit delivered to and received from the physical layer.

N(S)	=	Transmitter send sequence number (Bit 2 = LSB)
N(R)	=	Transmitter receive sequence number (Bit 10 = LSB)
S	=	Supervisory Function bit
M	=	Modifier function bit
Z	=	Reserved and set to zero
P/F	=	Poll bit - command PDU transmissions Final bit - response PDU transmissions (1 = Poll/Final)
L	=	Level of precedence (LSB on right) 1 1 = reserved (value = 3) 1 0 = routine (value = 2) 0 1 = priority (value = 1) 0 0 = urgent (value = 0)
C	=	Version received that this station cannot process (LSB on right). Obtained from the MIL-STD-188-220 Version field in the received Transmission Information header.
P	=	Preferred Version for future communications (LSB on right). This is the same value used to populate the MIL-STD-188-220 Version field in the Transmission Information header.

FIGURE 15. Data link PDU control field formats-Continued

5.3.4.2.3.1 Type 1 operations.
For Type 1 operations, the control field is either an 8-bit or 16-bit pattern designating 1 of 7 types of U PDUs. The following PDUs have an 8-bit control field: UI Command, URR Command, URNR Command, TEST Command, and TEST Response. The URR and URNR PDUs are used to indicate overall station status. The Type 1 U PDUs that have a 16-bit pattern are: Topology Update Indication and Version CANTPRO Indication.

5.3.4.2.3.2 Type 2 operations.
The Type 2 control field is a 16-bit pattern for I PDUs and S PDUs and includes sequence numbers. The Type 2 U PDUs have an 8-bit pattern. The Type 2 control field shall be repeated if more than one destination address is present. Each destination address field shall have a corresponding control field. Each of the corresponding control fields (when repeated) shall be identical except for the P/F bit and sequence numbers. The Type 1 Unnumbered Receive Ready (URR) and Unnumbered Receive Not Ready (URNR) PDUs are used to indicate overall station status. The RR and RNR are used to indicate station status for Type 2 operations only.

5.3.4.2.3.3 Type 3 operations.
For Type 3 operations, the control field is an 8-bit pattern designating 1 of 5 types of U PDUs: UI Command Acknowledgment Required, URR Response (used to acknowledge a Type 3 UI

Command), URNR Response, TEST Command, and TEST Response. The URR and URNR PDUs are used to indicate overall stations status.

5.3.4.2.3.4 Type 4 operations.
The Type 4 control field is a 16-bit pattern for U PDUs and S PDUs, and includes identification numbers. The control field distinguishes between a DIA PDU with a frame identification number and four S PDUs used in a connectionless environment with decoupled acknowledgments. The Type 1 URR and URNR are used to indicate overall station status. The DRR and Decoupled Receive Not Ready (DRNR) PDUs are used to indicate station status for Type 4 operations only.

5.3.4.2.3.5 Poll/final (P/F) bit.
The P/F bit serves a function in both command and response PDUs. In command PDUs, the P/F bit is referred to as the P-bit. In response PDUs, it is referred to as the F-bit. The P-bit set to 1 shall be used to solicit a response PDU, with the F-bit set to 1. On a data link, at most one PDU with P-bit set to 1 shall be outstanding in a given direction at a given time. Before a station issues another PDU with the P-bit set to 1 to a particular destination, it shall have received a response PDU from that remote station with the F-bit set to 1 or have timed out waiting for that response PDU. The P/F bit is not implemented in Type 4 operations.

5.3.4.2.3.6 Sequence numbers.
Sequence numbers are used only with Type 2 I and S PDUs. The Type 2 I and S PDUs shall contain sequence numbers. The sequence numbers shall be in the range of 0-127.

5.3.4.2.3.7 Identification numbers.
Identification numbers are used only with Type 4 DIA PDUs and DRR/DRNR S PDUs. The Type 4 DIA and DRR/DRNR response S PDUs shall contain an identification number. The identification number is used to identify each DIA PDU and permit decoupled acknowledgments in a connectionless environment. The identification numbers shall be in the range of 1-255. The identification number of an S PDU command (bits 9-16) shall be filled with zeroes.

5.3.4.2.3.8 Precedence.
The two level-of-precedence bits (L-bits) are used only in the control field of Type 4 PDUs. In the DIA PDU, the L-bits indicate the precedence of the data in the information field. In the DRR response S PDU, the L-bits are used to indicate the precedence of the DIA PDU information being acknowledged. The data link precedence values and their appropriate mappings to network layer precedence levels are indicated in 5.3.16.

5.3.4.2.4 Information field.
The information field may be present in either the I, UI, DIA, FRMR or TEST PDU. The length of the information field shall be a multiple of 8 bits, not to exceed 3345 octets. If the data is not a multiple of 8 bits, 1 to 7 fill bits (0) shall be added to meet this requirement. The maximum information field size defaults to 3345 octets. A smaller size may be established at initialization through local system information or using the exchange network parameters (XNP) messages

(see APPENDIX E). Contents of the information fields of the FRMR, TEST command and TEST response PDUs are described in 5.3.6.2.3.6, 5.3.6.1.6, and 5.3.6.1.7, respectively.

5.3.4.2.5 Frame Check Sequence (FCS).
For error detection, all frames shall include a 32-bit FCS prior to the closing flag sequence. The contents of the address, control, and information fields are included in the FCS calculation. Excluded from the FCS calculation are the 0's inserted by the 0-bit insertion algorithm. The formula for calculating the FCS, which is the 1's complement (inversion) of the remainder of a modulo-2 division process, employs the generator polynomial, P(X), having the form

$$P(x) = x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^{8} + x^{7} + x^{5} + x^{4} + x^{2} + x + 1$$

FCS generation shall be in accordance with the paragraph entitled "32-bit Frame Checking Sequence" in ISO 3309, and implemented in a manner that provides a unique remainder when a frame is received without bit errors incurred during transmission. (Note: When the FCS is implemented via a 32-bit shift register, the shift register shall be initialized to all ones before checking or calculation of the FCS). If the FCS of a received frame proves the frame to be invalid, the frame shall be discarded.

5.3.4.3 Data Link PDU construction.
The data link procedures that affect data link PDU construction include (a) order-of-bit transmission and 0-bit insertion, discussed below; and (b) FEC and TDC, discussed in 5.3.14.

5.3.4.3.1 Order-of-bit transmission.
The order-of-bit transmission function specifies the sequence in which bits are ordered by the data link layer for transmission by the PL. The Information Field and control field(s) shall be transmitted LSB of each octet first. The flag shall be transmitted LSB first. For the FCS, the most significant bit (MSB) shall be transmitted first.

For the address field, the source address octet is transmitted first and the destination address octet(s) are transmitted in order. For four octets addressing, the single octet 32-bit marker shall be transmitted first and the actual four octets link layer address shall be transmitted in the most significant to least significant octet order (Example: dot notation address 111.122.133.144, the most significant octet 111 is transmitted first, then 122, 133, 144 order). The LSB of each address octet is transmitted first. The information field octets shall be transmitted in the same order as received from the upper layers, LSB of each octet first.

5.3.4.3.2 Zero-bit insertion algorithm.
The occurrence of a spurious flag sequence within a frame or Transmission Header shall be prevented by employing a 0-bit insertion algorithm. After the entire frame has been constructed, the transmitter shall always insert a 0 bit after the appearance of five 1's in the frame (with the exception of the flag fields). After detection of an opening flag sequence, the receiver shall search for a pattern of five 1's. When the pattern of five 1's appears, the sixth bit shall be examined. If the sixth bit is a 0, the 5 bits shall be passed as data, and the 0 shall be deleted. If the sixth bit is a 1, the receiver shall inspect the seventh bit. If the seventh bit is a 0, a flag

sequence has been received. If the seventh bit is a 1, an invalid message has been received and shall be discarded.

5.3.5 Operational parameters.
The various parameters associated with the control field formats are described in the following sections.

5.3.5.1 Type 1 operational parameters.
The various parameters associated with the control field formats in Type 1 operation are described in 5.3.5.1.1 to 5.3.5.1.4.

5.3.5.1.1 P/F bit.
As all Type 1 commands are unacknowledged, the Poll (P) bit shall be set to 0 for all Type 1 PDUs.

5.3.5.1.2 Topology update ID.
The Topology Update ID field of this PDU shall contain the full 8-bit Topology Update ID used in the most recent Topology Update.

5.3.5.1.3 CANTPRO Version.
The CANTPRO Version Number subfield of the PDU Control field shall contain the unsupported Version from the received PDU.

5.3.5.1.4 Preferred Version Number.
The Preferred Version Number subfield of the PDU Control field shall contain the preferred Version for future communications. The Preferred Version should be consistent with the Version identifier used to populate the MIL-STD-188-220 Version subfield of the Transmission Information Header for transmitted messages.

5.3.5.2 Type 2 operational parameters.
The various parameters associated with the control field formats in Type 2 operation are described in 5.3.5.2.1 to 5.3.5.2.3.2.

5.3.5.2.1 Modulus.
Each I PDU shall be sequentially numbered with a numeric value between 0 and MODULUS minus ONE (where MODULUS is the modulus of the sequence numbers). MODULUS shall equal 128 for the Type 2 control field format. The sequence numbers shall cycle through the entire range. The maximum number of sequentially numbered I PDUs that may be outstanding (that is, unacknowledged) in a given direction of a data link connection at any given time shall never exceed one less than the modulus of the sequence numbers. This restriction will prevent any ambiguity in the association of sent I PDUs with sequence numbers during normal operation and error recovery action.

5.3.5.2.2 PDU-state variables and sequence numbers.
A station shall maintain a send-state variable, V(S), for the I PDUs it sends and a receive-state variable, V(R), for the I PDUs it receives on each data link connection. The operation of V(S) shall be independent of the operation of V(R).

5.3.5.2.2.1 Send-state variable V(S).
The V(S) shall denote the sequence number of the next in-sequence I PDU to be sent on a specific data link connection. The V(S) shall take on a value between 0 and MODULUS minus ONE. The value of V(S) shall be incremented by one with each successive I PDU transmission on the associated data link connection, but shall not exceed receive sequence number N(R) of the last received PDU by more than MODULUS minus ONE.

5.3.5.2.2.2 Send-sequence number N(S).
Only I PDUs shall contain N(S), the send sequence number of the sent PDU. Prior to sending an I PDU, the value of N(S) shall be set equal to the value of the V(S) for that data link connection, except for group or global addresses. The value for N(S) shall be set to 0 for group or global addresses and the P-bit shall be set to 0.

5.3.5.2.2.3 Receive-state variable V(R).
The V(R) shall denote the sequence number of the next in-sequence I PDU to be received on a specific data link connection. The V(R) shall take on a value between 0 and MODULUS minus ONE. The value of the V(R) associated with a specific data link connection shall be incremented by one whenever an error-free I PDU is received whose N(S) equals the value of the V(R) for the data link connection.

5.3.5.2.2.4 Receive-sequence number N(R).
All I and S PDUs shall contain N(R), the expected sequence number of the next received I PDU on the specified data link connection. Prior to sending an I or S PDU, the value of N(R) shall be set equal to the current value of the associated V(R) for that data link connection, except when the group or global address is utilized. When a group or global address is used, the associated N(R) shall be set to 0. N(R) shall indicate that the station sending the N(R) has received correctly all I PDUs numbered up through N(R)-1 on the specified data link connection, except for the N(R) associated with a group or global address. Group and global addresses provide no indication regarding correctly received PDUs.

5.3.5.2.3 Poll/final (P/F) bit.
The P/F bit shall serve a function in Type 2 operation in both command and response PDUs. In command PDUs the P/F bit shall be referred to as the P-bit. In response PDUs it shall be referred to as the F-bit. P/F bit exchange provides a distinct C/R linkage that is useful during both normal operation and recovery situations.

5.3.5.2.3.1 Poll-bit functions.
A command PDU with the P-bit set to 1 shall be used to solicit (poll) a response PDU with the F-bit set to 1 from the addressed station on a data link connection. Only one Type 2 PDU with a P-bit set to 1 shall be outstanding in a given direction at a given time on the data link connection

between any specified pair of stations. Before a station issues another PDU on the same data link connection with the P-bit set to 1, the station shall have received a response PDU with the F-bit set to 1 from the addressed station. If no valid response PDU is received within a system-defined P-bit timer time-out period, the resending of a command PDU with the P-bit set to 1 shall be permitted for error recovery purposes.

5.3.5.2.3.2 Final-bit functions.
The F-bit set to 1 shall be used to respond to a command PDU with the P-bit set to 1. Following the receipt of a command PDU with the P-bit set to 1, the station shall send a response PDU with the F-bit set to 1 on the appropriate data link connection at the first possible opportunity. First possible opportunity is defined as transmitting the frame ahead of other frames at the next network access opportunity. The response PDU shall be assigned an URGENT precedence. The station shall be permitted to send appropriate response PDUs with the F-bit set to 0 at any net access opportunity without the need for a command PDU.

5.3.5.3 Type 3 operational parameters.
The only parameter that exists in Type 3 operation is the P/F bit. As all Type 3 commands require acknowledgment, the Poll (P) bit shall be set to 1 to solicit (poll) an immediate correspondent response PDU with the Final (F) bit set to 1 from the addressed station. The response with F-bit set to 1 shall be transmitted in accordance with the response hold delay (RHD) procedures defined in APPENDIX C (C.4.2).

5.3.5.4 Type 4 operational parameters.
The two parameters associated with the control field formats in Type 4 operation are precedence described in 5.3.4.2.3.8 and Identification number.

5.3.5.4.1 Identification Number.
The Identification Number field is used in conjunction with the originator's station address to identify the PDU. The station's identification number is assigned just prior to the initial transmission of the PDU. This number is not changed on link layer retransmission of the PDU. Each station shall keep a number for originating PDUs. Duplicate frame identification numbers from the same originator shall not be used for more than one outstanding (unacknowledged) DIA PDU.

5.3.5.4.2 Type 4 duplicate frame detection.
Each station shall maintain historical information about recently received Type 4 DIA command frames. This historical information shall include, as a minimum, the source address, destination addresses, Identification number, FCS value, number of octets of user data and the number of times the DIA command frame has been received. The history shall not contain more than 255 entries for any sending station. When a station receives a Type 4 DIA command frame, it shall compare the frame against historical information about any DIA command frame in the history with the same Identification number that was previously received from the same sender. The DIA command frame shall be declared a non-duplicate if no matching history entry is found. If a matching history is found, the DIA command frame shall be declared a duplicate if both DIA command frames have the same number of octets of user data and the DIA command frame has

been received fewer than seven times and either the just received DIA command frame has fewer non-reserved destination addresses, or it has the same number of non-reserved destination addresses and the two frames have identical FCSs. If a matching history is found and the DIA command frame is not declared a duplicate, or whenever an XNP Hello or XNP Goodbye message is received from the sending station, all history entries associated with the sending station shall be discarded.

5.3.6 Commands and responses.

This section defines the commands and associated responses. Definitions of the set of commands and responses for each of the control field formats for Type 1, Type 2, Type 3, and Type 4 operations, respectively, are contained in 5.3.6.1, 5.3.6.2, 5.3.6.3, and 5.3.6.4. The C/R bit, the LSB of the source address field, is used to distinguish between commands and responses. The following discussion of commands and responses assumes that the C/R bit has been properly decoded. A single multi-addressed frame shall not contain different PDU types nor contain the same individual address more than once. The control field for all addresses in a single multi-addressed frame shall be the same except for the P/F bit and sequence number. Some of the commands described in the following paragraphs require a response at the earliest opportunity. Response PDUs requiring "earliest opportunity" transmission shall be queued ahead of all other PDUs, except those queued for "first possible opportunity" for transmission during the next network access opportunity. The response PDU shall assume the precedence level of the highest PDU queued or the mid (PRIORITY) level, whichever is greater. The Type 4 DRR response PDU shall assume the precedence of the DIA frame it is acknowledging.

5.3.6.1 Type 1 operation commands and indications.

Type 1 commands and indications are all U PDUs. The U PDU encodings for Type 1 operations are listed in FIGURE 16.

FIRST CONTROL FIELD BIT DELIVERED TO/RECEIVED FROM THE PHYSICAL LAYER
↓

LSB 1	2	3	4	5	6	7	MSB 8	Bit Position
1	1	0	0	0	0	0	0	UI Command
1	1	0	0	0	1	0	0	URR Command
1	1	0	1	0	0	0	0	URNR Command
1	1	0	0	0	0	0	1	Topology Update ID Indication
1	1	0	0	0	0	1	1	Version CANTPRO Indication
1	1	0	0	0	1	1	1	Test Command/Response

FIGURE 16. Type 1 operation control-field bit assignments.

5.3.6.1.1 Unnumbered Information (UI) command.
The UI PDU shall be used to send information to one or more stations. The P-bit of the control field of the UI PDU shall be set to 0 by the transmitter to specify that an acknowledgment is not required. The UI PDU shall be addressed to individual, special, group, or global addresses. The source address shall be the individual address of the transmitting station.

5.3.6.1.2 Unnumbered Receive-Ready (URR) command.
The Type 1 URR command PDU, with P-bit set to 0, shall be transmitted to one or more stations to indicate that the sending station is ready to receive I, DIA and UI PDUs. The URR PDU shall be addressed to individual, group, or global addresses. The source address shall be the individual address of the transmitting station.

5.3.6.1.3 Unnumbered Receive-Not-Ready (URNR) command.
The Type 1 URNR command PDU, with P-bit set to 0, shall be transmitted to one or more stations to indicate that the sending station is busy and cannot receive I, DIA or UI PDUs. The URNR PDU shall be addressed to individual, group, or global addresses. The source address shall be the individual address of the transmitting station.

5.3.6.1.4 Topology Update ID indication.
The Type 1 Topology Update ID indication PDU, with P-bit set to 0, shall be periodically transmitted to the global broadcast address (single octet 127) to indicate the most recent Topology Update ID in accordance with APPENDIX H (see H.4.4.3), if and only if Topology Updates are used (see 5.4.1.2). If no Topology Updates have been issued on the current network, this PDU shall not be transmitted.

5.3.6.1.5 Version CANTPRO indication.
The Type 1 Version CANTPRO indication PDU, with P-bit set to 0, shall be transmitted to a single station upon receipt of an incoming PDU with an unsupported MIL-STD-188-220 Version indicated in the subfield of the received Transmission Information header field. The PDU shall be transmitted to the station indicated in the originator address of the received PDU with the unsupported Version subfield. The “C” bits of the PDU Control field (see FIGURE 15) shall contain the received unsupported Version subfield. The “P” bits of the PDU Control field (see FIGURE 15) shall contain the Preferred Version for future communications. The Preferred Version should be consistent with the Version used to populate the MIL-STD-188-220 Version subfield of the Transmission Information header for transmitted messages (see 5.3.1.2). The action taken upon receiving a Version CANTPRO indication PDU will be determined by each individual system.

5.3.6.1.6 Test (TEST) command.
The TEST command shall be used to cause the destination station to respond with the TEST response at the earliest opportunity, thus performing a basic test of the transmission path. An information field is optional with the TEST command PDU. It may contain any bit pattern, but is limited to a maximum length of 128 octets. If present, however, the received information field shall be returned, if possible, by the addressed station in the TEST response PDU. The Type 1 TEST command, with the P-bit set to 0 shall cause each destination station (including members

of group and global addresses) to respond with a TEST response (with information field) with the F-bit set to 0 at the earliest opportunity. The TEST command PDU shall be addressed to an individual and/or group or global destination addresses. The source address shall be an individual address.

5.3.6.1.7 Test (TEST) response.
The Type 1 TEST response, with F-bit set to 0, shall be used by all addressees (individual, group and global) to reply to the TEST command with the P-bit set to 0 at the earliest opportunity. If an information field was present in the TEST command PDU that had the P-bit set to 0, the TEST response PDU shall contain the same information field contents. If the station cannot accept the information field of the TEST command, a TEST response without an information field may be returned. The source and destination addresses shall be an individual address.

5.3.6.2 Type 2 operation commands and responses.
Type 2 commands and responses consist of I, S, and U PDUs.

5.3.6.2.1 Information-transfer-format command and response.
The function of the information (I) command and response shall be to transfer sequentially numbered PDUs that contain an information field across a data link connection. N(S) and N(R) associated with group and global addresses shall be set to zero by the transmitter and ignored by the receiver and are not acknowledged. The encoding of the I PDU control field for Type 2 operation shall be as listed in FIGURE 17.

The I PDU control field shall contain two sequence number subfields: N(S), which shall indicate the sequence number associated with the I PDU; and N(R), which shall indicate the sequence number (as of the time the PDU is sent) of the next expected I PDU to be received, and, consequently, shall indicate that the I PDUs numbered up through N(R)-1 have been received correctly.

FIRST CONTROL FIELD BIT DELIVERED TO/RECEIVED FROM THE PHYSICAL LAYER ↓ LSB			MSB
1	2 3 4 5 6 7 8	9	10 11 12 13 14 15 16
0	N(S)	P/F	N(R)
INFORMATION TRANSFER FORMAT	SEND SEQUENCE NUMBER (0-127)	COMMAND (POLL) RESPONSE (FINAL)	RECEIVE SEQUENCE NUMBER (0-127)

FIGURE 17. Information-transfer-format control field bits.

5.3.6.2.2 Supervisory-format commands and responses.
Supervisory (S) PDUs shall be used to perform numbered supervisory functions such as acknowledgments, temporary suspension of information transfer, or error recovery. S PDUs shall not contain an information field and, therefore, shall not increment the V(S) at the sender or the V(R) at the receiver. Encoding of the S PDU control field for Type 2 operation shall be as

shown in FIGURE 18. An S PDU shall contain an N(R), which shall indicate, at the time of sending, the sequence number of the next expected I PDU to be received. This shall acknowledge that all I PDUs numbered up through N(R)-1 have been received correctly, except in the case of the selective reject (SREJ) PDU. The use of N(R) in the SREJ PDU is explained in 5.3.6.2.2.4 and 5.3.7.2.5.4.2.

FIRST CONTROL FIELD BIT DELIVERED TO/RECEIVED FROM THE PHYSICAL LAYER

LSB				MSB
1 2	3 4	5 6 7 8	9	10 11 12 13 14 15 16
1 0	S S	X X X X	P/F	N(R)
SUPER-VISORY FORMAT		RESERVED SET TO 0	COMMAND (POLL) RESPONSE (FINAL)	RECEIVE SEQUENCE NUMBER (0-127)

S S	COMMANDS/RESPONSES
00 (value 0)	RECEIVE READY (RR)
10 (value 1)	RECEIVE NOT READY (RNR)
01 (value 2)	REJECT (REJ)
11 (value 3)	SELECTIVE REJECT (SREJ)

FIGURE 18. Supervisory-format control field bits.

5.3.6.2.2.1 Receive-Ready (RR) command and response.
The RR PDU shall be used by a station to indicate it is ready to receive I PDUs. I PDUs numbered up through N(R)-1 shall be considered as acknowledged. When the RR command is transmitted using the group or global address, the receive sequence number in the control field associated with that group/global address shall be set to 0; and the P bit shall be set to 0.

5.3.6.2.2.2 Reject (REJ) command and response.
The REJ PDU shall be used by a station to request the resending of I PDUs, starting with the PDU numbered N(R). I PDUs numbered up through N(R)-1 shall be considered as acknowledged. It shall be possible to send additional I PDUs awaiting initial sending after the resent I PDUs. With respect to each direction of sending on a data link connection, only one "sent REJ" condition shall be established at any given time. The "sent REJ" condition shall be cleared upon receipt of an I PDU with an N(S) equal to the N(R) of the REJ PDU. The "sent REJ" condition may be reset in accordance with procedures described in 5.3.7.2.5.4. Receipt of a REJ PDU shall indicate the clearance of a busy condition except as noted in 5.3.7.2.5.8.

5.3.6.2.2.3 Receive-Not-Ready (RNR) command and response.
The RNR PDU shall be used by a station to indicate a busy condition (a temporary inability to accept subsequent I PDUs). I PDUs numbered up through N(R)-1 shall be considered as

acknowledged. I PDUs numbered N(R) and any subsequent I PDUs received shall not be considered as acknowledged; the acceptance status of these PDUs shall be indicated in subsequent exchanges. When the RNR command is transmitted using the group or global address, the receive sequence number in the control field associated with that group/global address shall be set to 0; and the P bit shall be set to 0.

5.3.6.2.2.4 Selective-Reject (SREJ) command and response.
The SREJ PDU is used by a station to request retransmission of the single I PDU numbered N(R). If the P/F-bit in the SREJ PDU is set to 1, then I PDUs numbered up to N(R)-1 shall be considered acknowledged. If the P/F-bit is set to 0, then the N(R) of the SREJ PDU does not indicate acknowledgment of any I PDUs. Each SREJ exception condition shall be cleared (reset) upon receipt of an I PDU with an N(S) equal to the N(R) of the SREJ PDU. A data station may transmit one or more SREJ PDUs, each containing a different N(R) with the P/F-bit set to 0, before one or more earlier SREJ exception conditions have been cleared. I PDUs that have been transmitted following the I PDU designated by the SREJ PDU shall not be retransmitted as the result of receiving the SREJ PDU. Additional I PDUs awaiting initial transmission may be transmitted following the retransmission of the specific I PDU requested by the SREJ PDU. The SREJ is used to recover from receipt of frames with various types of errors, including sequence number errors due to lost frames and FCS errors.

5.3.6.2.3 Unnumbered format (U) commands and responses.
U commands and responses shall be used in Type 2 operations to extend the number of data link connection control functions. The U PDUs shall not increment the state variables on the data link connection at either the sending or the receiving station. Encoding of the U PDU control field shall be as in FIGURE 19.

FIRST CONTROL FIELD BIT DELIVERED TO/RECEIVED FROM THE PHYSICAL LAYER
↓

LSB 1	2	3	4	5	6	7	MSB 8	
1	1	1	1	P	1	0	0	SABME Command
1	1	0	0	P	0	1	0	DISC Command
1	1	1	1	P	0	0	1	RSET Command
1	1	0	0	F	1	1	0	UA Response
1	1	1	1	F	0	0	0	DM Response
1	1	1	0	F	0	0	1	FRMR Response

FIGURE 19. Unnumbered-format control field bits.

5.3.6.2.3.1 Set Asynchronous Balanced Mode Extended (SABME) command.
The SABME command PDU shall be used to establish a data link connection to the destination station in the ABM. No information shall be permitted with the SABME command PDU. The destination station shall confirm receipt of the SABME command PDU by sending a UA

response PDU on that data link connection at the earliest opportunity. Upon acceptance of the SABME command PDU, the destination station V(S)s and V(R)s shall be set to 0. If the UA response PDU is received correctly, then the initiating station shall also assume the ABM with its corresponding V(S)s and V(R)s set to 0. Previously sent I PDUs that are unacknowledged when this command is executed shall remain unacknowledged. A station may resend the contents of the information field of unacknowledged outstanding I PDUs. The term "asynchronous" in this command does not necessarily imply the use of "asynchronous mode" as described in 5.2.1 Physical-layer Protocol Data Unit (PDU).

5.3.6.2.3.2 Disconnect (DISC) command.
The DISC command PDU shall be used to terminate an ABM previously set by a SABME command PDU. It shall be used to inform the destination station that the source station is suspending operation of the data link connection and the destination station should assume the logically disconnected mode. No information field shall be permitted with the DISC command PDU. Prior to executing the command, the destination station shall confirm the acceptance of the DISC command PDU by sending a UA response PDU on that data link connection. Previously sent I PDUs that are unacknowledged when this command is executed shall remain unacknowledged.

5.3.6.2.3.3 Reset (RSET) command.
The RSET command PDU shall be used by a station in an operational mode to reset the V(R) in the addressed station. No information field shall be permitted with the RSET command PDU. The addressed station shall confirm acceptance of the RSET command by transmitting a UA response PDU at the earliest opportunity. Upon acceptance of this command, the V(R) of the addressed station shall be set to 0. If the UA response PDU is received correctly, the initializing station shall reset its V(S) to 0.

5.3.6.2.3.4 Unnumbered Acknowledgment (UA) response.
The UA response PDU shall be used by a station on a data link connection to acknowledge receipt and acceptance of the SABME, DISC, and RSET command PDUs. These received command PDUs shall not be executed until the UA response PDU is sent. No information field shall be permitted with the UA response PDU.

5.3.6.2.3.5 Disconnect mode (DM) response.
The DM response PDU shall be used to report status indicating that the station is logically disconnected from the data link connection and is in asynchronous disconnected mode (ADM). No information field shall be permitted with the DM response PDU.

5.3.6.2.3.6 Frame Reject (FRMR) response.
The FRMR response PDU shall be used by the station in the ABM to report that one of the following conditions, which is not correctable by resending the identical PDU, resulted from the receipt of a PDU from the remote station:

a. The receipt of a command PDU or a response PDU that is invalid or not implemented. Below are three examples of invalid PDUs:

(1) the receipt of an S or U PDU with an information field that is not permitted,

(2) the receipt of an unsolicited F-bit set to 1, and

(3) the receipt of an unexpected UA response PDU.

b. The receipt of an I PDU with an information field that exceeded the established maximum information field length that can be accommodated by the receiving station for that data link connection.

c. The receipt of an invalid N(R) from the remote station. An invalid N(R) shall be defined as one that signifies an I PDU that has previously been sent and acknowledged, or one that signifies an I PDU that has not been sent and is not the next sequential I PDU waiting to be sent.

d. The receipt of an invalid N(S) from the remote station. An invalid N(S) shall be defined as an N(S) that is greater than or equal to the last sent N(R)+ k, where k is the maximum number of outstanding I PDUs. The parameter k is the window size indicated in the XNP message (see APPENDIX E).

The responding station shall send the FRMR response PDU at the earliest opportunity. An information field shall be returned with the FRMR response PDU to provide the reason for the PDU rejection. The information field shall contain the fields shown in FIGURE 20. The station receiving the FRMR response PDU shall be responsible for initiating the appropriate mode setting or resetting corrective action by initializing one or both directions of transmission on the data link connection, using the SABME, RSET or DISC command PDUs, as applicable.

FIRST CONTROL BIT DELIVERED TO/RECEIVED FROM THE PHYSICAL LAYER
↓
LSB … MSB

1--------------16	17	18-----24	25	26-----32	33--36	37--40
REJECTED PDU CONTROL FIELD	0	V(S)	C/R	V(R)	WXYZ	V000

Notes to FIGURE 20:

a. Rejected PDU control field shall be the control field of the received PDU that caused the FRMR exception condition on the data link connection. When the rejected PDU is a U PDU, the control field of the rejected PDU shall be positioned in bit positions 1-8, with 9-16 set to 0.
b. V(S) shall be the current send-state variable value for this data link connection at the rejecting station (bit 18 = low-order bit).
c. C/R set to 1 shall indicate that the PDU causing the FRMR was a response PDU, and C/R set to 0 shall indicate that the PDU causing the FRMR was a command PDU.

d. V(R) shall be the current receive-state variable value for this data link connection at the rejecting station (bit 26 = low-order bit).
e. W set to 1 shall indicate that the control field received and returned in bits 1 through 16 was invalid or not implemented. Examples of invalid PDU are defined as:
   i. the receipt of an S or U PDU with an information field that is not permitted,
   ii. the receipt of an unsolicited F-bit set to 1, and
   iii. the receipt of an unexpected UA response PDU.
f. X set to 1 shall indicate that the control field received and returned in bits 1 through 16 was considered invalid because the PDU contained an information field that is not permitted with this command or response. Bit W shall be set to 1 in conjunction with this bit.
g. Y set to 1 shall indicate that the information field received exceeded the established maximum information field length which can be accommodated by the rejecting station on that data link connection.
h. Z set to 1 shall indicate that the control field received and returned in bits 1 through 16 contained an invalid N(R).
i. V set to 1 shall indicate that the control field received and returned in bits 1 through 16 contained an invalid N(S). Bit W shall be set to 1 in conjunction with this bit.

FIGURE 20. FRMR information field format.

5.3.6.3 Type 3 operation commands and responses.
Type 3 commands and responses are all U PDUs. The U PDU encodings for Type 3 operations are listed in FIGURE 21.

FIRST CONTROL FIELD BIT DELIVERED TO/RECEIVED FROM THE PHYSICAL LAYER
↓

LSB 1	2	3	4	5	6	7	MSB 8	Bit Position
1	1	0	0	1	0	0	0	UI Command
1	1	0	0	1	1	0	0	URR Response
1	1	0	1	1	0	0	0	URNR Response
1	1	0	0	1	1	1	1	Test Command/Response

FIGURE 21. Type 3 operation control-field bit assignments.

5.3.6.3.1 Unnumbered Information (UI) command.
The UI PDU shall be used to send information to one or more stations. The P-bit of the control field of the UI PDU is used by the transmitter to request that individually addressed receiver(s) acknowledge receipt of the transmitted UI PDU. The UI PDU shall be addressed to individual, special, group, or global addresses. The source address shall be the individual address of the transmitting station.

5.3.6.3.2 Unnumbered Receive-Ready (URR) response.
The URR response shall be used to acknowledge a Type 3 UI command. The URR response shall be the first PDU sent by the receiving station upon receiving a UI command after the appropriate RHD period (see C.4.2). The source and destination shall be individual addresses.

5.3.6.3.3 Unnumbered receive-not-ready (URNR) response.
The URNR response PDU shall be used to reply to a Type 3 UI command if the UI command cannot be processed due to a busy condition. The URNR response PDU does not contain any acknowledgment information. If used, the URNR response shall be the first PDU transmitted by the receiving station, upon receiving a UI command, after the appropriate RHD period (see C.4.2). The URNR response shall have the F-bit set to 1 and shall be addressed to the source of the UI command.

5.3.6.3.4 Test (TEST) command.
The TEST command shall be used to cause the destination station to respond with the TEST response at the earliest opportunity, thus performing a basic test of the transmission path. An information field is optional with the TEST command PDU. It may contain any bit pattern, but is limited to a maximum length of 128 octets. If present, however, the received information field shall be returned, if possible, by the addressed station in the TEST response PDU. The Type 3 TEST command, with the P-bit set to 1, shall cause the individually addressed destination station(s) to respond with a TEST response PDU (with no information field), with the F-bit set to 1, after the appropriate RHD period (see C.4.2). Group and global addressees do not reply to a TEST command with the P-bit set to 1. The TEST command PDU shall be addressed to an individual and/or group or global destination addresses. The source address shall be an individual address.

5.3.6.3.5 Test (TEST) response.
The TEST response, with F-bit set to 1, without an information field shall be used by individual addressees to reply to the TEST command with the P-bit set to 1. The TEST response shall be the first PDU sent by the receiving station upon receiving a TEST command PDU, after the appropriate RHD period (see C.4.2). Group and global addressees do not reply to TEST command with P-bit set to 1. If the station cannot accept the information field of the TEST command, a TEST response without an information field may be returned. The source and destination addresses shall be an individual address.

5.3.6.4 Type 4 operation commands and responses.
The Type 4 commands and responses consist of U and S PDUs.

5.3.6.4.1 Unnumbered Information transfer format command.
The function of the Type 4 DIA commands shall be to transfer PDUs that contain an identification number and an information field across a connectionless link. The encoding of the PDU control field for Type 4 operation shall be as listed in FIGURE 22.

FIRST CONTROL BIT DELIVERED TO/RECEIVED FROM THE PHYSICAL LAYER ↓ LSB		MSB
PDU Identifier	L-bits	PDU Identification No.
1 2 3 4 5 6	7 8	9 10 11 12 13 14 15 16
1 1 0 1 0 1	L L	<---ID Number--->

FIGURE 22. Type 4 DIA PDU control field bit assignments.

5.3.6.4.1.1 DIA PDU acknowledgment.
Transmitted DIA PDUs are acknowledged by a Type 4 DRR response S PDU with the same precedence from the receiving stations, except for the following cases:

a. The receiving station is a global or group multicast addressee only.

b. The receiving station's link address is not in the destination address field.

c. The response mode parameter is set to no.

5.3.6.4.2 Supervisory format (S) commands and responses.
The S PDUs shall be used to convey link acknowledgment of a DIA PDU and whether or not a station is ready to receive Type 4 PDUs. The S PDU has a single destination address. For the command DRR and DRNR S PDUs the destination address is the global address and does not acknowledge DIA PDUs. These S PDUs are used to indicate Type 4 receive status. The response DRR S PDU contains a single destination address, that of the originator of the DIA PDU being acknowledged. The command S PDU level of precedence shall be set to the highest precedence while response S PDUs shall use the precedence of the DIA PDU which they are acknowledging. The encoding of the S PDU control field for Type 4 operation shall be as listed in FIGURE 23.

FIRST CONTROL BIT DELIVERED TO/RECEIVED FROM THE PHYSICAL LAYER ↓ LSB		MSB
PDU Identifier	L-bits	PDU Identification No.
1 2 3 4 5 6	7 8	9 10 11 12 13 14 15 16
1 0 0 0 1 0	0 0	0 0 0 0 0 0 0 0 DRR Command
1 0 0 0 1 0	L L	<---ID Number---> DRR Response
1 0 1 0 1 0	0 0	0 0 0 0 0 0 0 0 DRNR Command
1 0 1 0 1 0	L L	<---ID Number---> DRNR Response

FIGURE 23. Type 4 S PDU control field bit assignments.

5.3.7 Description of procedures by type.
The procedures for each operation type are described in 5.3.7.1, 5.3.7.2, 5.3.7.3, and 5.3.7.4 (and their subparagraphs). The four types of procedures can coexist on the same network.

5.3.7.1 Description of type 1 procedures.
The procedures associated with Type 1 operation are described in 5.3.7.1 and all subparagraphs.

Note: All stations must implement both Type 1 and Type 3 communications. Status of stations on the network, maintained by sending and receiving URR and URNR PDUs, shall be collaborated between Type 1 and Type 3 operations. For example, if a platform receives a Type 3 URNR Response from a station, that station should be considered busy for both Type 1 and Type 3 communications until a Type 1 URR Command is received by the platform. This applies to all URR Commands, URNR Commands, and URNR Responses.

5.3.7.1.1 Modes of operation.
In Type 1 operation, no modes of operation are defined. A station using Type 1 procedures shall support the entire procedure set described in the following paragraphs, whenever it is operational on the network.

5.3.7.1.2 Procedure for addressing.
The address fields shall be used to indicate the source and destinations of the transmitted PDU. The first bit in the source address field shall be used to identify whether a command or a response is contained in the PDU. Individual, group, special, and global addressing shall be

supported for destination addresses in command PDUs. The source address field shall contain an individual or special address.

5.3.7.1.3 Procedure for using the P/F bit.
For Type 1 operation, the transmitting station shall always set the P-bit equal to 0.

5.3.7.1.4 Procedures for logical data link set-up and disconnection.
Type 1 operation does not require any prior data link connection establishment (set-up), and hence no data link disconnection. Once the service access point has been enabled within the station, information may be sent to, or received from, a remote station also participating in Type 1 operation.

5.3.7.1.5 Procedures for information transfer.

5.3.7.1.5.1 Sending UI command PDUs.
Information transfer from an initiating station to a responding station shall be accomplished by sending the UI command PDU with the P-bit set to 0. Transmission of UI commands to stations detected as busy (due to receipt of a URNR Command or Response) shall be discontinued until the busy state is cleared. UI PDUs that have the P-bit set to 0 are not acknowledged nor retransmitted.

5.3.7.1.5.2 Receiving UI command PDUs.
Reception of the UI command PDU with P-bit set to 0 shall not be acknowledged.

5.3.7.1.5.3 Sending URNR command PDUs.
A URNR command PDU, with the P-bit set to 0, may be sent at any time to indicate a busy condition.

5.3.7.1.5.4 Receiving URNR command PDUs.
Receipt of the URNR indicates that the sending station is busy and, with one exception described below, no additional I, UI or DIA PDUs should be sent until the sending station regains its ability to receive messages. The URNR command PDU does not contain any acknowledgment information.

Exception: A Station may include a busy destination in a PDU that is addressed to multiple destination addresses if at least one of the multiple destinations is not busy.

5.3.7.1.5.5 Sending URR command PDUs.
A URR command PDU, with the P-bit set to 0, may be sent by a station at any time to indicate the regaining of its ability to receive messages.

5.3.7.1.5.6 Receiving URR command PDUs.
The receipt of the URR command PDU cancels the prior receipt of a URNR and indicates that the sending station is now operational.

5.3.7.1.5.7 Using TEST command and response PDUs.
The TEST function provides a facility to conduct loop-back tests of the station-to-station transmission path. The TEST function may be initiated within the data link layer by any authorized station within the data link layer. Successful completion of a test started by sending a TEST command PDU with the P-bit set to 0 consists of receiving a TEST response PDU with the F-bit set to 0 and containing the identical data from each individual, group or global addressee. The length of the information field is variable from 0 to 128 octets. Any TEST command PDU received in error shall be discarded and no response PDU sent. In the event of a test failure, it shall be the responsibility of the TEST function initiator to determine any future actions.

5.3.7.2 Description of type 2 procedures.
The procedures associated with Type 2 operation are described in 5.3.7.2.1 through 5.3.7.2.8.

5.3.7.2.1 Modes of operation.
Two modes of operation are defined for Type 2 operation: an operational mode and a non-operational mode.

5.3.7.2.1.1 Operational mode.
The operational mode shall be the ABM. ABM is a balanced operational mode in which a data link connection has been established between two stations. Either station shall be able to send commands at any time and initiate response transmissions without receiving explicit permission from the other station. Such an asynchronous transmission shall contain one or more PDUs that shall be used for information transfer and to indicate status changes in the station (for example, the number of the next expected I PDU; transition from a ready to a busy condition, or vice versa; occurrence of an exception condition). A station in ABM receiving a DISC command PDU shall respond with the UA response PDU if it is capable of executing the command. ABM consists of a data link connection phase, an information transfer phase, a data link resetting phase, and a data link disconnection phase.

5.3.7.2.1.2 Non-operational mode.
The non-operational mode shall be the ADM. ADM differs from ABM in that the data link connection is logically disconnected from the physical medium such that no information (user data) shall be sent or accepted. ADM is defined to prevent a data link connection from appearing on the physical medium in a fully operational mode during unusual situations or exception conditions. Such operation could cause a sequence number mismatch between stations or a station's uncertainty of the status of the other station. A data link connection shall be system-predefined as to the conditions that cause it to assume ADM. Below are three examples of possible conditions, in addition to receiving a DISC command PDU, that may cause a data link connection to enter ADM:

a. the power is turned on,

b. the data link layer logic is manually reset, or

c. the data link connection is manually switched from a local (home) condition to the connected-on-the-data-link (on-line) condition.

A station on a data link connection in ADM shall be required to monitor transmissions received from its PL to accept and respond to one of the mode-setting command PDUs (SABME, DISC), or to send a DM response PDU at a medium access opportunity, when required. In addition, since the station has the ability to send command PDUs at any time, the station may send an appropriate mode-setting command PDU. A station in ADM receiving a DISC command PDU or any I or S PDU shall respond with the DM response PDU. A station in ADM shall not establish a FRMR exception condition. ADM consists of a data link disconnected phase.

5.3.7.2.2 Procedure for addressing.
The address fields for a PDU shall be used to indicate the individual source and up to 16 destinations. The first bit in the source address field shall be used to identify whether a command or response is contained in the PDU. A single data link connection can be established between any two stations on the network.

5.3.7.2.3 Procedures for using the P/F bit.
An individually addressed station receiving a command PDU (SABME, DISC, RR, RNR, REJ, or I) with the P-bit set to 1 shall send a response PDU with the F-bit set to 1. The response PDU returned by a station to a RSET, SABME or DISC command PDU with the P-bit set to 1 shall be a UA or DM response PDU with the F-bit set to 1. The response PDU returned by a station to an I, RR, or REJ command PDU with the P-bit set to 1 shall be an I, RR, REJ, RNR, DM, or FRMR response PDU with the F-bit set to 1. The response PDU returned by a station to an RNR command PDU with the P-bit set to 1 shall be an RR, REJ, RNR, DM, or FRMR response PDU with the F-bit set to 1. The response PDU returned by a station to a SREJ with the P-bit set to one shall be the requested I PDU (response) with the F-bit set to one.

NOTE: The P-bit is usable by the station in conjunction with the timer recovery condition. (See 5.3.7.2.5.11)

5.3.7.2.4 Procedures for logical data link set-up and disconnection.

5.3.7.2.4.1 Data link connection phase.
Either station shall be able to take the initiative to initialize the data link connection.

5.3.7.2.4.1.1 Initiator action.
When the station wishes to initialize the link, it shall send the SABME command PDU to one or more individual addresses and start the acknowledgment timer(s). Upon receipt of the UA response PDU, the station shall reset both the V(S) and V(R) to 0 for the corresponding data link connection, shall stop the acknowledgment timer and shall enter the information transfer phase. When receiving the DM response PDU, the station that originated the SABME command PDU shall stop the acknowledgment timers for that link, shall not enter the information transfer phase for that station, and shall report to the higher layer for appropriate action. Should any acknowledgment timer run out before receiving all UA or DM response PDUs, the station shall

resend the SABME command PDU, after deleting the address and control fields corresponding to the received UAs or DMs, and restart the acknowledgment timers. After resending the SABME command PDU N2 times, the station shall stop sending the SABME command PDU, may report to the higher layer protocol and may initiate other error recovery action. The value of N2 is defined in 5.3.8.1.3.d. Other Type 2 PDUs received (commands and responses) while attempting to connect shall be ignored by the station.

5.3.7.2.4.1.2 Respondent action.
When a SABME command PDU is received, and the connection is desired, the station shall return a UA response PDU to the remote station, set both the V(S) and V(R) to 0 for the corresponding data link connection, and enter the information transfer phase. The return of the UA response PDU shall take precedence over any other response PDU that may be pending at the station for that data link connection. It shall be possible to follow the UA response PDU with additional PDUs, if pending. If the connection is not desired, the station shall return a DM response PDU to the remote station and remain in the link disconnected mode. For a description of the actions to be followed upon receipt of a SABME or DISC command PDU, see 5.3.7.2.4.4.

5.3.7.2.4.2 Information transfer phase.
After having sent the UA response PDU to an SABME command PDU or having received the UA response PDU to a sent SABME command PDU, the station shall accept and send I and S PDUs according to the procedures described in 5.3.7.2.5. Any time a station has established a connection and enters the information transfer phase, it should also send a DL-Status Indication to its local upper layer indicating a Type 2 connection has been established. When receiving an SABME command PDU while in the information transfer phase, the station shall conform to the resetting procedure described in 5.3.7.2.6. When receiving an RSET command PDU while in the information transfer phase, the station shall conform to the resetting procedure described in 5.3.7.2.7.

5.3.7.2.4.3 Data Link disconnection phase.
During the information transfer phase, either station shall be able to initiate disconnecting of the data link connection by sending a DISC command PDU and starting the acknowledgment timer(see 5.3.8.1.3.a). When receiving a DISC command PDU, the station shall return a UA response PDU and enter the Data Link disconnected phase. The return of the UA response PDU shall take precedence over any other response PDU that may be pending at the station for that data link connection. Upon receipt of the UA or DM response PDU from a remote station, the station shall stop its acknowledgment timer for that link, and enter the link disconnected mode. Should the acknowledgment timer run out before receiving the UA or DM response PDU for a particular link, the station shall send another DISC command PDU and restart the acknowledgment timer. After sending the DISC command PDU N2 times, the sending station shall stop sending the DISC command PDU, shall enter the data link disconnected phase, and shall report to the higher layer for the appropriate error recovery action. The value of N2 is defined in 5.3.8.1.3.d.

5.3.7.2.4.4 Data Link disconnected phase.
After having received a DISC command PDU from the remote station and returned a UA response PDU, or having received the UA response PDU to a sent DISC command PDU, the station shall enter the Data Link disconnected phase. In the disconnected phase, the station shall react to the receipt of an SABME command PDU, as described in 5.3.7.2.4.1, and shall send a DM response PDU in answer to a received DISC command PDU. When receiving any other Type 2 command, I or S PDU, the station in the disconnected phase shall send a DM response PDU. In the disconnected phase, the station shall be able to initiate a Data Link connection. Any time a station enters the disconnected phase, it should send a DL-Status Indication to its local upper layer indicating a Type 2 connection has been disconnected.

5.3.7.2.4.5 Contention of unnumbered mode-setting command PDUs.
A contention situation on a data link connection shall be resolved in the following way: If the sent and received mode- setting command PDUs are the same, each station shall send the UA response PDU at the earliest opportunity. Each station shall enter the indicated phase either after receiving the UA response PDU, or after its acknowledgment timer expires. If the sent and received mode-setting command PDUs are different, each station shall enter the data link disconnected phase and shall issue a DM response PDU at the earliest opportunity.

5.3.7.2.5 Procedures for information transfer.
The procedures that apply to the transfer of I PDUs in each direction on a data link connection during the information transfer phase are described in 5.3.7.2.5.1 through 5.3.7.2.5.11. When used, the term number one higher is in reference to a continuously repeated sequence series, that is, 127 is 1 higher than 126, and 0 is 1 higher than 127 for the modulo-128 series.

5.3.7.2.5.1 Sending I PDUs.
When the station has an I PDU to send (that is, an I PDU not already sent), it shall send the I PDU with an N(S) equal to its current V(S) and an N(R) equal to its current V(R) for that data link connection. At the end of sending the I PDU, the station shall increment its V(S) by 1. If the acknowledgment timer is not running at the time that an I PDU is sent, the acknowledgment timer shall be started. If the data link connection V(S) is equal to the last value of N(R) received plus *k* (where *k* is the maximum number of outstanding I PDUs; see 5.3.8.1.3.e), the station shall not send any new I PDUs on that data link connection, but shall be able to resend an I PDU as described in 5.3.7.2.5.6 or 5.3.7.2.5.9. Upon sending an I PDU that causes the number of outstanding I PDUs to be equal to the *k2* value for that connection, the station shall send an RR (or RNR) command to the destination station. The destination station shall respond with a RR Response with the N(R) indicating the last received I PDU. When a local station on a data link connection is in the busy condition, the station shall still be able to send I PDUs, provided that the remote station on this data link connection is not also busy. When the station is in the FRMR exception condition for a particular data link connection, it shall stop transmitting I PDUs on that data link connection. When a station is in the timer recovery condition, it shall not send any new I PDUs on that data link connection as per 5.3.7.2.5.11.

5.3.7.2.5.2 Receiving I PDUs.
When the station is not in a busy condition and receives an I PDU whose N(S) is equal to its V(R), the station shall accept the information field of this PDU, increment by 1 its V(R), and act as follows:

a. If an I PDU is available to be sent, the station shall be able to act as in 5.3.7.2.5.1 and acknowledge the received I PDU by setting N(R) in the control field of the next sent I PDU to the value of its V(R). The station shall also be able to acknowledge the received I PDU by sending an RR PDU with the N(R) equal to the value of its V(R).

b. If no I PDU is available to be sent by the station, then the station shall either:

(1) If the received I PDU is a command PDU with the P-bit set to 1, then send an S PDU with its F-bit set to 1 and its N(R) equal to the current value of V(R) at the first possible opportunity (this transmission is time critical to maintaining the connection), and stop the Response Delay Timer; or

(2) If the received I PDU is not a command PDU with the P-bit set to 1, then the station shall:

(a) If the number of outstanding I PDUs received since the last I PDU for which an acknowledgment was sent is equal to or greater than *k3*, then send an S PDU with its N(R) equal to the current value of V(R) at the earliest opportunity, and stop the Response Delay Timer; else

(b) If the number of outstanding I PDUs received since the last I PDU for which an acknowledgment was sent is less than *k3*, and if the Response Delay Timer is not already running, then start the Response Delay Timer. When the Response Delay Timer is running then the station shall:

(i) If an I PDU is sent back to the originator of the recently received I PDU before the Response Delay Timer expires, then stop the Response Delay Timer. The N(R) in the outgoing I frame will acknowledge any recently received correct in sequence I PDU frames as described in 5.3.7.2.5.1 (No S PDU needs to be sent); else

(ii) If another PDU of any type that can be concatenated is transmitted to any destination and adequate space exists to concatenate additional frames, then concatenate onto this PDU an S PDU with its N(R) equal to the current value of V(R) addressed to the originator of the recently received I PDU, and stop the Response Delay Timer; else

(iii) If the Response Delay Timer expires, then at the earliest opportunity, send an S PDU with its N(R) equal to the current value of V(R). (Note that S PDUs to other destinations may be concatenated with this frame as described in the preceding paragraph.)

c. If receipt of the I PDU caused the station to go into the busy condition with regard to any subsequent I PDUs, the station shall send an RNR PDU with the N(R) equal to the value of its V(R). If I PDUs are available to send, the station shall be able to send them (as in 5.3.7.2.5.1) prior to or following the sending of the RNR PDU.

When the station is in a busy condition, the station shall be able to ignore the information field contained in any received I PDU on that data link connection (See 5.3.7.2.5.10.).

5.3.7.2.5.3 Receiving incorrect PDUs.
When the station receives an invalid PDU or a PDU with an incorrect source address, the entire PDU shall be discarded. If an incorrect destination address is received, disregard that address field and continue processing the PDU.

5.3.7.2.5.4 Receiving out-of-sequence PDUs.
When the station receives one or more I PDUs whose N(S)s are not in the expected sequence, that is, not equal to the current V(R) but is within the receive window, the station shall respond by sending a REJ or a SREJ PDU as described in either 5.3.7.2.5.4.1 or 5.3.7.2.5.4.2. Use of the SREJ is the preferred method of indicating missing frames since it allows the receiving station to request the retransmission of only those frames that are actually missing. Use of REJ to indicate missing frames results in the unnecessary retransmission of frames that were received correctly since the procedure requires that frames received out of sequence be discarded until the missing frame is received. Use of REJ to indicate missing frames is intended for use by an implementation in the case that it is providing ordered delivery of I PDUs to the next layer and adequate storage is not available (on a static or dynamic basis) within the implementation to retain out-of-sequence frames until the missing frames are received.

5.3.7.2.5.4.1 Reject (REJ) response.
When an I PDU has been received out-of-sequence and more than one frame is missing, the station may discard the information field of the I PDU and send a REJ PDU with the N(R) set to the value of V(R). The station shall then discard the information field of all I PDUs until the expected I PDU is correctly received. When receiving the expected I PDU, the station shall acknowledge the PDU, as described in 5.3.7.2.5.2. The station shall use the N(R) and P-bit indications in the discarded I PDU. On a given data link connection, only one “sent REJ” exception condition from a given station to another given station shall be established at a time. A REJ and SREJ exception condition cannot be active at the same time. A “sent REJ” condition shall be cleared when the requested I PDU is received. The “sent REJ” condition shall be able to be reset when a REJ timer time-out function runs out. When the station perceives by REJ timer time-out that the requested I PDU will not be received, because either the requested I PDU or the REJ PDU was in error or lost, the station shall be able to resend the REJ PDU up to N2 times to reestablish the “sent REJ” condition. The value of N2 is defined in 5.3.8.1.2.b.

5.3.7.2.5.4.2 Selective reject (SREJ) response.
When an I PDU has been received and at least one frame is missing, the station may retain the information field of the out-of-sequence I PDUs and send SREJ PDUs for the missing I PDUs. A station may transmit one or more SREJ PDUs, each containing a different N(R) with the F-bit set to 0. However, a SREJ PDU shall not be transmitted if an earlier REJ condition has not been cleared. When the station perceives by the REJ timer time-out that the requested I PDU will not

be received, because either the requested I PDU or the SREJ PDU was in error or lost, the station shall be able to resend all outstanding SREJ PDUs in order to reestablish the "sent SREJ" condition up to N2 times.

5.3.7.2.5.5 Receiving acknowledgment.
When correctly receiving an I or S PDU, even in the busy condition (see 5.3.7.2.5.10), the receiving station shall consider the N(R) contained in this PDU as an acknowledgment for all the I PDUs it has sent on this data link connection with an N(S) up to and including the received N(R) minus one. The station shall reset the acknowledgment timer when it correctly receives an I or Type 2 S PDU with the N(R) higher than the last received N(R) (actually acknowledging some I PDUs). If High Reliability was requested for any of the acknowledged PDU(s), a DL-Status.Indication should be sent to the upper layer indicating acknowledgment success for those PDUs. If the timer has been reset and there are outstanding I PDUs still unacknowledged on this data link connection, the station shall restart the acknowledgment timer. If the timer then runs out, the station shall follow the procedures in 5.3.7.2.5.11 with respect to the unacknowledged I PDUs.

5.3.7.2.5.6 Receiving SREJ PDU.
If the received transmission is an SREJ command or response PDU, the I PDU corresponding to the N(R) being rejected shall be retransmitted.

5.3.7.2.5.7 Receiving RSET PDU.
Upon receipt of the RSET command PDU, the receiving station shall reply with a UA response PDU and shall then set its V(R) to 0 for the initiating station.

5.3.7.2.5.8 Receiving REJ PDU.
When receiving an REJ PDU, the station shall set its V(S) to the N(R) received in the REJ PDU control field. The station shall resend the corresponding I PDU as soon as it is available. If other unacknowledged I PDUs had already been sent on that data link connection following the one indicated in the REJ PDU, then those I PDUs shall be resent by the station following the resending of the requested I PDU. If retransmission beginning with a particular PDU occurs while waiting acknowledgment (see 5.3.7.2.5.11) and a REJ PDU is received, which would also start retransmission with the same I PDU [as identified by the N(R) in the REJ PDU], the retransmission resulting from the REJ PDU shall be inhibited.

5.3.7.2.5.9 Receiving RNR PDU.
A station receiving an RNR PDU shall, with one exception described below, stop sending I PDUs on the indicated data link connection at the earliest possible time and shall start the busy-state timer, if not already running. When the busy-state timer runs out, the station shall follow the procedure described in 5.3.7.2.5.11. In any case, the station shall not send any other I PDUs on that data link connection before receiving an RR or REJ PDU, or before receiving an I response PDU with the F-bit set to 1, or before the completion of a resetting procedure on that data link connection.

Exception: A Station may include a busy destination in a PDU that is addressed to multiple destination addresses if at least one of the multiple destinations is not busy.

5.3.7.2.5.10 Station-busy condition.
A station shall enter the busy condition on a data link connection when it is temporarily unable to receive or continue to receive I PDUs due to internal constraints; for example, receive buffering limitations. When the station enters the busy condition, it shall send an RNR PDU at the first possible opportunity. It shall be possible to send I PDUs waiting to be sent on that data link connection prior to or following the sending of the RNR PDU. The station may send a URNR command PDU to the global address after the RNR PDU. While in the busy condition, the station shall accept and process supervisory PDUs and return an RNR response PDU with the F-bit set to 1 if it receives an S or I command PDU with the P-bit set to 1 on the affected data link connection. To indicate the clearance of a busy condition on a data link connection, the station shall send an I response PDU with the F-bit set to 1 if a P-bit set to 1 is outstanding, an REJ response PDU, or an RR response PDU on the data link connection with N(R) set to the current V(R), depending on whether or not the station discarded information fields of correctly received I PDUs. The station may then send a URR command PDU to the global address. Additionally, the sending of a SABME command PDU or a UA response PDU shall indicate the clearance of a busy condition at the sending station on a data link connection.

5.3.7.2.5.11 Waiting acknowledgment.
The station maintains an internal retransmission count variable for each data link connection, which shall be set to 0 when the station receives or sends a UA response PDU to a SABME command PDU, when the station receives an RNR PDU, or when the station correctly receives an I or S PDU with the N(R) higher than the last received N(R) (actually acknowledging some outstanding I PDUs). If the acknowledgment timer, busy-state timer, or the P-bit timer runs out, the station on this data link connection shall enter the timer recovery condition and add 1 to its retransmission count variable. When a station is in the timer recovery condition, the station shall not send any new I PDUs to the destination station. The station shall then start the P-bit timer and send an S command PDU with the P-bit set to 1. The timer recovery condition shall be cleared on the data link connection when the station receives a valid I or S PDU from the remote station with the F-bit set to 1. If, while in the timer recovery condition, the station correctly receives a valid I or S PDU with:

a. the F-bit set to 1 and the N(R) within the range from the last value of N(R) received to the current V(S) inclusive, the station shall clear the timer recovery condition, set its V(S) to the received N(R), stop the P-bit timer, and resend any unacknowledged PDUs; or

b. the P/F bit set to 0 and the N(R) within the range from the last value of N(R) received to the current V(S) inclusive, the station shall not clear the timer recovery condition but shall treat the N(R) value received as an acknowledgment for the indicated previously transmitted I PDUs. (See 5.3.7.2.5.5.)

If the P-bit timer runs out in the timer recovery condition, the station shall add 1 to its retransmission count variable. If the retransmission count variable is less than N2, the station shall resend an S PDU with the P-bit set to 1 and restart its P-bit timer. If the retransmission count variable is equal to N2, the station shall initiate a resetting procedure, by sending a SABME command PDU, as described in 5.3.7.2.6. N2 is a system parameter defined in 5.3.8.1.2.b.

5.3.7.2.6 Procedures for mode resetting.
The resetting phase is used to initialize both directions of information transfer according to the procedure described in 5.3.7.2.6.1 through 5.3.7.2.6.3. The resetting phase shall apply only during ABM. Either station shall be able to initiate a resetting of both directions by sending a SABME command PDU and starting its acknowledgment timer. Any time a station resets its connection with a remote station, it should also send a DL-Status Indication to its local upper layer indicating a Type 2 connection has been reset.

5.3.7.2.6.1 Receiver action.
After receiving a SABME command PDU, the station shall return one of two types of responses, at the earliest opportunity:

a. a UA response PDU and reset its V(S) and V(R) to 0 to reset the data link connection, or

b. a DM response PDU if the data link connection is to be terminated.

The return of the UA or DM response PDU shall take precedence over any other response PDU for that data link connection that may be pending at the station. It shall be possible to follow the UA PDU with additional PDUs, if pending.

5.3.7.2.6.2 Initiator action.
If the UA PDU is received correctly by the initiating station, it shall reset its V(S) and V(R) to 0 and stop its acknowledgment timer. This shall also clear all exception conditions that might be present at either of the stations involved in the reset. The exchange shall also indicate clearance of any busy condition that may have been present at either station involved in the reset. If a DM response PDU is received, the station shall enter the data link disconnected phase, shall stop its acknowledgment timer, and shall report to the higher layer for appropriate action. If the acknowledgment timer runs out before a UA or DM response PDU is received, the SABME command PDU shall be resent and the acknowledgment timer shall be started. After the timer runs out N2 times, the sending station shall stop sending the SABME command PDU, and shall enter the ADM, may report to the higher layer protocol and may initiate other error recovery actions. The value of N2 is defined in 5.3.8.1.2.b. Other Type 2 PDUs, with the exception of the SABME and DISC command PDUs, received by the station before completion of the reset procedure shall be discarded.

5.3.7.2.6.3 Resetting with the FRMR PDU.
Under certain FRMR exception conditions (listed in 5.3.7.2.8), it shall be possible for the initiating station, by sending an FRMR response PDU, to ask the remote station to reset the data link connection. Upon receiving the FRMR response PDU (even during a FRMR exception condition), the remote station shall either initiate a resetting procedure, by sending a SABME or

RSET command PDU, or initiate a disconnect procedure, by sending a DISC command PDU. After sending an FRMR response PDU, the initiating station shall enter the FRMR exception condition. The FRMR exception condition shall be cleared when the station receives or sends a SABME or DISC command PDU, DM response PDU or RSET command PDU. Any other Type 2 command PDU received while in the FRMR exception condition shall cause the station to resend the FRMR response PDU with the same information field as originally sent. In the FRMR exception condition, additional I PDUs shall not be sent, and received I and S PDUs shall be discarded by the station. It shall be possible for the station to start its acknowledgment timer on the sending of the FRMR response PDU. If the timer runs out before the reception of a SABME or DISC command PDU from the remote station, it shall be possible for the station to resend the FRMR response PDU and restart its acknowledgment timer. After the acknowledgment timer has run out N2 times, the station shall reset the data link connection by sending a SABME command PDU. The value of N2 is defined in 5.3.8.1.2.b. When an additional FRMR response PDU is sent while the acknowledgment timer is running, the timer shall not be reset or restarted.

5.3.7.2.7 Procedures for sequence number resetting.
This resetting procedure, employing the RSET command, is used to reinitialize the V(R) in the addressed station and the V(S) in the local station. The addressed station shall confirm acceptance of the RSET command by transmission of a UA response at the earliest opportunity. Upon acceptance of this command, the addressed station V(R) shall be set to 0. If the UA response is received correctly, the initializing station shall reset its V(S) to 0. The RSET command shall reset all PDU rejection conditions in the addressed station, except for an invalid N(R) sequence number condition which the addressed station has reported by a FRMR. The RSET command may be sent by the station that detects an invalid N(R) to clear such a frame rejection condition in place of sending a FRMR frame. To clear an invalid N(R) frame rejection condition with an RSET command, the RSET command shall be transmitted by the station that detects the invalid N(R). A station may resend the contents of the information field of unacknowledged outstanding I PDUs. Any time a station resets its connection with a remote station, it should also send a DL-Status Indication to its local upper layer indicating a Type 2 connection has been reset.

5.3.7.2.8 FRMR exception conditions.
The station shall request a resetting procedure by sending an FRMR response PDU, as described in 5.3.7.2.6.3, after receiving, during the information transfer phase, a PDU with one of the conditions identified in 5.3.6.2.3.6. The coding of the information field of the FRMR response PDU that is sent is given in 5.3.6.2.3.6. The other station shall initiate a resetting procedure by sending a SABME or RSET command PDU, as described in 5.3.7.2.6, after receiving the FRMR response PDU.

5.3.7.3 Description of type 3 procedures.
The procedures associated with Type 3 operation are described in 5.3.7.3 and all subparagraphs.

Note: All stations must implement both Type 1 and Type 3 communications. Status of stations on the network, maintained by sending and receiving URR and URNR PDUs, shall be correlated between Type 1 and Type 3 operations. For example, if a platform receives a Type 3 URNR Response from a station, that station should be considered busy for both Type 1 and Type 3 communications until a Type 1 URR Command is received by the platform. This applies to all URR Commands, URNR Commands, and URNR Responses.

5.3.7.3.1 Modes of operation.
In Type 3 operation, no modes of operation are defined. A station using Type 3 procedures shall support the entire procedure set whenever it is operational on the network.

5.3.7.3.2 Procedure for addressing.
The address fields shall be used to indicate the source and destinations of the transmitted PDU. The first bit in the source address field shall be used to identify whether a command or a response is contained in the PDU. Individual, group, special, and global addressing shall be supported for destination addresses in command PDUs. The source address field shall contain an individual or special address.

5.3.7.3.3 Procedure for using the P/F bit.
For Type 3 operation, the transmitting station shall always set the P-bit equal to 1. The station receiving a UI or TEST command PDU with the P-bit set to 1 shall send an appropriate response PDU with the F-bit set to 1.

5.3.7.3.4 Procedures for logical data link set-up and disconnection.
Type 3 operation does not require any prior data link connection establishment (set-up), and hence no data link disconnection. Once the service access point has been enabled within the station, information may be sent to, or received from, a remote station also participating in Type 3 operation.

5.3.7.3.5 Procedures for information transfer.

5.3.7.3.5.1 Sending UI command PDUs.
Information transfer from an initiating station to a responding station shall be accomplished by sending the UI Command Acknowledgment Required PDU. When a sending station sends a UI command PDU with the P-bit set to 1, it shall start an acknowledgment timer for that transmission and initialize the internal transmission count variable to zero. If all expected URR or URNR response PDUs are not received before the timer runs out, the sending station shall resend the UI command PDU, increment the internal transmission count variable, and restart the acknowledgment timer. Prior to resending the UI command PDU, the group and global addresses shall be removed as well as individual and special addresses from which a response (URR or URNR) was received. The special address 3, if used, shall not be removed prior to retransmission unless it is the only address remaining. No retransmission shall be attempted unless an individual or special address other than 3 remains. If a URR response PDU is still not received, this resending procedure shall be repeated until the value of the internal transmission count variable is equal to the value of the logical link parameter N4, as described in 5.3.8.1.4.c, at which time a DL-Status-Indication shall be reported to the upper layer indicating an acknowledgment failure. An internal transmission count shall be maintained for each UI

information exchange (where P-bit = 1) between a pair of sending and receiving stations. Both the acknowledgment timer and the internal transmission count, for that exchange, shall not affect the information exchange with other receiving stations. If a URNR response PDU is received in response to a UI command with the P-bit set to 1, the receiving station shall designate the sending station as busy. The retransmission of the UI command shall follow the rules for the busy condition. Transmission of UI commands to that station shall be discontinued until the busy state is cleared.

5.3.7.3.5.2 Receiving UI command PDUs.
A station shall acknowledge the receipt of a valid UI command PDU, which has the P-bit set to 1 and contains the station individual address, by sending a URR response PDU to the originator of the command UI PDU. If the receiving station is unable to accept UI PDUs due to a busy condition, it may respond with a URNR response PDU, with the F-bit set to 1.

5.3.7.3.5.3 Sending URR response PDUs.
A URR response PDU, with the F-bit set to 1, shall be sent only upon receipt of a UI command PDU, with the P-bit set to 1. The URR response PDU shall be sent to the originator of the associated UI command PDU.

5.3.7.3.5.4 Sending URNR response PDUs.
A URNR response PDU, with the F-bit set to 1, may be sent by the remote station to advise the originator of the associated UI command PDU that it is experiencing a busy condition and is unable to accept UI PDUs.

5.3.7.3.5.5 Receiving UI acknowledgment.
After sending a UI command PDU with the P-bit set to 1, the sending station shall expect to receive an acknowledgment in the form of a URR response PDU from the station to which the command PDU was sent. No acknowledgment shall be expected from group or global addresses or from the special address 3. Upon receiving such a response PDU, the station shall stop the acknowledgment timer associated with the transmission for which the acknowledgment was received and reset the associated internal transmission count to zero. If the response was a URNR response PDU, the sending station will stop sending UI, I, and DIA PDUs to that remote station until a URR command PDU is received or the busy-state timer expires, indicating termination of the busy condition. If High Reliability was requested for the command PDU, a DL-Status-Indication should be sent to the upper layer indicating acknowledgment success.

5.3.7.3.5.6 Using TEST command and response PDUs.
The TEST function provides a facility to conduct loop-back tests of the station-to-station transmission path. The TEST function may be initiated within the data link layer by any authorized station within the data link layer. Successful completion of a test started by sending a TEST command PDU with the P-bit set to 1 consists of receiving a TEST response PDU with the F-bit set to 1 and containing no data from each individual addressee. Any TEST command PDU received in error shall be discarded and no response PDU sent. In the event of a test failure, it shall be the responsibility of the TEST function initiator to determine any future actions.

5.3.7.4 Description of type 4 procedures.
The procedures associated with Type 4 operation are described in 5.3.7.4.1 through 5.3.7.4.5.3.

5.3.7.4.1 Modes of operation.
In Type 4 operation, no modes of operation are defined. A station using Type 4 procedures shall support the entire set whenever it is operational on the network.

5.3.7.4.2 Procedure for addressing.
The address field shall be used to indicate the source and destinations of the transmitted PDU. The first bit in the source address shall be used to identify whether a command or a response is contained in the PDU. Individual, group, and global addressing shall be supported for the destination addresses in command PDUs. The source address shall contain an individual address.

5.3.7.4.3 Procedure for using the P/F bit.
The P/F bit is not implemented in Type 4 operation.

5.3.7.4.4 Procedures for logical Data Link set-up and disconnection.
Type 4 operation does not require any prior data link set-up and disconnection. Data link set-up and disconnection procedures are not required for Type 4 operation. All stations shall advance to the information transfer state.

5.3.7.4.5 Procedures for information transfer.

5.3.7.4.5.1 Sending DIA command frames.
The DIA PDU may either be a new PDU from the local user, or a retransmission of a DIA PDU which was not acknowledged within the period determined by the T1 parameter. DIA PDUs are retransmitted up to N2 times, where N2 is as specified by the station parameters. If a DIA PDU is not acknowledged after N2 retransmissions, an indication should be sent to the upper layer indicating an acknowledgment failure.

5.3.7.4.5.2 Decoupled Receive Not Ready (DRNR) procedures.

5.3.7.4.5.2.1 Sending a DRNR command PDU.
A station may generate and transmit a DRNR command PDU if its Quiet Mode is disabled and it receives a DIA PDU which it cannot accept because its receive buffers are full. A station may generate a DRNR command PDU when directed by the management function (e.g., operator). The DRNR command S PDU does not acknowledge a DIA PDU. The station may send a URNR command PDU to the global address after the DRNR PDU.

5.3.7.4.5.2.2 Receiving a DRNR command PDU.
Upon receipt of a DRNR PDU a station shall, with one exception described below, inhibit transmission of DIA PDUs to the station which originated the DRNR command by updating the station status table to reflect this busy condition. The DRNR PDU shall not change the Quiet Mode status of a station. Any PDUs in the retransmission queue addressed to the busy station

shall be modified to delete (null) the busy station from the destination address list. Normal transmissions of DIA PDUs to that station shall resume upon receipt of a DRR command from the station.

Exception: A Station may include a busy destination in a PDU that is addressed to multiple destination addresses if at least one of the multiple destinations is not busy.

5.3.7.4.5.2.3 Sending a DRNR response PDU.
A station shall generate and transmit a DRNR response PDU after it has sent a DRNR command PDU (if its Quiet Mode is disabled) while it is processing frames in its receive queues in the busy condition. A DRNR response acknowledges the DIA PDU indicated in the PDU identification number field while reinforcing the station's busy condition.

5.3.7.4.5.2.4 Receiving a DRNR response PDU.
Upon receipt of a DRNR response PDU, a station shall search the destination addresses associated with the identification number in the DRNR response PDU. The response PDU originator's address shall be deleted from the destination address field (if it is still there) of the DIA being acknowledged.

5.3.7.4.5.3 Decoupled receive ready (DRR) procedures.

5.3.7.4.5.3.1 Sending a DRR PDU.
A station shall generate and transmit a DRR PDU if its Quiet Mode is disabled and one of the following conditions exist.

a. The station is no longer busy and had previously sent a DRNR command PDU.

b. The station is not busy and the station received a DIA PDU from a transmitting station which requires acknowledgment.

c. If directed by the user interface.

5.3.7.4.5.3.1.1 Sending a DRR command PDU.
The DRR command PDU is generated and transmitted by a station to indicate the end of a Type 4 busy/buffer full condition. The DRR command S PDU does not acknowledge DIA PDUs. The DRR command PDU only changes the status from busy to receive ready. This frame does not change the Quiet Mode status. The station may send a URR command PDU to the global address after the DRR PDU.

5.3.7.4.5.3.1.2 Sending a DRR response PDU.
The DRR response PDU is generated and transmitted by a station whose Quiet Mode is disabled to acknowledge the acceptance of a DIA PDU, and is addressed to the originator of the DIA PDU. The DIA PDU which is being acknowledged is indicated by the PDU identification number.

5.3.7.4.5.3.2 Receiving a DRR response PDU.
Upon receipt of a DRR response PDU a station shall search the destination addresses associated with the identification number in the DRR response PDU. The DRR response PDU originator's address shall be deleted from the destination address field of the DIA being acknowledged. If High Reliability was requested for the DIA, an indication should be sent to the upper layer indicating acknowledgment success.

5.3.8 Data Link initialization.
The XNP messages, described in APPENDIX E, are used to establish and control Data Link parameters. The Join Request message contains the link operating parameters such as net busy detect time, station rank, and net access method. Initialization is caused by an operator or system request. The Join Request is sent to the default NETCON destination address, which shall be the station assigned to perform NETCON station responsibilities. The NETCON station verifies Data Link parameters and provides values for missing or incorrect parameters to ensure that the new station will not disrupt the net. The NETCON station will reply with either a Join Reject or Join Accept PDU. If the initializing station receives a Join Reject PDU, it should not attempt any link activity until the correct parameters have been obtained.

NOTE: Link initialization may also occur without an XNP message exchange. Prearrangement by timing, voice, written plans, or orders provides the operator with the necessary frequency, link address, data rate, and other parameters to enter a net and establish a link. With the prearranged information, an operator may begin link activity on the net and initialization is assumed when the new station senses the net and transmits its first message.

5.3.8.1 List of Data Link parameters.
This document defines a number of Data Link parameters for which the system-by-system range of values is determined at network establishment. The actual parameter values selected play an important role in determining the efficiency and effectiveness of the network configuration. It is therefore important to select proper values. Even more important is the need to insure that all participants on a subnetwork use the same parameter values. A bad choice of parameter values can significantly degrade the network performance. Using different values, even if the values are reasonable, can lead to a breakdown of the network precluding interoperability. A list of the parameters and their recommended values is provided in a separate document entitled "MIL-STD-188-220 Parameter Table". All systems should utilize these values. The definitions of the parameters for the four types of operation are summarized in 5.3.8.1.1 through 5.3.8.1.5.

5.3.8.1.1 Logical Data Link parameters for all types.
The logical Data Link parameters that do not depend upon the Type of operation in use are as follows:

a. Maximum number of octets. The maximum number of octets in the information field of a UI, I or DIA PDU is an adjustable data link parameter in the range of 708 – 3345.

b. Maximum Transmit Time (MTT). MTT represents the maximum time allowed on the network for a single transmission. It is the time from when the Radio's Push To Talk (PTT) is activated until the PTT is deactivated. It is used to limit physical and data link frame concatenation only.

5.3.8.1.2 Type 1 logical Data Link parameters.
The logical data link parameters for Type 1 operation shall be as follows:

a. Busy-state timer. The busy-state timer is a data link parameter that defines the time interval following receipt of the URNR command PDU during which the station shall wait for the other station to clear the busy condition. Default value is 120 seconds.

b. Minimum number of octets in a PDU. The minimum-length valid data link PDU shall contain 2 flags, 2 addresses, one 8-bit control field, and the FCS. The minimum number of octets in a valid data link PDU shall be 9.

c. TEST Time to Live (TTTL). TTTL represents the maximum time to wait to transmit a TEST Response frame. If the TTTL time expires and the TEST Response frame has not been transmitted then the TEST Response frame shall be deleted from the queue. The values are established at protocol initialization and are in the range of 0.000 to 65.535 seconds. A value of 0 indicates that the message shall not time out (see E.4.3.3).

5.3.8.1.3 Type 2 logical Data Link parameters.
The logical data link connection parameters for Type 2 operation shall be as follows:

a. Acknowledgment timer. The acknowledgment timer is a data link connection parameter that shall define the time interval during which the station shall expect to receive acknowledgment to one or more outstanding I PDUs or an expected response to a sent U command PDU. The acknowledgment timer should not be activated until the corresponding PDU has been transmitted. Time values are established at protocol initialization and are in the range of 10 to 1800 seconds in one-second increments. Default is 120 seconds.

b. P-bit timer. The P-bit timer is a data link connection parameter that defines the time interval during which the station shall expect to receive a frame with the F-bit set to 1 in response to a sent Type 2 command with the P-bit set to 1. The P-bit timer should not be activated until the corresponding PDU has been transmitted. Time values are established at protocol initialization and are in the range of 10 to 60 seconds in increments of 1 second. Default is 10 seconds.

c. Reject (REJ) timer. The REJ timer is a data link connection parameter that defines the time interval during which the station shall expect to receive a reply to a sent REJ or SREJ PDU. The REJ timer value shall be equal to or less than twice the acknowledgment timer. The REJ timer should not be activated until the corresponding PDU has been transmitted.

d. Maximum number of retransmissions, N2. N2 is a data link connection parameter that indicates the maximum number of times that a PDU (including the S command PDU that is sent as a result of the acknowledgment P-bit or REJ timer expiring) is sent, following the running out of the acknowledgment timer, the P-bit timer, or the REJ timer. The maximum number of times that a PDU is retransmitted following the expiration of the timers is established at protocol initialization. This value is in the range of 0 through 5 and defaults to 2. The retransmission of PDUs may be overridden by the Quiet Mode parameter, which is described in 5.3.11.2.

e. Maximum number of outstanding I PDUs, *k*. The maximum number (*k*) of sequentially numbered I PDUs that the sending station may have outstanding (i.e. unacknowledged) on a single data link connection simultaneously. The value of this parameter is in the range 1 through 127. (This value of this parameter may be established through the use of the Type 2 *k* Window field of an XNP message as described in APPENDIX E, “Type 2 Parameters”.)

f. Maximum number of outstanding I PDUs at which an acknowledgment is requested, *k2*. The maximum number (*k2*) of outstanding (i.e. unacknowledged) I PDUs that can be sent by a source station on a data link connection before the station requests acknowledgment. When this threshold is reached the sending station sends an S PDU that both acknowledges received I frames and causes an S PDU to be sent in return to acknowledge outstanding I PDUs. The value of this parameter is in the range 1 through 127, but would normally be less than or equal to the value of parameter *k*.

g. Maximum number of outstanding received I PDUs threshold, *k3*. The maximum number (*k3*) of correct in sequence I PDUs received on a data link connection since the last I PDU received on the data link connection was acknowledged. When this threshold is reached the receiving station generates an S PDU to acknowledge received frames. The value of this parameter is in the range 1 through 127, but would normally be less than or equal to the value of parameter *k*.

h. Response delay timer, percent. The amount of time, as a percent of Type 2 Acknowledgment Timer seconds, that a station waits after an I PDU Response or an I PDU Command with its P-bit set to 0 is received until it is acknowledged by transmission of an S PDU in the case that no other frames are available for transmission. The value of this parameter is in the range of 0 - 99%. (The value of this parameter may be established by the Type 2 Acknowledgment Timer and Response Timer fields of an XNP Parameter Update message as described in APPENDIX E, “Type 2 Parameters” or from the Protocol Parameters Table.)

i. Minimum number of octets in a PDU. A minimum-length valid data link PDU shall contain exactly 2 flags, 2 address fields, 1 control field, and the FCS. Thus, the minimum number of octets in a valid data link PDU shall be 9 or 10, depending on whether the PDU is a U PDU, or an I or S PDU, respectively.

5.3.8.1.4 Type 3 logical Data Link parameters.
The logical Data Link parameters for Type 3 operation shall be as follows:

a. Acknowledgment timer. The acknowledgment timer is a Data Link parameter that shall define the timeout period (TP) during which the sending station shall expect an acknowledgment from a specific destination station. The acknowledgment timer should not be activated until the corresponding PDU has been transmitted. TP shall take into account any delay introduced by the physical sublayer. The value of TP is described in APPENDIX C (C.4.3).

b. Busy-state timer. The busy-state timer is a data link parameter that defines the time interval following receipt of the URNR Response PDU during which the station shall wait for the other station to clear the busy condition. Default value is 120 seconds.

c. Maximum number of retransmissions, N4. N4 is a data link parameter that indicates the maximum number of times that an UI or TEST command PDU is retransmitted by a station trying to accomplish a successful information exchange. Normally, N4 is set large enough to overcome the loss of a PDU due to link error conditions. The maximum number of times that a PDU is retransmitted following the expiration of the acknowledgment timer is established at protocol initialization. This value is in the range of 0 through 5 and defaults to 2. The retransmission of PDUs may be overridden by the Quiet Mode parameter, which is described in 5.3.11.2.

d. Minimum number of octets in a PDU. The minimum-length valid data link PDU shall contain 2 flags, 2 addresses, one 8-bit control field, and the FCS. The minimum number of octets in a valid data link PDU shall be 9.

5.3.8.1.5 Type 4 logical Data Link parameters.
The logical Data Link parameters for Type 4 operation shall be as follows:

a. Acknowledgment (T1) timer. The T1 timer is the maximum time a station shall wait for an acknowledgment of a transmitted DIA PDU before that PDU is retransmitted. The value of T1 shall be in the range of 5-120 seconds in increments of 0.2 seconds. Each DIA PDU transmitted shall be assigned a T1 timer. When the T1 timer expires for DIA PDU, that DIA PDU shall be retransmitted in the next transmission opportunity for that precedence, assuming the N2 count has not been reached. DIA PDUs with only one destination will be discarded if the destination replied with a DRNR or DRR response PDU. If the DIA PDU is multi-addressed, the receive station is removed (nulled) from the destination address field. This timer shall be paused whenever the net is busy with voice. This timer is resumed when voice transmission has completed.

b. Maximum number of retransmission attempts, N2. The N2 parameter shall indicate the maximum number of retransmission attempts to complete the successful transmission of a DIA PDU. The value of N2 shall be the maximum retransmit value (range = 0-5).

c. k maximum number of outstanding DIA frames. The value of *k* indicates the maximum number of DIA PDUs that a station may have outstanding (awaiting acknowledgment) to all stations at any given time. The value of *k* ranges from 5 - 40 DIA PDUs.

d. Minimum number of octets in a PDU. A minimum-length valid data link PDU shall contain exactly 2 flags, 2 address fields, one (1) 16-bit control field, and the FCS. Thus, the minimum number of octets in a valid data link PDU shall be 10.

e. ACK list length. The number of Type 4 DIA frames remembered in the list used to detect and discard duplicates. The number in the list can range from 0 - 255. The value of “0” is used to turn off this detect capability.

5.3.9 Frame transfer.
After a station has joined the net, it can begin to send frames. The data link layer shall request the transmission of a frame by the PL.

5.3.9.1 PDU transmission.
The data link layer initiates transmission by building a transmission unit and passing it to the PL. The elements of a transmission unit include one Transmission Header (see 5.3.1), one or more PDUs (see data link concatenation, below), the additional bits resulting from the operations of zero-bit-insertion, optional FEC encoding, optional TDC and optional scrambling. To request transmission, a PL-Unitdata-Request is issued by the data link layer protocol after a transmission unit has been constructed. PDUs shall be queued for transmission in such a manner that the highest precedence PDUs are transmitted before lower precedence PDUs. If a prioritized net access scheme is active, the precedence access level used shall be the precedence of the PDU that is to be transmitted next. Transmission units of the same precedence shall be in first-in first-out (FIFO) order. Type 2 I PDUs for a particular connection shall be transmitted in the order of their sequence numbers. Only Type 1, Type 2 and Type 4 PDUs may be concatenated at the data link layer or PL.

5.3.9.2 Data Link concatenation.
The sending station may only concatenate Type 1,Type 2 or Type 4 PDUs. This is done by using one or two flags to separate each PDU. All receiving stations shall be able to de-concatenate the reception into separate PDUs. The combined length of the concatenated PDUs, before 0-bit insertion, may not exceed the established maximum PDU size for a single PDU (see 5.3.8.1). The PDUs are concatenated after the 0-bit insertion algorithm is applied. FEC, with or without TDC, and scrambling are optionally applied before the transmission unit is passed to the PL in a PL-Unitdata-Request. Data Link concatenation to add another interior data frame shall not be performed if the resulting frame would take longer to transmit than the maximum transmit time allowed for the network. Data link concatenation is shown in FIGURE 24.

5.3.9.3 Physical Layer (PL) concatenation.
PL concatenation does not apply when Packet Mode is used. More than one PDU may be passed to the PL without waiting for an intervening NAD period. The time to transmit the combined length of the transmission frame, shall not exceed the maximum transmit time allowed for the network. The PL shall transmit each transmission unit following the complete PL procedures with no additional bits between Interior Transmission Units (except for bit synchronization when used in Asynchronous Mode). PL concatenation is shown in FIGURE 25. Note that the Phasing field described in 5.2.1.2 shall precede the first Interior Transmission Unit only.

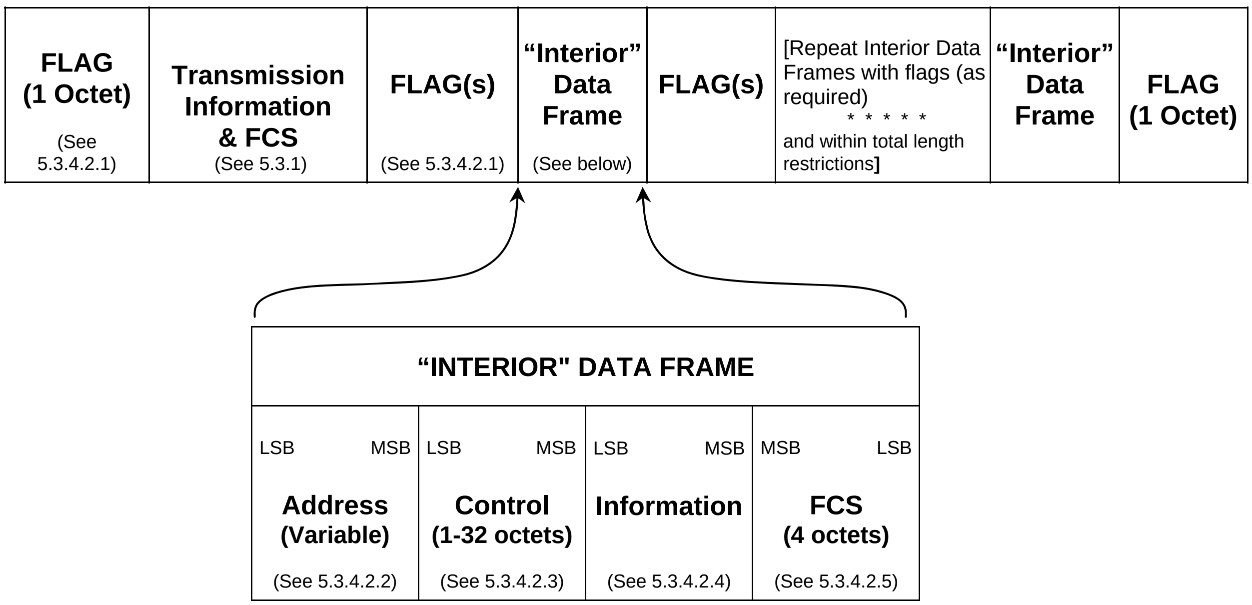


FIGURE 24. Data link concatenation.

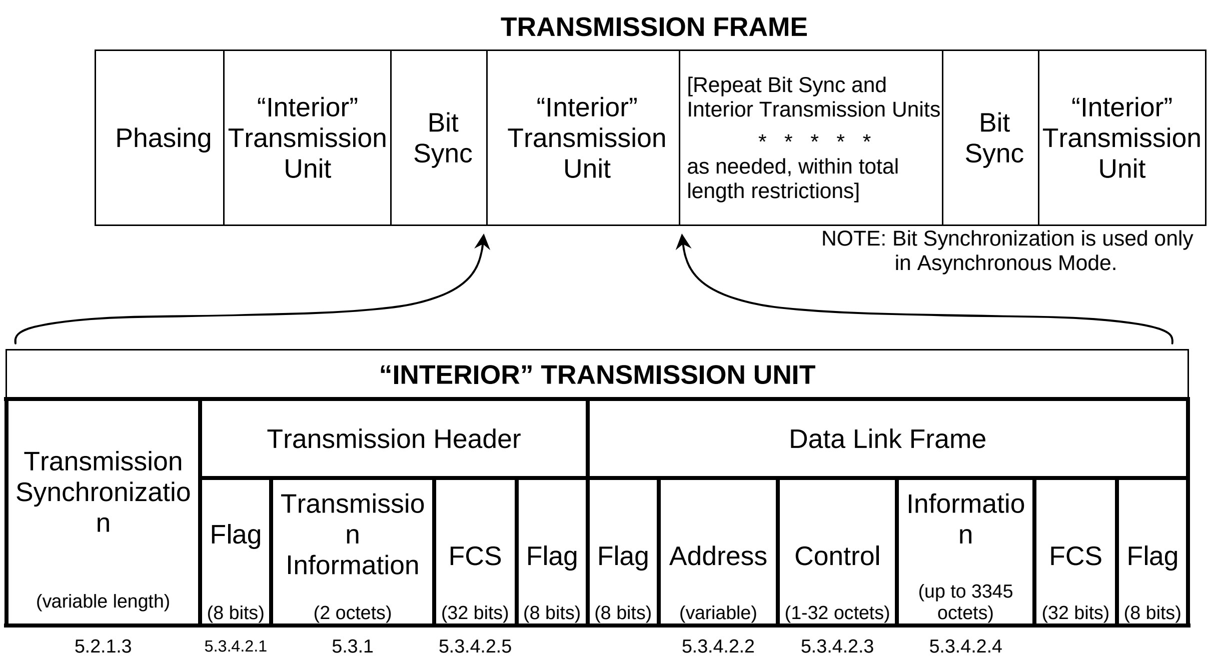


FIGURE 25. Physical Layer concatenation.

5.3.9.4 PDU transmissions.

Both Data Link Layer (DL) and PL concatenation may be used to build a single transmission frame. All types of operation PDUs, except Type 3 PDUs may be concatenated within the same single transmission frame. PDUs are placed in the appropriate precedence-level queue, with each level queue using a single FIFO order. If the first PDU in the highest precedence level queue (or only queue) may be concatenated, then other PDUs may be concatenated with that PDU even if a PDU that does not allow concatenation is queued ahead of them. The PDU that did not allow concatenation shall be at the head of its appropriate queue for the next net access period. If the first PDU in the highest precedence level queue (or only queue) does not allow concatenation, it shall be the only PDU transmitted in that net access period.

5.3.10 Flow control.

Flow control provides the capability of reducing the allowed input rate of information to prevent congestion to the point where normal operation may become impossible. The control-field sequence numbers are available for this service.

5.3.10.1 Type 1 flow control.

Type 1 transmissions are unacknowledged. Unacknowledged operations can perform flow control using URR and URNR messages, in conjunction with Type 3 messages. These messages announce the station's ability to accept incoming frames. A station will correlate information between Type 1 and Type 3 communications to maintain a single flow control for unacknowledged and acknowledged connectionless communications.

5.3.10.2 Type 2 flow control.

The N(S) and N(R) are used in conjunction with the V(S) and V(R) to control data flow. Flow control is implemented by the window method. The window defines the maximum number of undelivered frames a given user may have outstanding. The maximum number (k) of sequentially numbered I PDUs that may be outstanding (that is, unacknowledged) at any given time is a data link connection parameter, which shall never exceed 127. The incremental updating of N(R) acts as the positive acknowledgment of transmitted frames up to, but not including, that frame number. The window flow-control mechanism requires that the highest sequence number transmitted by the user be less than the sum of the last received N(R) plus k mod MODULUS (see 5.3.5.2.1). Window size (k) is a feature that is agreed upon by the users at initialization. The larger the window, the greater the traffic loading a given user places on a single channel (SC).

5.3.10.3 Type 3 flow control.

Type 3 transmissions are acknowledged. Acknowledged operations can perform flow control using URR and URNR messages, in conjunction with Type 1 messages. These messages announce the station's ability to accept incoming frames. A station will correlate information between Type 1 and Type 3 communications to maintain a single flow control for unacknowledged and acknowledged connectionless communications.

5.3.10.4 Type 4 flow control.

Type 4 flow control is performed using DRR and DRNR messages. These messages indicate a station's ability to accept incoming DIA frames. In addition, a window method is used to define the maximum number of frames a given station may have outstanding. The maximum number of

DIA PDUs that may be outstanding (unacknowledged) at any given time is the Type 4 *k* parameter.

5.3.11 Acknowledgment and response.
All UI, DIA or I PDUs that require an acknowledgment shall be acknowledged except for the following cases:

a. The control field of the received PDU specifies that no acknowledgment is required.

b. The Quiet Mode (described in 5.3.11.2), has been set to ON.

c. The receiving station is a group (including global) addressee only.

d. The receiving station's individual address is not in the address field.

e. The PDU is invalid.

5.3.11.1 Acknowledgment.
Acknowledgments are applicable for Type 3, Type 2 and Type 4 operations.

5.3.11.1.1 Type 3 acknowledgment.
Each Type 3 PDU shall be responded to before another PDU is transmitted. This is defined as a coupled acknowledgment. All Type 3 UI and TEST command PDUs shall be acknowledged. The RHD procedures (see C.4.2) shall be followed by all stations on the network to allow each responding station an interval in which they can transmit their response.

5.3.11.1.2 Type 2 acknowledgment.
Type 2 PDUs that require acknowledgment shall activate the acknowledgment timer. Type 2 also uses P and F-bit procedures for acknowledgments, but these P and F-bit procedures do not involve coupled acknowledgments. The Type 2 operation does not use the RHD timer, which allows receiving stations to send their acknowledgments during the current net access period. All acknowledgments are transmitted in another net access period. An I PDU acknowledgment does not necessarily correspond on a one-to-one basis with the I PDU and does not necessarily apply to the immediately preceding I PDU.

5.3.11.1.3 Type 4 acknowledgment.
The DIA PDU shall activate the acknowledgment timer. The Type 4 operation does not use the RHD timer. All acknowledgments are sent in another channel access period. All DIA PDUs are independently acknowledged.

5.3.11.2 Quiet mode.
The protocol shall allow an operator to initiate Quiet Mode as an override feature that, when invoked, prevents any transmission (including retransmission) without explicit permission from the operator. As a security feature, the operator shall be able to turn off automatic transmissions but still continue to receive. Normal protocol exchanges shall occur when the Quiet Mode is OFF. Only the operator can initiate a transmission when the Quiet Mode is ON. The Quiet

Mode shall override the Maximum Number of Retransmissions data link parameters. The default value of the Quiet Mode is OFF. If the Quiet Mode is ON during Type 2 operations, the flow control mechanism and retransmission timers in the remote system will eventually cause the connection to be lost. UI, I, or DIA PDUs received by a station with Quiet Mode ON shall be serviced in the normal way except nothing will be returned nor queued for later transmission.

5.3.11.3 Immediate retransmission.
Certain time critical exchanges require immediate retransmission if the acknowledgment is not received in the allocated response interval. This is accomplished by using the special address of 3 in the destination field with the Type 3 operation. All receiving stations calculate their TP based upon the total number of individual and special addresses. The sending station shall not include the special address 3 in its TP calculation and shall schedule any necessary retransmissions during the longer TP experienced by other stations.

5.3.12 Invalid frame.
A frame is invalid if it has one or more of the following characteristics:

a. Not bounded by a beginning and ending flag.
b. Too short.
c. Too long.
d. Has an invalid address or control field.
e. Has an FCS error.

A frame is too short if it contains less than 9 bytes. A frame is too long if it exceeds the maximum PDU length as described in 5.3.8.1.1.a. Any invalid frame shall be discarded.

5.3.13 Retransmission.
The data link layer will retransmit a command frame waiting for a response. The default number of retransmissions is 2, but the data link layer protocol may be initialized to automatically retransmit 0 to 5 times. If the Quiet Mode is ON, no automatic retransmissions shall be made.

5.3.14 Error Detection and Correction (EDC).
FEC coding alone, or FEC coding in unison with TDC, may be used to provide EDC capabilities to compensate for errors induced during transmission. If selected, the FEC process shall be used to encode the data link frame of 5.3.4. If selected, the TDC process shall be applied to the FEC-encoded data link frame and to the fill bits. Three modes of EDC shall be supported: FEC OFF, FEC ON with TDC, and FEC ON without TDC (NOTE: FEC ON without TDC may be used when the transmission channel provides the TDC capability). The EDC modes are selectable.

5.3.14.1 Forward-Error-Correction (FEC) coding.
When FEC is selected, the Golay (24,12) cyclic block code, described in detail in APPENDIX F, shall be used for FEC. The generator polynomial to obtain the 11 check bits shall be

$$g(x) = x^{11} + x^{10} + x^6 + x^5 + x^4 + x^2 + 1$$

where g(x) is a factor of $x^{23} + 1$.

5.3.14.2 Forward-Error-Correction preprocessing.
When either FEC only or FEC/TDC is selected, data bits shall be divided into a sequence of 12-bit segments prior to Golay encoding. The total number of 12-bit segments shall be an integral number. If FEC/TDC is selected and a coupled acknowledgment of Type 3 URR, URNR and TEST Response frames with their F-bit set to 1 is being transmitted, the coupled acknowledgment frame shall be duplicated and then data link concatenated to the end of the original coupled acknowledgment frame. This provides a receiving station two opportunities for capturing an error-free frame without increasing the size of the transmission. This shall not be applied when the four octets addressing, described in 5.3.4.2.2.1.2, is used. If the data bits do not divide into an integral number of 12-bit segments, after coupled acknowledgment duplication (as appropriate), then from 1 to 11 zeros (0's) shall be added at the end to form an integral number of 12-bit segments.

5.3.14.3 Time-Dispersive Coding (TDC).
TDC bit interleaving may be selected in unison with FEC. When TDC is selected, data shall be formatted into a sequence of TDC blocks composed of sixteen 24-bit Golay (24, 12) codewords (that is, there are 384 FEC-encoded bits per TDC block). Each TDC block shall contain a total of 16 FEC codewords. If the last TDC block of a message contains less than 16 FEC codewords, fill codewords shall be added to complete the TDC block. These 24-bit fill codewords shall be created by Golay-encoding an alternating sequence of 12-bit data words, with the first word composed of 12 ones followed by a word composed of 12 zeros. The fill codewords shall alternate until the TDC block is filled. The TDC block shall be structured into a 16 x 24 matrix (the Golay codewords appear as rows), as shown in FIGURE 26.

A_1 through A_{24} are the bits of the first Golay codeword. A_{25} is the first bit of the second Golay codeword. Each TDC block matrix shall be rotated to form a 24 x 16 matrix. The Golay codewords now appear as columns, as shown in FIGURE 27. The TDC block is transmitted row by row with the LSB (A_1) of the first row first. At the receiver, the TDC-encoded bit stream shall be structured into a 24 x 16 matrix. Each received TDC block matrix shall be rotated to form the original 16 x 24 matrix, as shown in FIGURE 26. The TDC decoder at the receiver shall perform the inverse of the TDC encoding process.

A_1	A_2	A_3	...	A_{22}	A_{23}	A_{24}
A_{25}	A_{26}	A_{27}	...	A_{46}	A_{47}	A_{48}
A_{49}	A_{50}	A_{51}	...	A_{70}	A_{71}	A_{72}
⋮	⋮	⋮	⋮	⋮	⋮	⋮
A_{361}	A_{362}	A_{363}	...	A_{382}	A_{383}	A_{384}

Golay Codeword in each row
A_1, A_2 , ... , A_{23}, A_{24}

FIGURE 26. 16 x 24 matrix before interleaving.

A_1	A_{25}	A_{49}	...	A_{313}	A_{337}	A_{361}
A_2	A_{26}	A_{50}	...	A_{314}	A_{338}	A_{362}
A_3	A_{27}	A_{51}	...	A_{315}	A_{339}	A_{363}
⋮	⋮	⋮	⋮	⋮	⋮	⋮
A_{24}	A_{48}	A_{72}	...	A_{336}	A_{360}	A_{384}

Golay Codeword in each row
A_1, A_{25}, ... A_{337}, A_{361}

FIGURE 27. Transmitter's 24 x 16 matrix after interleaving.

5.3.15 <u>Data scrambling.</u>
Data scrambling shall be performed if the transmission medium does not have a DC response and there is the possibility that "long" strings of NRZ ones or zeros are transmitted. Long is a relative term that is dependent on the data rate, the low frequency channel cutoff frequency, and the channel S/N, since at low S/N there is less margin for DC drift.

a. At the Data Link layer, the Transmission Header selects a CCITT V.36 scrambler, which includes a randomizer function as well as a pseudo-noise (PN) generator. It is applied inside the FEC (that is, before FEC is applied).

b. CCITT V.36 scrambling shall not be applied outside the FEC because bit errors at the receiver will be extended. In a high BER environment this extension will become catastrophic. For that reason a modified CCITT V.33 scrambler defined in section J.3.3, which uses a PN generator but not a randomizer, is specified for use at the PL (as part of the multi-dwell protocol; see J.3.3). In both cases, there is a very small probability that the interleaving for the Data Link layer scrambler and the fixed PN sequence for the PL scrambler may do more harm than good. Therefore, they are individually selectable. Both scramblers should not be used at the same time.

If CCITT V.36 scrambling/descrambling is used, the contents of the 20-state shift register shall be initialized to all ones prior to scrambling or descrambling data link frames in each interior transmission unit. The Adverse State Detector (ASD) counter shall be initialized such that at least 32-bits will have been counted, starting from the first bit input to the 20-state shift register, when the first adverse state is detected. The operation of the scrambling/descrambling shall be as shown in FIGURE 28. FIGURE 29 illustrates an example implementation for the CCITT V.36 scrambling/descrambling.

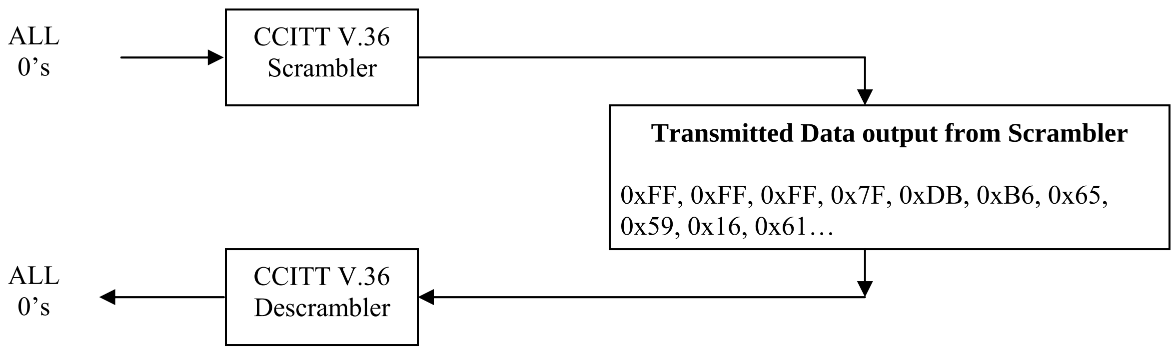
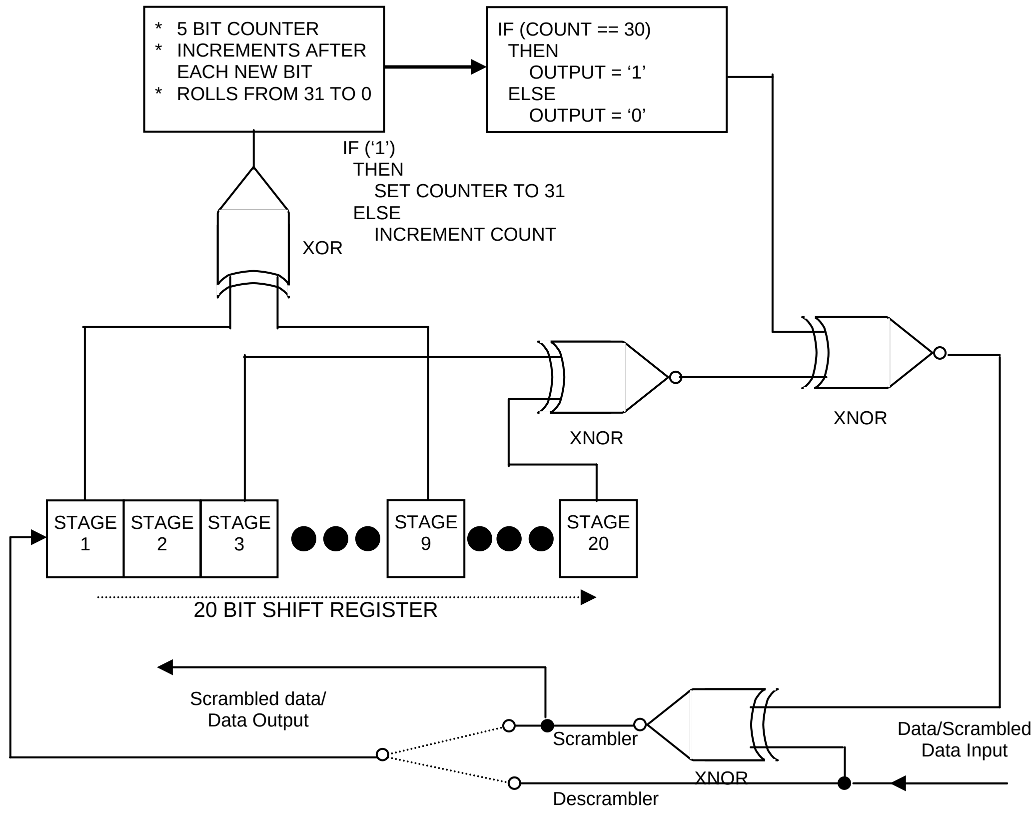


FIGURE 28. Required CCITT V.36 scrambling/descrambling operation.



XNOR

A	B	C
0	0	1
0	1	0
1	0	0
1	1	1

XOR

A	B	C
0	0	0
0	1	1
1	0	1
1	1	0

NOTES:

1. SHIFT REGISTER SHIFTS AND COUNTER IS SET OR INCREMENTS AFTER EACH INPUT/OUTPUT

2. SHIFT REGISTER INITIALIZED TO ALL '1s' AND COUNTER INITIALIZED TO '31' BEFORE FIRST INPUT/OUTPUT

FIGURE 29. Example implementation of CCITT V.36.

5.3.16 Data Link Layer interactions.

The data link layer interacts with both the next higher and next lower layer to pass or receive information regarding services requested or performed. The following primitives are used to pass information for the sending and receiving of data across the upper layer boundary.

a. Requests for transmission of data are sent by the upper layer, using the Data Link Layer (DL) Unitdata Request primitive, with the following parameters:

DL-Unitdata Request
- Message ID
- Destination(s)
- Source
- Topology Update ID
- Quality of Service
  - Precedence
  - Throughput Requested (Normal/High)
  - Delay Requested (Normal/Low)
  - Reliability Requested (Normal/High)
- Data/Data Length

b. Indications are provided to the upper layer through the DL-Unitdata Indication, DL-Unitdata Status Indication, DL-Maximum Data Link Transmission Unit Indication, and DL-Address Indication primitives with the following parameters:

DL-Unitdata Indication
- Destination(s)
- Source
- Topology Update ID
- Data/Data Length

DL-Status Indication
- Message ID
- Destination(s)
- Acknowledgment Success/Failure
- Connection Status
- Neighbor detection

DL-Maximum Data Link Transmission Unit Indication
- Maximum Data Link Transmission Unit

DL-Address Indication
- Local Data Link Layer Address

DL-Error Indication
Description of Error

c. Descriptions of the above parameters follow:

(1) Message ID is an indicator established by the upper layer in the DL-Unitdata Request and used to associate a subsequent DL-Status Indication acknowledgment status with that request.

(2) The destination(s) can be 1 to 16 individual, special or multicast (including global) addresses.

(3) The source address is the individual address of the outgoing link.

(4) Topology Update ID, in a DL-Unitdata Request, shall contain the most recent Topology Update ID sent from the upper layer. Topology Update ID, in a DL-Unitdata Indication, shall contain the Topology Update Identifier field from the Transmission Header.

(5) Quality of Service parameters are used to determine the service provided by the data link layer.

(a) Precedence parameters are used by the prioritized transmission scheme and are used to order outgoing queues. The precedence levels available to the network will be mapped into three levels (urgent, priority, and routine) in the data link layer. DL Precedence levels shall be mapped to the Intranet Sublayer of the Network Layer as shown in TABLE VIII.

(b) Precedence and the other Quality of Service parameters are used to select a preferred data link type of procedure. The recommended mapping shown in TABLE IX is provided for guidance.

(c) The data link type of procedure may be predetermined regardless of the Quality of Service parameters used.

(6) Data/Data Length is the block of data exchanged between the data link layer and its upper layer user, and an indication of the data's length.

(7) Acknowledgment Success/Failure is an indicator to inform the upper layer whether a data link acknowledgment was received from the remote station when high reliability was requested in a Unitdata Request.

(8) Connection Status is an indicator to inform the upper layer if a Type 2 connection has been established, reset or disconnected.

(9) Neighbor detection is an indicator to inform the upper layer when a data link transmission is detected from a previously unknown station.

(10) Maximum Data Link Transmission Unit (MDLTU) parameter indicates the largest value that is permitted for the Data Length parameter in the DL-Unitdata Request. Data Length parameter values that are larger than MDLTU shall be failed with the corresponding DL-Status Indication reflecting whether or not the message was transmitted as appropriate. The default value for the MDLTU is 581. MDLTU values contained in the MIL-STD-188-220D Parameter Table shall be used when applicable for a specific net configuration.

TABLE VIII. Intranet sublayer to Data Link Layer precedence mapping

Intranet Precedence	Data Link Precedence
Network Control Internet Control Critic/ECP	Urgent
Flash Override Flash Immediate Priority	Priority
Routine	Routine

TABLE IX. Mapping intranet TOS field to data link TOS.

TOS						STATION CLASS (see 5.3.3.5)			
	D	T	R		Precedence	A	B	C	D
	0	0	0		Urgent	**3**	**3**	**3**	**3**
	(& other)				Priority	**3**	**2**	**3**	**2**
					Routine	**1**	**2**	**4**	**2**
	1	0	0		Urgent	**3**	**3**	**3**	**3**
					Priority	**3**	**2**	**3**	**2**
					Routine	**1**	**1**	**1**	**1**

TABLE IX. Mapping intranet TOS field to data link TOS-Continued

TOS						STATION CLASS (see 5.3.3.5)			
	D	T	R		Precedence	A	B	C	D
	0	1	0		Urgent Priority Routine	3 3 1	2 2 2	3 3 4	2 2 2
	0	0	1		Urgent Priority Routine	3 3 3	2 2 2	3 3 4	2 2 2

NOTE: Type 3 Immediate Retransmission is invoked for Urgent precedence messages when Delay, Throughput and Reliability (DTR) is 000 or 100.

5.4 Network Layer.

5.4.1 Intranet protocol.

The Intranet Layer (IL), layer 3a, routes data packets between a source and possibly multiple destinations within the same broadcast network. The IL also accommodates the exchange of topology and connectivity information packets to support Intranet relaying path discovery. When necessary, to maintain a high speed of service for small high precedence messages, the IL will break a larger IL-Unitdata Request into multiple smaller IL Data Packet fragments prior to transmission via the data link layer. The destination IL transparently reassembles the IL PDU fragments received via the data link layer to recreate the original data prior to generating an IL-Unitdata Indication.

5.4.1.1 Intranet header.

FIGURE 30 defines the Intranet header. The Version Number, Message Type, Intranet Header Length (HLEN) and Type of Service (TOS) fields compose the mandatory fields of the Intranet Header and shall be present in the Intranet Header of all Intranet Data Packets. When optional Intranet Fragmentation/Reassembly is utilized, the Message Identification Number, Total Number of Fragments, and Fragment Number fields shall be present in addition to the mandatory fields, and any other optional fields in use. When optional Intranet Relaying is being utilized the Message Identification Number, Maximum Hop Count, Originator Address, and one to many Destination/Relay Status and Destination/Relay Address fields shall be present in the Intranet Header as appropriate based on the topology of the network in addition to the mandatory fields, and any other optional fields in use. The Intranet Header and any associated data contained in the IL Data Packet shall be exchanged using Data Link Layer UI, I and/or DIA PDUs.

<table>
<tr><th>MSB
7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>LSB
0</th></tr>
<tr><td colspan="4">MESSAGE TYPE</td><td colspan="4">VERSION NUMBER</td></tr>
<tr><td colspan="8">INTRANET HEADER LENGTH</td></tr>
<tr><td colspan="8">TYPE OF SERVICE</td></tr>
<tr><td colspan="8">MESSAGE IDENTIFICATION NUMBER</td></tr>
<tr><td colspan="4">FRAGMENT NUMBER</td><td colspan="4">TOTAL NUMBER OF FRAGMENTS</td></tr>
<tr><td colspan="4">SPARE</td><td colspan="4">MAX. HOP COUNT</td></tr>
<tr><td colspan="8">ORIGINATOR ADDRESS
(Single Octet, Four Octets plus Marker, or Six Octets plus Marker)
.
.
.</td></tr>
<tr><td colspan="8">DESTINATION/RELAY STATUS BYTE 1</td></tr>
<tr><td colspan="8">DESTINATION/RELAY ADDRESS 1
(Single Octet, Four Octets plus Marker, or Six Octets plus Marker)
.
.
.</td></tr>
<tr><td colspan="8">DESTINATION/RELAY STATUS BYTE 2</td></tr>
<tr><td colspan="8">DESTINATION/RELAY ADDRESS 2
(Single Octet, Four Octets plus Marker, or Six Octets plus Marker)
.
.
.</td></tr>
<tr><td colspan="8">DESTINATION/RELAYS 3 through N-1
.
.
.</td></tr>
<tr><td colspan="8">DESTINATION/RELAY STATUS BYTE N</td></tr>
<tr><td colspan="8">DESTINATION/RELAY ADDRESS N
(Single Octet, Four Octets plus Marker, or Six Octets plus Marker)
.
.
.</td></tr>
<tr><td colspan="8">DESTINATION/RELAY ADDRESS N
(Single Octet or Four Octets plus Marker)
.
.
.</td></tr>
</table>

Note: N is the total number of Destination / Relay Address(es) required for the transmission. It is limited to the size of the HLEN and the type of Data Link address format supported.

FIGURE 30. Intranet header.

5.4.1.1.1 Version Number.
The Version Number shall indicate which version of the intranet protocol is being used. The value of the Version Number is 1.

MIL-STD Version	Version Number
MIL-STD-188-220A	0
MIL-STD-188-220B	0
MIL-STD-188-220C	0
MIL-STD-188-220D	1

If a station supporting MIL-STD-188-220D is connected to a network containing stations supporting a different version of the MIL-STD it is possible that an IL PDU with a Version field value other than 1 will be received by the station supporting MIL-STD-188-220D. Received IL PDUs with a Version field value that is not equal to 1 shall be discarded by MIL-STD-188-220D stations and an IL-Error Indication shall be generated indicating that an invalid Version field value was received, IL PDU source/originator, the Message Type, and the unsupported Version field value (which should be 0).

5.4.1.1.2 Message types.
The Message Type field is a number from 0 to 15 which indicates the type of data in the data field of the IL packet. TABLE X lists all the valid Message Type field values. Since the Message Type field in the Intranet Header is always present in information frames of any Data Link Layer type, it is used to determine what type of data is borne by the Data Link information frame. The transmission and reception of all valid message types indicated by the Message Type field values shall be supported such that systems using MIL-STD-188-220 compliant implementations can support any of the upper layer protocols corresponding to the valid message types. MIL-STD-188-220 compliant systems shall support the upper layer interactions indicated in the message type field for transmit and receive as indicated in TABLE X.

5.4.1.1.2.1 Interoperability with Internet Protocols (IP Packets).
Systems implementing the IP protocol at the Internet Sub-Layer of the Network Layer shall implement Intranet message type 4 (IPv4 Packets) and type 11 (IPv6 Packets) as defined in TABLE X at the Intranet Sub-Layer of the Network Layer. Systems implementing the IP protocol shall implement both IPv4 and IPv6 protocols as a dual stack. For each network attachment point, the system shall be able to configure that point to use either IPv4 or IPv6. IPv4 and IPv6 are defined in RFC 791 and RFC 2460, respectively.

TABLE X. Intranet message types.

Field Value	Transmit	Receive	Message Type
0	X	X	Reserved
1	C	C	Intranet Acknowledgment
2	C	C	Topology Update
3	C	C	Topology Update Request
4	M	M	IPv4 Packets (RFC 791)
5	M	M	ARP
6	O	O	XNP
7	M	M	MIL-STD-2045-47001 Header (N-Layer Pass Through)
8	R	R	Reserved
9	R	R	Reserved
10	M	M	Segmentation/Reassembly (S/R) Protocol (N-Layer Pass Through)
11	M	M	IPv6 Packets (RFC 2460)
12 to 15	X	X	Spare

Note for TABLE X: M indicates Mandatory for compliant systems, O indicates optional for compliant systems, C indicates Conditionally Mandatory for compliant systems implementing Intranet Relaying, X indicates that compliant systems should neither transmit nor accept IL packets with this field value. The Message Types with a value of R are reserved for Situational Awareness data internal to the FBCB2 system.

5.4.1.1.2.2 Address Resolution Protocol (ARP).
ARP is defined in Request For Comment (RFC) 826. All systems implementing IPv4 or N-Layer Pass-Through shall be able to respond to an ARP request in accordance with RFC 826. For hardware type (ar$hrd) = 22 (CNR), the source hardware address (ar$sha) field shall contain the data link address (see 5.3.4.2.2). The hardware address length (ar$hln) field value (specifying the number of octets in the hardware address field) shall be set to one octet when the net is configured for 7-bit addressing or to four octets when the net is configured for 32-bit addressing, or six octets when the net is configured for 48-bit addressing.

ARP is replaced by Neighbor Discovery and ICMPv6 in IPv6. Neighbor Discovery is defined in RFC 2461 and ICMPv6 is defined in RFC 2463. Any system implementing IPv6 shall implement both ICMPv6 and Neighbor Discovery. Systems shall not use ARP messages on IPv6 networks.

5.4.1.1.2.3 Exchange Network Parameter (XNP).
XNP messages may be used for CNR management (see APPENDIX E).

5.4.1.1.2.4 MIL-STD-2045-47001 header.
When set to 7, the Intranet message type field specifies a direct connection from the IL to the MIL-STD-2045-47001 Application header. This allows messages using N-layer pass through to utilize the upper layer services provided by the MIL-STD-2045-47001 header.

5.4.1.1.2.5 Segmentation/Reassembly (S/R) Protocol.
When the Intranet Message type is set to 10, it specifies a direct connection from the Intranet Header to the Segmentation/Reassembly Protocol header defined in MIL-STD-2045-47001. This allows messages using N-layer pass through to utilize the upper layer services provided by the Segmentation/Reassembly Protocol including segmentation, reassembly, ETE recovery, and delivery to any application as specified within the S/R header destination port number.

5.4.1.1.3 Intranet Header length.
The HLEN field value shall indicate the number of octets in the Intranet Header only. The HLEN field value shall be interpreted as follows:

HLEN	Description
3	Minimum HLEN value. Basic 3-octet header. No Intranet Fragmentation/Reassembly. No Intranet Relaying. Only the mandatory fields will be present.
5	Intranet Fragmentation/Reassembly utilized. No Intranet Relaying. Mandatory and Fragmentation/Reassembly fields will be present.
>= 9	Intranet Fragmentation/Reassembly optionally utilized. Intranet Relaying utilized. Mandatory, Fragmentation/Reassembly, and Relaying fields will be present.

When Intranet Relaying is utilized, the HLEN field value will vary based on the relay path dictated by the intranet topology, number of destinations, and the size for the addresses being utilized.

5.4.1.1.4 Type of Service (TOS).
The TOS field in the Intranet header is modeled exactly upon the Type of Service field in the Internet header as described in RFC 791 paragraph 3.1.

5.4.1.1.5 Message identification number.
The message identification number shall be a number, 0-255, assigned by the originating host for messages that require Intranet Fragmentation/Reassembly and/or that require Intranet Relaying. For messages that require Intranet Fragmentation/Reassembly without Intranet Relaying, the source address contained in the DL-Unitdata Indication combined with the Message Identification Number field value shall uniquely identify fragments of the same message. For messages that require Intranet Relay, the Originator Address field value combined with the Message Identification Number field value shall uniquely identify relayed fragments of the same message. Sending/Originating stations shall insure that the Message Identification Number field value assigned to each pending message transmission is unique. After all 256 of the Message

Identification field values have been associated with a message transmission for the first time, the least recently used Message identification field value associated with a message transmission that is no longer pending shall be used for the next new message transmission.

5.4.1.1.6 Fragment Number.
The Fragment Number field shall have a numeric value, from 1 to 15, that indicates the position of an intranet fragment relative to other intranet fragments generated by a source/originator for a single Message Identification Number. The Fragment Number field value shall be less than or equal to the Total Number of Fragments field value. The sending station shall number the fragments contiguously starting with 1. When Intranet Fragmentation is not required and Intranet Relaying is required, the Fragment Number field value shall be set to 1.

5.4.1.1.7 Total number of fragments.
The Total Number of Fragments field shall have a numeric value, from 1 to 15, that indicates the total number of intranet fragments generated by an originator for a specific Message Identification Number field value. All intranet fragments associated with the same Message Identification Number field value shall have the same Total Number of Fragments field value. The Total Number of Fragments field value shall be greater than or equal to the Fragment Number field value. When Intranet Fragmentation is not required and Intranet Relaying is required, the Total Number of Fragments field value shall be set to 1, indicating that Intranet Fragmentation is not used.

5.4.1.1.7.1 Sending IL fragments.
When the number of octets contained in the Intranet Header combined with the number of data related octets needed to be sent exceeds the MDLTU, the Intranet Layer of the sending station shall break the data packet into fragments. The number of octets in each data fragment, when combined with the size of the Intranet Header, shall be less than or equal to the MDLTU. An identical Intranet Header, except for the Fragment Number field value, shall be pre-appended to each data fragment to form an IL PDU fragment. The amount of data contained in each IL PDU fragment shall be the same, except possibly for the last fragment, which may be smaller. The Fragment Number field of the Intranet Header of each IL PDU fragment shall indicate the unique position of each data fragment relative to the other fragments associated with the same Message Identification Number field value.

5.4.1.1.7.1.1 Sending IL fragments requiring ETE Intranet Acknowledgments.
When an IL-Data Request requiring IL ETE Intranet Acknowledgment requires fragmentation, special consideration is required with regard to selecting the size of the data fragments because the size of the Intranet Header can be different when the message is retried subsequent to ETE Intranet Acknowledgment timer expiration. The maximum size of the Intranet Header for the initial and any subsequent retries shall be determined based on the current topology and then be subtracted from the MDLTU in order to determine the size of the data fragments. For a given topology the maximum Intranet Header size shall be bounded based on the maximum number of Intranet hops permitted and the ultimate number of destinations of the message.

5.4.1.1.7.2 Receiving IL fragments.
When an IL fragment is received, a destination station shall attempt to reassemble it with any other previously received fragments from the same source/originator having the same Message Identification Number and Total Number of Segments field values. Related fragments received over time at the destination stations shall be reassembled back into the original data packet. The fragments shall be reassembled at the proper location based on their relative positions as indicated by the Fragment Number field value, Total Number of Fragments field value, and the fact that all fragments except possibly the last fragment contain the same amount of data.

5.4.1.1.7.2.1 Reassembly logic.
The reassembly logic shall be able to handle segments received in an order different from the order they were offered for transmission by the source/originator to its local Data Link Layer. For example, segment 4 of 4 received prior to 1 of 4, 2 of 4, and 3 of 4 (all with the same Message Identification Number from the same source/originator). The reassembly logic shall be able to handle the receipt of duplicate fragments, e.g. 2 of 15 is received a second time before 3 of 15 through 15 of 15 are received. When all of the related data fragments are received (e.g. segment 2 of 4 could be the last of the four segments received) and the message has been successfully reassembled by the destination, an IL-Data Indication shall be generated by the destination Intranet Layer. If an ETE Intranet Acknowledgment was requested by the source/originator, it shall be generated as described below in 5.4.1.1.9.5 when the final segment is received.

5.4.1.1.7.2.2 Reassembly inactivity timer.
The Reassembly Inactivity Timer value is an Intranet parameter that defines the timer period measured from when the last fragment of a partially reassembled message was received until when storage will be deallocated due to the failure to receive another (possibly duplicate) fragment related to the given message. In cases where no additional fragments are received within a reasonable time period, memory associated with the partially reassembled message must be deallocated. Each time a fragment is received that is associated with a partially reassembled message, the Reassembly Inactivity Timer shall be started/restarted for the given message. The default value of the Reassembly Inactivity Timer shall be two times the ETE Intranet Acknowledgment Timer. There shall be one Reassembly Inactivity Timer for each partially reassembled message. When the Reassembly Inactivity Timer expires, the memory associated with the partially reassembled message shall be deallocated.

5.4.1.1.8 Maximum hop count.
The maximum hop count shall be the maximum number of times this intranet packet can be relayed on the radio net. A hop is defined as a single link between two adjacent nodes. This number is set by the source host and is decremented each time a device receives the intranet header. If the maximum hop count is decremented to 0, the intranet packet shall not be forwarded any further, however it shall be processed locally if applicable.

5.4.1.1.9 Destination/Relay Status Byte.
The Destination/Relay Status Byte (see FIGURE 31) shall provide Intranet routing information for each destination and/or relay address. In addition, this octet also selects ETE Intranet Acknowledgments.

MSB 7	*6*	*5*	*4*	*3*	*2*	*1*	*LSB 0*
ACK	**DES**	**Relay Type**		**REL**	**Distance**		

FIGURE 31. Destination/Relay status byte.

5.4.1.1.9.1 Distance.
The distance subfield specifies how many hops a relay address is away from the originator node. For final destination addresses which are not relayers, the distance field gives the number hops from the originator node to the destination node.

5.4.1.1.9.2 REL.
The REL bit when set indicates that the given node will participate in relaying.

5.4.1.1.9.3 Relay Type.
The Relay Type bits indicate the type of relaying to be performed. The relay types are defined in TABLE XI. The value of 0 indicates source directed relay defined in APPENDIX I.

TABLE XI. Relay Types.

0	Source Directed Relay
1	Spare
2	Spare
3	Spare

5.4.1.1.9.4 DES.
When the DES bit is set, the following address is at least one of the destinations for the packet. The following address may also be a next hop relay for another destination.

5.4.1.1.9.5 ACK.
The ACK bit when set requests ETE Intranet Acknowledgments for the associated node only. The procedure for ETE Intranet Acknowledgment follows.

5.4.1.1.9.5.1 Receiver generation of ETE Intranet Acknowledgment.
When a node has received all of the IL fragment(s) associated with the same source/originator and Message Identification Number and the ACK bit is set in the IL fragment(s), it shall return

an Intranet Acknowledgment packet at the first possible opportunity. The Intranet Acknowledgment packet shall have the same Message Identification Number as the received Intranet fragment(s). The path specified in the Intranet Acknowledgment packet shall be the reverse path specified in the most recently received Intranet fragment. The Intranet Acknowledgment packet shall specify exactly one destination, namely the originator of the received Intranet fragment(s).

5.4.1.1.9.5.2 ETE Intranet Acknowledgment Timer.
When an originator node sends an intranet fragment(s) with the ACK bit set, it shall start its ETE acknowledgment timer after the last fragment is sent. The ETE acknowledgment timer is an intranet parameter that defines the period within which a sending station shall expect to receive an ETE acknowledgment for the associated IL fragment(s) from the destination(s). The value of the ETE acknowledgment timer shall be a fixed factor plus a factor proportional to the number of hops required for all destinations to receive the last fragment. The default value for the fixed factor shall be 20 seconds. The default value for the proportional factor shall be twice the value of the DL acknowledgment timer, multiplied by the number of hops to the furthest destination. The maximum value for the ETE Intranet Acknowledgment Timer shall be 10 minutes (600 seconds).

5.4.1.1.9.5.3 Receiving an ETE Intranet Acknowledgment.
When an ETE Intranet Acknowledgment Packet is received, that destination shall be removed from the list of destinations from which an acknowledgment is required. If no destinations remain on the list, the ETE Intranet Acknowledgment Timer shall be stopped and an IL-Status Indication shall be generated indicating that all destinations did acknowledge. When all destinations have acknowledged, no further action is taken at the IL.

5.4.1.1.9.5.4 Expiration of the ETE Intranet Acknowledgment timer.
When the ETE Intranet Acknowledgment timer expires and the maximum number of Intranet retransmissions has not been reached, the sending station shall retry the transmission of all of the associated IL fragment(s) to any destinations that have not yet acknowledged the receipt of the fragment(s). The number of retries shall be a value between 1 and 4, with a default of 2. Each retransmission may use a new path to each destination that has not acknowledged. If only one path exists to a destination, that path shall be used until either the acknowledgment is received or the maximum number of Intranet retransmissions is exhausted. The size of the data contained in each IL fragment shall be the same for the initial and each subsequent retransmission for the same Message Identification Number. As a result of this approach, an acknowledgment may be received from the destination(s) as soon as any missing fragments are retransmitted/received (i.e. as soon as all the segments have been received). If an acknowledgment is not received from every destination after the maximum number of Intranet retransmissions, an IL-Status-Indication shall be sent to the upper layer specifying which destination(s) did and did not acknowledge the IL PDU.

Each retransmitted fragment shall have a recreated Intranet Header with the same Version, Message Type, TOS, Message Identification Number, Fragment Number, and Total Number of Fragments field values as the previous transmission. The Intranet Header shall be recreated to specify an alternative path to the remaining destination(s) (if an alternate path exists) and the Intranet Header Length field value shall be updated correspondingly. This recreated Intranet Header shall not specify paths to nodes that have already acknowledged the message. This recreated Intranet Header shall not specify paths to nodes from which an acknowledgment is not required. This recreated Intranet Header shall include paths to all nodes from which an acknowledgment is required, but from which an acknowledgment has not yet been received.

5.4.1.1.10 Originator address.
The originator address shall be the link layer address of the originating node. Single octet, four octets, and six octets addressing may be used following the link layer addressing rules in 5.3.4.2.2. The four octets or six octets of address space shall be preceded by a single octet 32-bit marker or 48-bit marker subfield, as per 5.3.4.2.2.2.

5.4.1.1.11 Destination/Relay address.
The intranet destination/relay address shall be the link layer address. It is either the destination address for an intranet packet or the relay address. The extension bit (LSB) is available for use by relaying procedures. Single octet, four octets, and six octets addressing may be used following the link layer addressing rules in 5.3.4.2.2. The four octets or six octets of address space shall be preceded by a single octet 32-bit marker or 48-bit marker subfield, as per 5.3.4.2.2.2.

5.4.1.2 Topology update.
Connectivity and topology information of the intranet is essential for a node to initiate and/or perform intranet relay. Each node on the radio network needs to determine what nodes are on the network and whether they are 1 or more hops away. This information can be partially determined passively by listening to a node's traffic at layers 3a and 2 and/or actively by exchanging topology information. The topology update data structure, defined in FIGURE 32, has been provided for nodes in the intranetwork to exchange topology and connectivity information. APPENDIX H specifies the procedure for exchanging topology information between nodes.

5.4.1.2.1 Topology Update Length.
The Topology Update Length field is the length in octets of topology update data. Topology Update Length shall not exceed the maximum transmission unit (MTU) minus 8 octets.

5.4.1.2.2 Topology Update ID.
The Topology Update ID is a number from 1 to 255. Together with the originator's link layer address, the Topology Update ID uniquely identifies each topology update generated by the originating node. This number is incremented by 1 every time a topology update is generated. The Topology Update ID for the first topology update generated shall be 1.

MSB 7	6	5	4	3	2	1	LSB 0
Topology Update Length							
Topology Update ID							
Node 1 Address (Single Octet, Four Octets plus Marker, or Six Octets plus Marker) . . .							
Node 1 Status Byte							
Node 1 Predecessor Address (Single Octet, Four Octets plus Marker, or Six Octets plus Marker) . . .							
Node 2 Address (Single Octet, Four Octets plus Marker, or Six Octets plus Marker) . . .							
Node 2 Status Byte							
Node 2 Predecessor Address (Single Octet, Four Octets plus Marker, or Six Octets plus Marker) . . .							
Nodes 3 through N-1 . . .							
Node N Address (Single Octet, Four Octets plus Marker, or Six Octets plus Marker) . . .							
Node N Status Byte							
Node N Predecessor Address (Single Octet, Four Octets plus Marker, or Six Octets plus Marker) . . .							

FIGURE 32. Topology update data structure.

5.4.1.2.3 Node Address.
The Node Address is the Data Link Layer address of node in the intranet.

5.4.1.2.4 Node Status Byte.
The *i*th Node Status Byte characterizes the link between originator host (the host whose address appears in the originator address of the intranet header) and the *i*th node predecessor whose address immediately follows the Node Status Byte as defined in FIGURE 33.

MSB *7*	*6*	*5*	*4*	*3*	*2*	*1*	*LSB* *0*
QUIET	NR	HOP LENGTH			LINK QUALITY		

FIGURE 33. Node status byte.

5.4.1.2.4.1 Link Quality.
The Link Quality subfield for the *i*th node provides an assessment of the link quality between the *i*th node predecessor and the *i*th node. The Link Quality is set to 0 if the quality of a link is unknown. Increasing Link Quality value infers a poorer link. Link Quality is set to 7 to indicate that the node is static. Static nodes do not trigger Intranet Topology updates as they enter and leave the network. TABLE XII lists the Link Quality values.

TABLE XII. Topology link quality values.

Link Quality	Description
0	Unknown
1	Best Link
2	
3	
4	
5	
6	Worst Link
7	Static Node

5.4.1.2.4.2 Hop Length.
The Hop Length subfield defined in TABLE XIII indicates the distance in hops from the source to the given node. Hop Length = 1 means the node can be reached directly by the source - no relays are required. A hop length of 0 indicates the source node itself or that the source may know that node should be on the network but does not know where it is.

5.4.1.2.4.3 NR.
The NR bit when set to 1 indicates that the node is not participating as a relayer.

5.4.1.2.4.4 Quiet.
The Quiet bit, when set, indicates the node is either in Quiet Mode or going into Quiet Mode and cannot transmit any traffic.

TABLE XIII. Hop length values.

Hops	Description
0	Unknown
1	0 relays required
2	1 relay required
3	2 relays required
4	3 relays required
5	4 relays required
6	5 relays required
7	6 or more relays required

5.4.1.2.5 Node predecessor address.
Each node maintains intranet topology as routing tree rooted at itself. For the *i*th node in the routing tree, the Node Predecessor Address is the link layer address of the node one branch up from the *i*th node in the routing tree. The predecessor for all nodes within 1 hop of the originator node, which is the root of the routing tree is the originator node. The predecessor for all nodes n hops away is a node which is n-1 hops away from the originator and that can talk directly with the node n hops away. If the *i*th node has not been integrated into the source node's routing tree, the Node Predecessor Address for the *i*th node should be set to 0.

5.4.1.3 Topology Update Request message.
The Topology Update Request message, Intranet Relay Message Type 3, consists of the Intranet Header with one originator and possibly multiple destination addresses. No Information field is permitted. The maximum hop count and distance field shall be set to 1. The Relay, Relay Type, and ACK bit shall be always zero. The DES bit shall be always 1. The destination address in the Intranet Header shall be the link layer address to which this request has been made. The addressing at the link layer may be either the broadcast address or the individual link layer addresses.

5.4.1.4 Intranet Layer (IL) interactions.
The IL (Layer 3A) interacts with both the next higher layer and next lower layer to pass or receive information regarding services requested or performed. Three primitives are used to pass information for the sending and receiving of data across the upper layer boundary.

a. Requests for transmission of data are sent by the upper layer, using the IL Unitdata Request primitive, with the following parameters:

IL-Unitdata Request
- Destination(s)
- Source
- Quality of Service
- Precedence
- Throughput (Normal/High)
- Delay (Normal/Low)

Reliability (Normal/High)
Data/Data Length
Intranet Message Type
IL-Unitdata-ID

b. Indications are provided to the upper layer when data is received through the IL-Unitdata Indication, IL-Status Indication, IL-Data Length Indication, and IL-Error Indication primitive, with the following parameters:

IL-Unitdata Indication
Destination(s)
Source
Data/Data Length

IL-Status Indication
Acknowledgment success/failure
Intranet Path Status
IL-Unitdata-ID

IL-Data Length Indication
MTU
MTU without IL Fragmentation

IL-Error Indication
Description of Error

c. Descriptions of the above parameters follow:

(1) The destination can be 1 to 16 individual or DL multicast (including global) addresses.

(2) The source address is the DL individual address of the outgoing link.

(3) Quality of Service parameters are used in determining the service provided by the IL. Quality of Service parameters are identical to those at the DL, described in 5.3.16.c(5).

(a) For IPv4, precedence shall be mapped from the TOS field (see 5.4.1.1.4) as shown below. For IPv6 with Class Selector Codepoints (see RFC 2474), precedence shall be mapped from the Differentiated Services (DS) field as shown below. For IPv6 with other DS Codepoints, the IL precedence shall be selected to match the Per Hop Behavior (PHB) defined by the DS Codepoint.

$P_0P_1P_2$	Precedence
111	Network Control
110	Internet Control

101 CRITIC/Emergency Command Precedence (ECP)
100 Flash Override
011 Flash
010 Immediate
001 Priority
000 Routine

where the MSB is P_0 and the LSB is P_2.

(b) For IPv4, the other Quality of Service parameters shall be mapped from the TOS field (see 5.4.1.1.4) as shown below. For IPv6, the DTR bits shown below will be set to match the PHB defined by the DS Codepoint in the DS field. For IPv6 with Class Selector Codepoints (see RFC 2474), the D, T, and R bits shall be set to 0.

D=0 Normal Delay
D=1 Low Delay
T=0 Normal Throughput
T=1 High Throughput
R=0 Normal Reliability
R=1 High Reliability

(c) The ETE intranet acknowledgment procedures described in 5.4.1.1.9.5 shall be used when R=1, and relaying is used to deliver the message to any destination of the packet.

(4) Data/Data Length is the block of data exchanged between the IL and its upper layer (i.e. IP) user, and an indication of the data's length.

(5) Acknowledgment Failure is an indicator to inform the upper layer if an Intranet acknowledgment was not received from the remote station when high reliability was requested in an IL-Unitdata Request.

(6) Whenever a node becomes reachable or unreachable, an Intranet Path Status indication is sent to the upper layer identifying the destination link address.

(7) Intranet Message Type is defined in 5.4.1.1.2.

(8) IL-Unitdata-ID is an indicator established by the upper layer in the IL-Unitdata Request and used to associate a subsequent IL-Status Indication acknowledgment status with that request.

(9) Description of Error is provided with an IL-Error Indication. This should provide as many details about the error as such that a communications knowledgeable operator reading the description would likely be able to correct the condition that is causing the error.

(10) MTU is a numeric parameter provided with an IL-Data Length Indication. This parameter indicates the maximum value permitted for the Data Length parameter in the IL-Unit Data Request. IL-Unit Data Request with Data Length parameter values that are greater than the MTU shall not be honored by the IL resulting in the failure of the request without any attempt to send the data.

(11) MTU Without IL Fragmentation is a numeric parameter provided with an IL-Data Length Indication. This parameter indicates the maximum value permitted for the Data Length parameter in the IL-Unit Data Request such that IL fragmentation will not occur. IL-Unit Data Request with the Data Length parameter value that are greater than the MTU Without IL Fragmentation and less than or equal to MTU shall be honored using IL Fragmentation. IL-Unit Data Request with a Data Length parameter value that is less than or equal to the MTU Without IL Fragmentation shall be honored without the use of IL Fragmentation.

5.4.2 Subnetwork Dependent Convergence Function (SNDCF).
The ISO description of the network layer defines a subnetwork dependent convergence layer, between the intranet and Internet layers. The layer shall assure that expected services are provided within a particular subnetwork type for both IP datagram exchanges and n-layer pass through exchanges. Note that the ISO description does not include n-layer pass through exchanges. Implementers shall insure that n-layer pass through is supported. The functions required to converge services within a MIL-STD-188-220 subnetwork (layers 3a and below) services are: (1) determine the complete list of IP final destinations within the subnetwork; (2) determine the associated subnetwork address(es) for each address; and (3) determine the subnetwork Type of Service requirements (reliability, throughput, delay, immediate retransmission and precedence) specified by the TOS field for IPv4 or the Differentiated Services (DS) field for IPv6.

The Differentiated Service Working Group has defined a Differentiated Services architecture (RFC 2475) for implementing service differentiation at the IP layer. As such, IPv4 TOS and IPv6 Traffic Class have been re-named the DS field, when interpreted in accordance with RFC 2474. However, for the purpose of this standard, IPv4 TOS will remain as identified in RFC 791. Within the DS field, DS Codepoint values are used to select specific PHBs. Class Selector Codepoints have been standardized to allow for compatibility with IPv4 legacy nodes, and have the following structure: bits 0-2 correspond to RFC 791 TOS Precedence bits, bits 3-5 are set to 0, and bits 6 and 7 must be set to 0. The RFC 791 TOS DTR bits are not carried forth in the DS field.

The preceding information is contained in the IP header (for IP datagram exchanges) or in the application interface (for n-layer pass through exchanges). If the IP protocol implementation does not provide the required information, the SNDCF must query the upper layer to "learn" the destinations and Type of Service. The SNDCF is only active for an IL-Unitdata request from the upper layer. The convergence functions for a MIL-STD-188-220 subnetwork using n-layer pass through exchanges or the Selective Directive Broadcast protocol described in RFC 1770 for IP datagram exchanges are described below. Selective Directive Broadcast for IPv6 will be defined in a future RFC.

5.4.2.1 Determine Destination function.
The Determine Destination function obtains final destination information from the upper layer protocol (1) IP header for IP datagram exchanges or (2) MIL-STD-2045-47001 application interface for n-layer pass through or (3) the application associated with the Segmentation/Reassembly protocol for n-layer pass through). For IP datagram exchanges, the IP destination address field of the IP header is examined first. If the address in that field is an individual address, broadcast address (all 1's), or multicast address (Class D IP address), the Determine Destination function is complete and it passes the single IP address to the Address Mapping Function. If the IP destination address is a directed broadcast address, (all ones in the host portion of the IP address only) the network portion of the IP address (NET ID) is compared to the local NET ID. If the NET ID portion of the directed broadcast address is not the same as the local NET ID, the single IP directed broadcast address is passed to the Address Mapping function. If the NET ID portion of the directed broadcast IP address is the same as the local NET ID, the Determine Destination function examines the IP option field for the presence of the multi-address IP option (selective directed broadcast). If the option is present, the list of individual IP addresses contained in the option is passed to the Address Mapping function. If the option is not present, the single IP directed broadcast address is passed to the Address Mapping function. For n-layer pass through exchanges, (MIL-STD-2045-47001 with or without S/R) the interface shall provide the necessary addresses using the IL Unitdata Request primitive.

5.4.2.2 Address Mapping function.
The SNDCF Address Mapping function is provided one or more addresses from the Determine Destinations function. The Address Mapping function determines the data link address(es) associated with an IP address or with the addresses provided in the IL Unitdata Request primitive. The Address Mapping function accesses an information base to determine the DL addresses associated with IP addresses or the addresses provided from the Application. Application broadcast address(es), IP broadcast (all 1's) addresses and directed broadcast address for the local subnetwork are mapped to the data link global address.

5.4.2.3 Type of Service (TOS) function.
The SNDCF TOS function obtains the requirements from the IPv4 Type of Service or IPv6 Differentiated Services header field or the IL Unitdata Request primitive. The values in the field are provided to the IL protocol.

5.4.2.4 Intranet send request.
After the SNDCF layer performs all of its functions, it issues an IL-Unitdata Request that includes the list of data link addresses and the Type of Service data.

5.4.3 Implementation directions.
Systems implementing this version of MIL-STD-188-220 shall be able to utilize/support UDP/IP for transmission and receipt of upper layer protocols, i.e. MIL-STD-2045-47001 and Segmentation/Reassembly (S/R) over MIL-STD-188-220 networks. Systems implementing this version of MIL-STD-188-220 shall be able to utilize/support MIL-STD-188-220 N-Layer pass through for the transmission and receipt of upper layer protocols, i.e. MIL-STD-2045-47001 and S/R over the MIL-STD-188-220 networks. N-Layer pass through is used as a means of

improving net performance (by eliminating UDP/IP overhead) when communicating directly with any destination over a MIL-STD-188-220 net.

5.5 Lower layer protocol network settings.

5.5.1 Reason for Table.

MIL-STD-188-220 has a large number of parameters that makes it difficult to achieve interoperability between operational systems. A table providing a list of pre-defined parameters will reduce interoperability problems.

5.5.2 Table description.

TABLE XIV describes a standard set of lower layer protocols that may be used by all systems to enhance interoperability. The table is a listing of typical numbered low level Operational Parameter Sets (OPS). The table is constructed as follows:

a. Column 1 specifies the OPS number.

b. Column 2 describes the name of the DMTD typically used for the OPS.

c. Columns 3 to 20 define the RF and protocol parameters that shall be used by a DMTD to comply with the OPS serial number.

d. Column 21 specifies the DMTD variants/models.

e. Column 22 provides additional comments where appropriate.

f. Additional numbered notes are provided after the table that refer to specific fields in the table.

5.5.2.1 Table map.
TABLE XIVis too large (too many columns) to be viewed on one sheet. FIGURE 34 depicts the overall configuration of TABLE XIV. For example, OPS code 1 on sheet 1 of 7 Operational Parameter Settings stretches from the left panel crosses over to the right panel. Each OPS setting identifies a different set of parameters extending down to sheets 5 and 6 of 7. The final sheet contains all the notes.

TABLE XIV. Standard Network Settings. (Sheet 1 of 7) OPS 0 – 13 (Left Panel)	TABLE XIV. Standard Network Settings. (Sheet 2 of 7) OPS 0 – 13 (Right Panel)
TABLE XIV. Standard Network Settings. (Sheet 3 of 7) OPS 14 – 25 (Left Panel)	TABLE XIV. Standard Network Settings. (Sheet 4 of 7) OPS 14 – 25 (Right Panel)
TABLE XIV. Standard Network Settings. (Sheet 5 of 7) OPS 26 – 31 (Left Panel)	TABLE XIV. Standard Network Settings. (Sheet 6 of 7) OPS 26 – 31 (Right Panel)
TABLE XIV. Standard Network Settings. (Sheet 7 of 7) Comments	

FIGURE 34. Table XIV map.

5.5.3 Table use.
Network managers may select a pre-defined OPS and promulgate its OPS number to all intended users. Users may look up that OPS number and set the defined parameters in their system. A system option may be used to automate the process so that when the system is initialized with an OPS number, the parameters are automatically implemented. A new system wishing to join an established network can be provided with the OPS number for that network. This process reduces the probably of errors when given a long string of parameters. The use of the table is

optional but strongly recommended. If an OPS is selected from the table then the parameters in columns 3 to 20 are mandatory.

5.5.4 Changing from OPS parameters.
A network may change parameters from an OPS at any time. However, if this is done then that network can no longer be said to be using that OPS. If only a minor change is made to an OPS (e.g. OPS 1 but using R-NAD rather than DAP/NAD) then a joining system may be told to "…use OPS 1 with R-NAD".

5.5.5 Custom OPS.
If a Custom OPS is chosen then this shall be referred to as OPS number "0". This number shall be associated with parameter settings other than those with OPS serial numbers, it shall simply mean that custom settings are in use. Details of those settings shall be obtained by other means as determined by the local procedures.

TABLE XIV. Standard Network Settings.

OPS Number	OPS Name	Rate	Modulation	Crypto Mode	Crypto Type	Hop Mode	Channel Spacing	220 EDC Mode	220 Data Link LayerScrambling	220 NAD Mechanism	Net Traffic Type	Enable Data Link Layer Concatenation On Transmit
0	CUSTOM	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any
1	SINCGARS 4800 PT SC	4800	NRZ	PT	None	SC	N/A	FEC/TDC	Off	DAPNAD	Data Only	True
2	SINCGARS 4800 CT SC	4800	NRZ	CT	Vinson	SC	N/A	FEC/TDC	Off	DAPNAD	Data Only	True
3	SINCGARS 4800 CT FH	4800	NRZ	CT	Vinson	FH	N/A	FEC/TDC	Off	DAPNAD	Data Only	True
4	SINCGARS 1200N PT SC	1200N	NRZ	PT	None	SC	N/A	None	Off	DAPNAD	Data Only	True
5	SINCGARS 1200N CT SC	1200N	NRZ	CT	Vinson	SC	N/A	None	Off	DAPNAD	Data Only	True
6	SINCGARS 1200N CT FH	1200N	NRZ	CT	Vinson	FH	N/A	None	Off	DAPNAD	Data Only	True
7	SINCGARS 2400N CT FH	2400N	NRZ	CT	Vinson	FH	N/A	None	Off	DAPNAD	Data Only	True
8	SINCGARS 4800N CT FH	4800N	NRZ	CT	Vinson	FH	N/A	None	Off	DAPNAD	Data Only	True
9	Two Wire 1200 PT SC	1200	FSKC	PT	None	SC	N/A	FEC/TDC	Off	DAPNAD	Data Only	True
10	Two Wire 32000 PT SC	32000	CDP	PT	None	SC	N/A	FEC/TDC	Off	DAPNAD	Data Only	True
11	HF CONFIG 1200 CT SC	1200	NRZ	CT	ANDVT	SC	N/A	FEC/TDC	Off	DAPNAD	Data Only	True
12	HF CONFIG 2400 CT SC	2400	NRZ	CT	ANDVT	SC	N/A	FEC/TDC	Off	DAPNAD	Data Only	True
13	SATCOM 5KHZ 2400 3KG84	2400	NRZ	CT	3KG84	SC	5KHZ	FEC/TDC	Off	DAPNAD	Data Only	True

TABLE XIV. Standard Network Settings - Continued

OPS Number	OPS Name	Enable Physical Layer Concatenation On Transmit	Amplitude	Local Station Class	Initial Default for Enable Topology Updates And Intra-Net Relay (can be changed)	Initial Default for Enable Use Of Net Busy Indication From Device (can be changed)	Initial Default for Number Of Stations (can be changed)	Initial Default Standard Configuration for new 220 nets (can be changed)	Radio Equipment /Model Supported By This Standard Configuration (Using 220 Standard Parameter Tables)	Row Specific Comments
0	CUSTOM	Any	Any	Any	Any	Any	Any	No	Any	Note 1
1	SINCGARS 4800 PT SC	False	N/A	D (1,2,3,4)	False	False	10	No	RT-1439 (non ICOM), RT-1523 (ICOM), RT-1523C (SIP), RT-1523E (ASIP)	
2	SINCGARS 4800 CT SC	False	N/A	D (1,2,3,4)	False	False	10	No	RT-1439 (non ICOM), RT-1523 (ICOM), RT-1523C (SIP), RT-1523E (ASIP)	
3	SINCGARS 4800 CT FH	False	N/A	D (1,2,3,4)	False	False	10	No	RT-1439 (non ICOM), RT-1523 (ICOM), RT-1523C (SIP), RT-1523E (ASIP)	
4	SINCGARS 1200N PT SC	False	N/A	D (1,2,3,4)	False	False	10	No	RT-1523C (SIP), RT-1523E (ASIP)	
5	SINCGARS 1200N CT SC	False	N/A	D (1,2,3,4)	False	False	10	No	RT-1523C (SIP), RT-1523E (ASIP)	
6	SINCGARS 1200N CT FH	False	N/A	D (1,2,3,4)	False	False	10	No	RT-1523C (SIP), RT-1523E (ASIP)	
7	SINCGARS 2400N CT FH	False	N/A	D (1,2,3,4)	False	False	10	No	RT-1523C (SIP), RT-1523E (ASIP)	
8	SINCGARS 4800N CT FH	False	N/A	D (1,2,3,4)	False	False	10	Yes	RT-1523C (SIP), RT-1523E (ASIP)	
9	Two Wire 1200 PT SC	False	Zero Dbm	D (1,2,3,4)	False	N/A	10	No	Field Wire	
10	Two Wire 32000 PT SC	False	N/A	D (1,2,3,4)	False	N/A	10	No	Field Wire	
11	HF CONFIG 1200 CT SC	False	N/A	D (1,2,3,4)	False	N/A	2	No	PRC-150, KY99A/PRC-104, KY-99A/PRC-138, ANDVT(AN/USC-43)/HFRG (URC-131), ANDVT(AN/USC-43)/URC-109	
12	HF CONFIG 2400 CT SC	False	N/A	D (1,2,3,4)	False	N/A	2	No	PRC-150, KY99A/PRC-104, KY-99A/PRC-138, ANDVT(AN/USC-43)/HFRG (URC-131), ANDVT(AN/USC-43)/URC-109	
13	SATCOM 5KHZ 2400 3KG84	False	N/A	D (1,2,3,4)	N/A	N/A	5	No	PSC-5A (RT-1672/U(c)), PSC-5C (RT-1672C(c)/U), PSC-5D (RT-1672D(c)/U)	Note 2

TABLE XIV. Standard Network Settings - Continued

OPS Number	OPS Name	Rate	Modulation	Crypto Mode	Crypto Type	Hop Mode	Channel Spacing	220 EDC Mode	220 Data Link Layer Scrambling	220 NAD Mechanism	Net Traffic Type	Enable Data Link Layer Concatenation On Transmit
14	SATCOM 5KHZ 2400 ANDVT	2400	NRZ	CT	ANDVT	SC	5KHZ	FEC/TDC	Off	DAPNAD	Data Only	True
15	SATCOM 25KHZ 9600 3KG84	9600	NRZ	CT	3KG84	SC	25K HZ	FEC/TDC	Off	DAPNAD	Data Only	True
16	SATCOM 25KHZ 16000 VINSON	16000	NRZ	CT	Vinson	SC	25K HZ	FEC/TDC	Off	DAPNAD	Data Only	True
17	RESERVED											
18	UHF 16000 CT SC	16000	NRZ	CT	Vinson	SC	N/A	FEC/TDC	On	DAPNAD	Data Only	False
19	SINCGARS 16000 PT SC	16000	NRZ	PT	None	SC	N/A	FEC/TDC	On	DAPNAD	Data Only	False
20	SINCGARS 16000 CT SC	16000	NRZ	CT	Vinson	SC	N/A	FEC/TDC	On	DAPNAD	Data Only	False
21	RESERVED											
22	HAVEQUICK 16000 CT FH	16000	NRZ	CT	Vinson	FH	N/A	FEC/TDC	On	DAPNAD	Data Only	False
23	SINCGARS 16000 PT FH	16000	NRZ	PT	None	FH	N/A	FEC/TDC	On	DAPNAD	Data Only	False
24	SINCGARS 16000 CT FH	16000	NRZ	CT	Vinson	FH	N/A	FEC/TDC	On	DAPNAD	Data Only	False
25	SINCGARS 2400N PT SC	2400N	NRZ	PT	NONE	SC	N/A	None	Off	DAPNAD	Data Only	True

TABLE XIV. Standard Network Settings - Continued

OPS Number	OPS Name	Enable Physical Layer Concatenation On Transmit	Amplitude	Local Station Class	Initial Default for Enable Topology Updates And Intra-Net Relay (can be changed)	Initial Default for Enable Use Of Net Busy Indication From Device (can be changed)	Initial Default for Number Of Stations (can be changed)	Initial Default Standard Configuration for new 220 nets (can be changed)	Radio Equipment /Model Supported By This Standard Configuration (Using 220 Standard Parameter Tables)	Row Specific Comments
14	SATCOM 5KHZ 2400 ANDVT	False	N/A	D (1,2,3,4)	N/A	N/A	5	No	PSC-5A (RT-1672/U(c)), PSC-5C (RT-1672C(c)/U), PSC-5D (RT-1672D(c)/U), ANDVT(AN/USC-43)/MD1324/WSC-3	Note 2
15	SATCOM 25KHZ 9600 3KG84	False	N/A	D (1,2,3,4)	N/A	N/A	5	No	PSC-5A (RT-1672/U(c)), PSC-5C (RT-1672C(c)/U), PSC-5D (RT-1672D(c)/U)	Note 3
16	SATCOM 25KHZ 16000 VINSON	False	N/A	D (1,2,3,4)	N/A	N/A	5	No	PSC-5A (RT-1672/U(c)), PSC-5C (RT-1672C(c)/U), PSC-5D (RT-1672D(c)/U), KY-58A/WSC-3	Note 3
17	RESERVED									
18	UHF 16000 CT SC	False	N/A	A (1,3)	False	N/A	6	No	RT-1824(C), PRC-113	
19	SINCGARS 16000 PT SC	False	N/A	A (1,3)	False	False	6	No	RT-1824(C), RT-1439 (non-ICOM), RT-1523 (ICOM), RT-1523C (SIP), RT-1523E (ASIP)	
20	SINCGARS 16000 CT SC	False	N/A	A (1,3)	False	False	6	No	RT-1824(C), RT-1439 (non-ICOM), RT-1523 (ICOM), RT-1523C (SIP), RT-1523E (ASIP)	Note 4
21	RESERVED									
22	HAVEQUICK 16000 CT FH	False	N/A	A (1,3)	False	N/A	6	No	RT-1824(C), PRC-113	
23	SINCGARS 16000 PT FH	False	N/A	A (1,3)	False	False	6	No	RT-1824(C), RT-1439 (non-ICOM), RT-1523 (ICOM), RT-1523C (SIP), RT-1523E (ASIP)	Note 4
24	SINCGARS 16000 CT FH	False	N/A	A (1,3)	False	False	6	No	RT-1824(C), RT-1439 (non-ICOM), RT-1523 (ICOM), RT-1523C (SIP), RT-1523E (ASIP)	Note 4
25	SINCGARS 2400N PT SC	False	N/A	D(1,2,3,4)	False	False	10	No	RT-1439 (non ICOM), RT-1523 (ICOM), RT-1523C (SIP), RT-1523E (ASIP)	

TABLE XIV. Standard Network Settings - Continued

OPS Number	OPS Name	Rate	Modulation	Crypto Mode	Crypto Type	Hop Mode	Channel Spacing	220 EDC Mode	220 Data Link Layer Scrambling	220 NAD Mechanism	Net Traffic Type	Enable Data Link Layer Concatenation On Transmit
26	SINCGARS 2400N CT SC	2400N	NRZ	CT	VINSON	SC	N/A	None	Off	DAPNAD	Data Only	True
27	SINCGARS 4800N PT SC	4800N	NRZ	PT	NONE	SC	N/A	None	Off	DAPNAD	Data Only	True
28	SINCGARS 4800N CT SC	4800N	NRZ	CT	VINSON	SC	N/A	None	Off	DAPNAD	Data Only	True
29	SINCGARS 9600N PT SC	9600N	NRZ	PT	NONE	SC	N/A	None	Off	DAPNAD	Data Only	True
30	SINCGARS 9600N CT SC	9600N	NRZ	CT	VINSON	SC	N/A	None	Off	DAPNAD	Data Only	True
31	SINCGARS 9600N CT FH	9600N	NRZ	CT	VINSON	FH	N/A	None	Off	DAPNAD	Data Only	True
Column Specific Comments												

TABLE XIV. Standard Network Settings - Continued

OPS Number	OPS Name	Enable Physical Layer Concatenation On Transmit	Amplitude	Local Station Class	Initial Default for Enable Topology Updates And Intra-Net Relay (can be changed)	Initial Default for Enable Use Of Net Busy Indication From Device (can be changed)	Initial Default for Number Of Stations (can be changed)	Initial Default Standard Configuration for new 220 nets (can be changed)	Radio Equipment /Model Supported By This Standard Configuration (Using 220 Standard Parameter Tables)	Row Specific Comments
26	SINCGARS 2400N CT SC	False	N/A	D (1,2,3,4)	False	False	10	No	RT-1439 (non ICOM), RT-1523 (ICOM), RT-1523C (SIP), RT-1523E (ASIP)	
27	SINCGARS 4800N PT SC	False	N/A	D (1,2,3,4)	False	False	10	No	RT-1439 (non ICOM), RT-1523 (ICOM), RT-1523C (SIP), RT-1523E (ASIP)	
28	SINCGARS 4800N CT SC	False	N/A	D (1,2,3,4)	False	False	10	No	RT-1439 (non ICOM), RT-1523 (ICOM), RT-1523C (SIP), RT-1523E (ASIP)	
29	SINCGARS 9600N PT SC	False	N/A	D (1,2,3,4)	False	False	10	No	RT-1439 (non ICOM), RT-1523 (ICOM), RT-1523C (SIP), RT-1523E (ASIP)	
30	SINCGARS 9600N CT SC	False	N/A	D (1,2,3,4)	False	False	10	No	RT-1439 (non ICOM), RT-1523 (ICOM), RT-1523C (SIP), RT-1523E (ASIP)	
31	SINCGARS 9600N CT FH	False	N/A	D (1,2,3,4)	False	False	10	No	RT-1439 (non ICOM), RT-1523 (ICOM), RT-1523C (SIP), RT-1523E (ASIP)	
Column Specific Comments			Note 5			Note 6	Note 7	Note 8	Note 9	

TABLE XIV. Standard Network Settings - Continued

Notes:	
1	When the operator changes from a Standard Configuration to Custom "0" Configuration, parameter values initially remain unchanged, and then parameters that are normally not editable as part of a standard configuration, e.g. rate, can be changed to any value that results in a supportable combination of parameter values.
2	Requires a dedicated 5KHZ Satellite Channel whose bandwidth will then be shared among MIL-STD-188-220 capable stations. The DAMA method of sharing a SATCOM channel is not yet supported using MIL-STD-188-220.
3	Requires a dedicated 25KHZ Satellite Channel whose bandwidth will then be shared among MIL-STD-188-220 capable stations. The DAMA method of sharing a SATCOM channel is not yet supported using MIL-STD-188-220.
4	Improved network throughput may be realized by turning the Scrambling feature OFF.
5	The amplitude parameter only applies for nets that use FSK encoding. The Zero Dbm value for FSKC over wireline provides maximum power for longer wire lengths.
6	SINCGARS provides an early net busy indication on the Squelch Pin. When this SINCGARS net busy indication is used, the shorter net busy detect time in the MIL-STD-188-220 parameter table should be used. Because not all MIL-STD-188-220 capable stations, e.g. those equipped with older TCIM 1 models, the default configuration is to Disable the use of the net busy indication from SINCGARS such that net busy detect time will be set consistently at all MIL-STD-188-220 stations. The setting of this parameter is not a mandatory part of the standard configuration (even though it is critical that all stations on a SINCGARS net use the same Net Busy Detect Time).
7	This is just a recommended default parameter setting for when a standard configuration is initially selected. The number of stations is not a mandatory part of the standard configuration.
8	This is just the recommended default standard configuration setting for when a new MIL-STD-188-220 net is created. This default is not a mandatory part of the standard configuration.
9	The timing parameters that are used with these standard configuration and are a part of the MIL-STD-188-220 standard were only tested against the indicated radio equipment (in the indicated modes) and may not be compatible with other equipment/models (and/or equipment modes).

6 NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Subject term (key word) listing.

The follow key words and phrases apply to this document.

Asynchronous Mode
Combat Network Radio (CNR)
Data Communications Protocol
Data Link Layer
Error Detection and Correction
Golay
HAVEQUICK
Interoperability
Intranet
Logical Link Control
Media Access Control
MIL-STD-188-220
MIL-STD-2045-47001
Network Access Delay (NAD)
Packet Mode
Packets
Radio
Relay
Robust Communications Protocol (RCP)
SINCGARS
Synchronous Mode
Tactical Internet
Topology Update
Type of Service (TOS)
VMF
XNP

6.2 Issue of the DoD index of specifications and standards.

When this document is used in procurement, the applicable issue of the DoDISS will be cited in the solicitation.

6.3 Interoperability considerations.

This section addresses some of the aspects that terminal designers and systems engineers should consider when applying MIL-STD-188-220 in their communications system designs. The proper integration of MIL-STD-188-220 into the total system design will help to ensure the interoperability of stations that exchange information over a data communications link consisting of a DMTD, a transmission channel, and a DMTD or C^4I system.

6.3.1 Transmission channel.
For the purpose of this document, the transmission channel (from the transmitter to the receiver) is considered transparent to the DMTD subsystem. However, the transmission channel will be interoperable within itself. The transmission channel may be secured or non-secured, using such media as line-of-sight (LOS) radio, high frequency (HF) radio, wireline, and satellite communications (SATCOM).

6.3.2 Physical interface.
The specific details of the physical interface for connecting DMTDs to the equipment that implements the transmission channel are beyond the scope of this document. The actual physical connections will depend on the interface characteristics required by the particular transmission equipment. These unique physical interface characteristics may be defined in the equipment specifications or in technical interface specifications. Therefore, the requirements for the electrical features (such as data, clock, and control) and mechanical features (such as connectors, pin assignments, and cable) of the connection between the DMTD and the associated transmission channel equipment are left to the equipment designer. The design philosophy is that what appears at the input end of the transmission channel should be the same at the output end. Implementation notes for effecting a working interface to specific radios are provided in the following subparagraphs.

6.3.2.1 SINCGARS System Improvement Program (SIP) Receiver/Transmitter (R/T) interface.
The DTE (DMTD or C^4I system) interacts with the DCE via an X.21 data interface and an External Control Interface. When the precedence level of the transmission changes, the DTE will set the precedence level for the new transmission via the External Control interface. This precedence level will correspond to the frame with the highest precedence value within the series of concatenated frames.

Information on interfaces for SINCGARS ASIP radios can be found in the following reference:

Interface Control Document (ICD)	Title
A3266178	SINCGARS ASIP – RT1523E Advanced SINCGARS SIP Interface Control Document

6.3.2.1.1 Carrier Sense Multiple Access (CSMA) network access.
Although all SINCGARS SIP R/Ts in a given network are not required to use the same CSMA slot offsets and limits for voice and/or precedence levels, it is highly recommended that the same slot settings be used within a network. All SINCGARS SIP R/Ts in a network will be using the same slot width (18ms - FH; 54ms - SC) and the same mode of operation (plain text or cipher text).

6.3.2.1.2 Network busy sensing and receive status.
The presence of multiple stations on a single random access communications network requires voice/data Network Busy Sensing and the use of NAC to reduce the possibility of data collisions

on the net. The combined Data and Voice Networks require cooperation between the DTE (DMTD or C^4I system) and the DCE.

The DCE indicates the presence of receive data and voice via the X.21 Indication line "I" signal. A precise determination of the network status is obtained via the X.21 DTE Receive line "R" signal in combination with the "I" signal:

I = OFF and R = 1's ->	Idle/Transmission Completed
I = OFF and R = Flags ->	Data being transmitted
I = ON and R = Flags ->	Data being received
I = ON and R = 1's ->	Voice operation if this condition persists for more than 750 msec. From 0 to 750 msec the radio is busy, but voice or data reception can't be determined until either the presence of flags on the R-line for data or the expiration of 750 msec when voice reception is assumed.

The transmission of data takes effect by driving the X.21 Control line "C" (push-to-talk) and DTE Transmit line "T", as follows:

Verify I = OFF and R = 1's, then assert C = ON and send flags T = Flags

Verify I = OFF and R = Flags, then transmit data T = Data

Upon transmit completion, assert C = OFF and send T = 1's

The time between the SINCGARS SIP R/T detection of network busy and the determination of network busy with voice is added to any suspended timers. The timers are suspended in the INC only after network busy with voice is indicated. Therefore, adding the time period in which the radio detects network busy with "something" until network busy with voice is determined accounts for the period of time voice was actually present.

6.3.2.1.3 Network timing model parameters.

The Network Timing Model is described in APPENDIX C. The model defines parameters necessary to ensure interoperability. It is important to ensure that all systems participating in a network use the same parameter values. Parameter values are provided in a separate document entitled "MIL-STD-188-220 Parameter Table", which is available on the CNRWG website specified at 2.3.4. This table should be utilized by all systems.

6.3.2.1.4 Other SINCGARS SIP implementation details.

a. The RE-NAD slot assignment for Type 3 PDUs is offset=0, limit=0. The "offset" is the number of the first slot while the "limit" is the number of slots associated with the particular parameter (e.g., a precedence level). Offset=0, limit=0 means there is no randomized delay associated with the Type 3 PDUs or the returned Type 3 acknowledgments in the SIP R/T due to the RE-NAD process. The 0-second Immediate Mode scheduler is used with these PDUs and returned acknowledgments so that no additional randomized delay is incurred from the INC (where the scheduler is implemented).

b. The SINCGARS SIP R/T does not manipulate any trailing flags included in the data stream presented to it. These flags are transmitted over the air.

c. From the SINCGARS SIP R/T perspective, any trailing flags are part of the data stream and should be calculated into DATA.

d. The DTE (e.g. INC) will achieve synchronization with the SINCGARS SIP R/T within four flag sequences. Data may be sent upon detection of a valid flag sequence.

6.3.2.2 SINCGARS Integrated COMSEC (ICOM) R/T interface.
Information on interfaces for SINCGARS ICOM radios can be found in the following reference:

Interface Control Document (ICD)	Title
A3017864	SINCGARS ICOM – Receiver-Transmitter Radio RT-1523

6.3.2.2.1 NRZ physical interface between DTE and R/T.
The SINCGARS ICOM digital data interface to a DTE is a synchronous, unbalanced, half-duplex serial interface.

a. The signaling format is NRZ, at voltage levels compatible with those specified in MIL-STD-188-114A for a single receiver load termination.

b. Digital data rates of 600, 1200, 2400, 4800 and 16000 bps are supported by the ICOM R/T. When a data rate below 16000 bps is selected at a transmitter, a Data Rate Adapter (DRA) internal to the ICOM converts the data to 16000 bps, using majority logic FEC techniques.

c. The ICOM R/T also provides a receive squelch indication to the DTE when channel activity is sensed.

6.3.2.2.2 Network busy sensing and receive status.
Network Busy Sensing provides a mechanism to manage channel access among members of a common network. Without managed channel access, multiple stations attempting simultaneous transmissions will collide, degrading network performance. Managing channel access also minimizes the network performance loss due to mixing both voice and data in a common net.

a. For both voice and digital data receptions, the DCE provides a receive squelch indication via the Analog Data Mode Control_Not (ADMC_N) line. This ADMC_N squelch indication is a composite signal from several internal sources. Using this signal, the worst-case network busy detect times are 350 msec for FH and 100 msec for SC.

b. For digital data receptions, the DCE presents a synchronous clock on the Digital Data Clock Out (DDCO) line. ADMC_N will typically precede DDCO for all digital data receptions. The exception is for PT 16000 bps data, when both ADMC_N and DDCO will be coincident.

c. For voice receptions, the DCE will provide a receive squelch indication via ADMC_N, but will not present DDCO.

d. If both ADMC_N and DDCO are considered as binary signals, there are four possible indications which a DTE can use to infer network status. TABLE XV summarizes the four possible receive states and their interpretation.

TABLE XV. SINCGARS ICOM receive states.

	ADMC_N Active	ADMC_N Inactive
DDCO Active	Digital data reception	Not Applicable
DDCO Inactive	Voice reception	R/T idle

6.3.2.2.3 Network timing model parameters.
The Network Timing Model is described in APPENDIX C. Parameter values are provided in a separate document entitled “MIL-STD-188-220 Parameter Table”. This table should be utilized by all systems.

6.3.2.3 HAVEQUICK II R/T interface.

6.3.2.3.1 Network timing model parameters.
The Network Timing Model is described in APPENDIX C. Parameter values are provided in a separate document entitled “MIL-STD-188-220 Parameter Table”. This table should be utilized by all systems.

6.3.2.4 COMSEC interoperability.
The COMSEC function provides a link encryption capability. In the traditional COMSEC mode of operation, the COMSEC function (normally implemented in ancillary equipment) is considered part of the transmission channel. In the embedded COMSEC mode, the COMSEC function is an integral part of the DMTD subsystem.

6.3.3 Data Link Layer.
The following implementation details should be considered when implementing the DL of MIL-STD-188-220:

a. The first bit of the Transmission Header that is transmitted (after the flag) will be the FEC selection bit and the last bit transmitted will be bit 9 of FIGURE 11.

b. The last 2 sentences of 5.3.1 says that the TDC block for the 12-bit TWC and 64-bit Transmission Header contains seven 24-bit codewords, encoded as a 168-bit TDC block. 5.3.14.2 says that if the (12+64=76, plus a few inserted zeros) data bits do not divide into an integral number of 12-bit segments, fill bits of zeros are added to the end. Note that this does NOT require the PL to parse the Transmission Header, since the length of the Transmission Header is fixed at 64 bits (see FIGURE 9).

c. Reliable broadcast involves the need for stations to return an acknowledgment to the originator of messages that are received with only the global data link address (see 5.3.4.2.2.2.2.8 -- the broadcast address is used at higher protocol layers) -- and the receiving station is not individually addressed in the message. There is no requirement for reliable broadcast at the Intranet or Data Link layer.

d. Type 4 acknowledgments (DRR and DRNR are discussed in 5.3.7.4.5.3.1.2 and 5.3.7.4.5.2.3, respectively) may be transmitted twice. The second transmission of the DRR/DRNR should be concatenated with other data link frame transmissions. The DTE should not access the network merely to transmit the second DRR/DRNR.

e. When a station receives an out-of-sequence I frame (see 5.3.7.2.5.4) it may send either an REJ or SREJ, depending upon whether the station can perform resequencing. A station should send SREJ when it can resequence received I frames and should send REJ otherwise.

f. N4 (see 5.3.8.1.4.c) is the number of permitted re-transmissions. The number of times that a message may be transmitted is N4+1.

g. The following definition of Quiet Mode (see 5.3.11.2) will be used: When a station can not determine whether another station is in Quiet Mode, it should assume that the station is not in Quiet Mode. The fact that a station has entered Quiet Mode will be known globally over the Internet. While there is a possibility that some stations will not get the information, or will ignore the information; the protocol will not try to fix the problem. Specifically, there is no requirement for the last relayer to issue a proxy acknowledgment for stations that are operating in Quiet Mode.

6.3.3.1 <u>Frequency of Access Ranking (FOAR).</u>
FOAR is intended to increase the fairness of network access in DAP-NAD and DAV-NAD. This paragraph describes a network management tool that may be used as a stand alone mechanism or integrated into the system. It is recommended that systems implementing DAP-NAD or DAV-NAD utilize the FOAR algorithm to designate Station Number (SN). The algorithm requires that stations be numbered sequentially from 1 to NS where NS represents the total number of stations participating in the subnetwork. The number 1 should be provided to the station expected to require the most accesses (busiest station) and the highest number (NS) provided to the least busy station. The algorithm for this scheme is shown below.

SN = ((FOAR + 1) / 2): if FOAR is odd
SN = FOAR/2 + (INT (NS + 1) / 2): if FOAR is even, where INT (NS +1)/2 is a number truncated to the nearest integer.

Example: Using a network with 8 nodes (A-H). H is busiest, A is next busiest, B is next, D is next and G is least. The ordering for FOAR would be H, A, B, D, C, E, F, G which are assigned sequential numbers 1-8 respectively.

Station Name	Station FOAR	Station Number for DAP-NAD
H	1	1=(1+1)/2
A	2	5=2/2 + INT ((8+1)/2)
B	3	2=(3+1)/2
D	4	6=4/2 + INT ((8+1)/2)
C	5	3=(5+1)/2
E	6	7=6/2 + INT ((8+1)/2)
F	7	4=(7+1)/2
G	8	8=8/2 + INT ((8+1)/2)

A network manager would provide each participating system in the network with a unique Station Number based on the above algorithm.

6.3.3.2 Generation of unique six octet Data Link Layer address for IPv6.
Section 5.3.4.2.2.1.3.1 requires any system using IPv6 at the Network Layer to have a static and universally unique six octet Data Link Layer address. This is a condition that must be met in the commercial world for Ethernet cards, which serve as the primary means of participation on the internet. This is achieved through the use of 48-bit Extended Unique Identifiers (EUI-48), which are regulated by the Institute of Electrical and Electronics Engineers (IEEE). EUI-48 values are formed by concatenating a 24-bit Organizational Unique Identifier (OUI) administered by the IEEE Registration Authority and a 24-bit extension identifier assigned by the organization with that OUI assignment. This allows the assignee to generate approximately 16 million unique EUI-48 values.

The recommended implementation for guaranteeing a static and universally unique six octet Data Link Layer address in MIL-STD-188-220 applications is to follow the commercial standards as closely as possible. This presents the advantages of capitalizing on commercial practices and reducing government overhead. Equipment using IPv6 for the Network Layer will obtain its six octet Data Link Layer address in one of two ways, depending on the status of the hardware.

6.3.3.2.1 Pre-fielded equipment.
This method for assigning six octet Data Link Layer addresses applies to equipment that have not yet been fielded (i.e. delivered equipment in spares status, laboratory equipment, and commercial equipment).

a. The equipment Vendor must register for an OUI with the IEEE Registration Authority.

b. The equipment Vendor must serialize their equipment produced that uses IPv6 at the Network Layer with a MIL-STD-188-220 protocol stack using 24-bit serial numbers, which serves as a 24-bit extension identifier.

c. The equipment Vendor assigns the static six octet Data Link Layer address to the equipment by concatenating their Vendor OUI with the equipment serial number.

d. The Vendor must store this six octet address in the equipment in non-volatile memory.

e. The Vendor must provide a utility for changing this stored address.

6.3.3.2.2 Fielded equipment.
This method for assigning static and universally unique six octet Data Link Layer addresses applies to equipment that is actively fielded.

a. The fielding Service must register for an OUI with the IEEE Registration Authority.

b. The fielding Service must assign the equipment a 24-bit Unit Reference Number (URN), which serves as a 24-bit extension identifier.

c. The fielding Service uses the Vendor-supplied utility for changing the stored six octet Data Link Layer address to assign the static and universally unique address, formed by concatenating their Service OUI with the equipment URN.

Additional information concerning the commercial standard (EUI-48) can be found here: http://standards.ieee.org/regauth/oui/tutorials/EUI48.html .

6.3.4 Intranet Layer.
The following implementation details should be considered when implementing the DL of MIL-STD-188-220:

a. Relayers optionally may collapse the Intranet Header to remove addresses that are not on the path to or from the relaying node (see 5.4.1.1.9.5.1). The destination node would still have sufficient information to return an acknowledgment. Interoperability is not affected because the complete path between originator and destination is not corrupted. Collapsing the Intranet Header would minimize bandwidth utilization but would probably increase processing time at each relayer and could destroy information that might be useful to network management functions.

b. The source node will be included as the first entry in every Topology Update (see 5.4.1.2) sent by the INC. The Node Address and Node Predecessor will be set to the station ID (link address) of the source node. The Quiet and Non-relay Status bits will be set to that station's current status. The hop length field will be set to 0. The remaining entries in the Topology Update have no implied ordering. A node aware only of itself will generate an initial update containing just its own entry.

c. Topology Update messages (see 5.4.1.2) are broadcast unreliably.

d. In the Topology Update Data Structure (FIGURE 32), the "node address" and "node predecessor address" (see 5.4.1.2.3 and 5.4.1.2.5, respectively) have been implemented in the INC and some IDMs in the following manner, for single octet addressing only:

> *Both of these addresses are "the link address of the node in the Intranet". The link address is seven bits long (see 5.3.4.2.2.1). As such, bits 0 through 6 contain the "link address" used in the node address and node predecessor address. Bit 7 will be zero. Note: The C/R bit and the extension bit associated with the link address will not be used in the Topology Update Data Structure.*

e. Topology Update (see 5.4.1.2) and Topology Update Request messages (see 5.4.1.3) use Data Link Type 1, unacknowledged, procedures.

f. The precedence of Topology Update (see 5.4.1.2) and Topology Update Request messages (see 5.4.1.3) is user defined.

g. Receiving a Topology Update Request (see 5.4.1.3) indicates an operational two-way (bi-directional) link.

h. It is possible for the Min_Update_Per parameter (see H.4.4.2) to take different values on a node-by-node basis within a net. There is essentially no problem unless one of the nodes takes the value 0. Assume node A has this value set to 0. Node A is not permitted to respond to topology requests. Nodes without traffic for this node issue topology update requests to try to set up links. Node A does not respond. Once a node (e.g. B) sets up a valid link with a link layer acknowledgment, a topology update listing this connection is advertised. All other nodes without a link will switch to a 2-hop path using node B as a relayer to node A. Therefore, it is logical that the Min_Update_Per value should be set on a network-wide basis. An alternative solution is available: The non-participant can announce this fact in a Topology Update message that identifies itself in the Node 1 Address field and the Node 1 Predecessor Address field and by setting the NR bit in the Node 1 Destination/Status Byte.

i. I.5.3 presents the solution to Source Directed Relay Example 3 as C-E-F-G-H-D. An equally valid solution is D-C-E-F-G-H.

6.3.4.1 <u>Allocation of memory required for reassembly.</u>
The allocation of finite memory resources used for reassembling fragments must be considered. When available, implementations should allocate the total amount of memory required to

reassemble the original data based on the Total Number of Fragments field value and the amount of data contained in the first complete fragment (i.e. not the fragment with Fragment Number equal to Total Number of Fragments) received. Once all of the memory required for reassembly is allocated, received fragments can be copied directly to the proper location within memory, even in the case that a fragment is received out of order. In the event that adequate memory is not available to reassemble a higher precedence message, the reassembly of one or more lower precedence messages with the smallest number of received fragments should be aborted such that the memory space required to begin reassembling the higher precedence message can be allocated.

6.3.4.2 Deallocation of memory used for reassembly.
The deallocation of finite memory resources used for reassembling fragments must be considered. After a IL-Data Indication has been generated (subsequent to the reassembly of all fragments associated with a source/originator and Message Identification Number) and the upper layer protocol has finished processing the received message, or if the Reassembly Inactivity Timer has expired, storage for that message can be deallocated and reused for the reassembly of subsequent packets.

6.3.5 CNR Management process using XNP.

a. The CNR Management process is recommended to reduce operator burden by providing automated support for the management function.

b. There is no requirement to respond to an XNP Join Request message (see E.4.2.1). If operational conditions permit, an interval timer may be used to schedule the retransmission of an XNP Join Request message (see E.6.2).

6.3.6 Interoperation with Internet Protocols.

a. Figure 4 of RFC 791 (Internet Protocol) is interpreted as having the LSB on the RIGHT. This means that the Internet Header Length (IHL) field will be transmitted before the Version Number by the MIL-STD-188-220 lower layers.

b. Message exchanges using this standard over CNR should be accomplished using User Datagram Protocol (UDP), as described in RFC 768. Transmission Control Protocol (TCP), described in RFC 793, should be reserved for upper layer services that require Transport layer reliability.

c. The Internet Address Numbering Authority has assigned Open Shortest Path First Version 2 (OSPF2) (see RFC 2328) interface Type Value 85 for CNR.

6.4 Changes from previous issue.
Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

APPENDIX A

ABBREVIATIONS AND ACRONYMS

A.1 General.

A.1.1 Scope.
This appendix used to contain a list of abbreviations and acronyms pertinent to MIL-STD-188-220. The acronyms are in section 3 of this standard. This appendix is left blank to maintain appendix conformity.

APPENDIX B

DOD STANDARDIZED PROFILE IMPLEMENTATION CONFORMANCE STATEMENTS (DSPICS) REQUIREMENTS LIST (DPRL)

B.1 General.
This appendix has two functions:

a. It provides the DoD Standardized Profile Implementation Conformance Statements (DSPICS) Requirements List (DPRL) for implementations of Combat Net Radios. An implementation's completed DPRL is called the DSPICS. The DSPICS states which features, capabilities and options have been implemented by any system built using this standard.

b. It provides a summary of which MIL-STD-188-220 features and capabilities are mandatory or optional. In the event that there is an apparent conflict between this appendix and the main volume, one of the following actions shall be taken:

1. The "mandatory" option shall be selected in preference to the "optional" option.

2. The matter shall be referred to the CNRWG for adjudication.

This document contains numerous essential technical parameters in the form of mandatory and optional design objectives in which, in some situations, the parent capability is optional but the value is mandatory if the optional capability is elected. Even though the child value is mandatory, it does not mean the parent capability is mandatory.

Example: The Synchronous capability is a mandatory requirement that all systems must implement. The Asynchronous capability is an optional requirement, but if elected then the Frame Synchronization field is mandatory. The fact that the Frame Synchronization field is mandatory if the Asynchronous process is selected does not mean that the Asynchronous process is a mandatory requirement.

The main part of this appendix is a fixed-format questionnaire divided into a number of major sections; these can be divided into subsections each containing a group of individual items. Answers to the questionnaire items shall be provided in the Support column by simply marking an answer (i.e., by checking the applicable entry) to indicate a restricted choice (Yes or No) or by entering a value or a set of range of values.

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The structure of the DSPICS questionnaire consists of 3 main sections:

(1) Physical Layer
(2) Data Link Layer
(3) Network Layer [Intranet and Subnetwork Dependent Convergence Function (SNDCF)]

An item identification number in the first column identifies each item. The second column contains the statement of function or the question to be answered. The third column contains the reference to the material that specifies the item in the main body of the standard. The next two columns record the status of the item – whether support is mandatory, optional, prohibited or conditional – and provide the space for answers. The last column is used to list comments by their numerical endnote designator.

Implementers shall show the extent of compliance by completing the DPRL. That is, compliance to all mandatory requirements and the options that are not supported are shown. The resulting completed DPRL is called a DSPICS. If a conditional requirement is inapplicable, the "No" choice shall be used. If a mandatory requirement is not satisfied, exception information must be supplied by entering a reference Xi in the Notes column, where i is a unique identifier, to an accompanying rationale for the noncompliance.

B.1.1 Scope.
This appendix contains the minimum set of MIL-STD-188-220 features required for joint interoperability. It is intended to be used by a variety of personnel including system designers, procurers, implementers, developers and users. The following shall use the DSPICS:

a. The protocol implementer, as a checklist to reduce the risk of failure to conform to the standard through oversight and to inform any interested parties of the system implementation.

b. The supplier and acquirer or potential acquirer of the implementation, as a detailed indication of the capabilities of the implementation, stated relative to the common basis for understanding provided by the standard DSPICS proforma.

c. The user or potential user of the implementation, as a basis for initially checking the level of interoperability with another implementation. (Note that, while interoperability can never be guaranteed, failure to interoperate can often be predicted from incompatible DSPICSs).

d. A protocol tester, as the basis for selecting appropriate tests against which to assess the claim for conformance of the implementation.

B.1.2 Application.
The content of this appendix is a mandatory part of MIL-STD-188-220. The information contained herein is intended for compliance.

B.2 Applicable documents.
None.

B.3 Notation.
The following notations and symbols are used in the DPRL to indicate the status of features:

Status Symbols

M	- mandatory
M.<n>	- support of every item of the group labeled by the same numeral <n> required, but only one is active at a time
O	- optional
O.<n>	- optional, <n> is the number of optional selections
P	- item number
P:O.<n>	- parent item number of this option and number of options related to the parent when there is more than one
C	- conditional
NA	- non-applicable (i.e., logically impossible in the scope of the profile)
X	- excluded or prohibited
i	- out of scope of profile (left as an implementation choice)

In addition, the symbol "•" is used to indicate an option whose status is not constrained by the profile (status in the base standard). The O.<n> notation is used to show a set of selectable options (i.e., one or more of the set must be implemented) with the same identifier <n>.

Notations for Conditional Status
The following predicate notations are used:

<predicate>:: This notation introduces a group of items, all of which are conditional on <predicate>.
<predicate>: This notation introduces a single item, which is conditional on <predicate>.

In each case, the predicate may identify a profile feature, or a Boolean combination of predicates. ("^" is the symbol for logical negation.)

<index>:	This predicate symbol means that the status following it applies only when the DSPICS states that the features identified by the index are supported. In the simplest case, <index> is the identifying tag of a single DSPICS item. The symbol <index> also may be a Boolean expression composed of several indices.
<index>::	When this group predicate is true, the associated clause should be completed.

Support Column Symbols
The support of every item as claimed by the implementer is stated by checking the appropriate answer (Yes or No) in the support column:

Yes Supported by the implementation
No Not supported by the implementation
- Not applicable

B.4 Implementation requirements.
MIL-STD-188-220 requirements are described in Section 5 and APPENDIX B, APPENDIX C, APPENDIX D, APPENDIX E, APPENDIX F, APPENDIX G, APPENDIX H, APPENDIX I, APPENDIX J, APPENDIX K, and APPENDIX L. This appendix categorizes requirements, identified by MIL-STD-188-220 paragraph numbers, as Mandatory, Conditional or Optional. Unless otherwise specified, the category assigned to a requirement applies to all subordinate subparagraphs for the requirement. Fully compliant systems shall implement all mandatory and conditional requirements. Minimally compliant systems shall implement all mandatory requirements and some conditional requirements as described in this appendix.

B.5 Detailed Requirements.
For detailed requirements see ANNEX A.

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ANNEX A

A.1 MIL-STD-188-220D Profile Protocol Stack.

MIL-STD-188-220D Layers	Base Standard
NETWORK LAYER	5.4
INTRANET LAYER	5.4.1
DATA LINK LAYER	5.3
PHYSICAL LAYER	5.1 & 5.2

A.2 Implementation Identification.

Supplier	
Contact point for queries about the DSPICS	
Implementation Name(s) and Version(s)	
Other information necessary for full identification (e.g. name(s) and version(s) of machines and/or operating systems, system name(s))	

A.2.1 Protocol Summary.

Identification of Protocol Specification	Military Standard, Interoperability Standard for Digital Message Transfer Device Subsystems, MIL-STD-188-220D.
Identification of amendments and corrigenda to the DSPICS Proforma	Military Standard, Interoperability Standard for Digital Message Transfer Device Subsystems, MIL-STD-188-220D. Am.: Corr.: Am.: Corr.: Am.: Corr.: Am.: Corr.: Am.: Corr.:
Protocol Version(s) supported	
Date of Statement	

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ANNEX A

A.3 CNR Requirements List.

The following tables give the DPRL for the MIL-STD-188-220 Intranet Layer, Data Link Layer and Physical Layer. The support column describes the implementation.

A.3.1 Basic Requirements.

Item (series)	Protocol Feature	Reference	Status	Support	Notes
100	Physical Layer	5.1 5.2	M	Yes__ No__	
200	Data Link Layer	5.3	M	Yes__ No__	
300	Network Layer	5.4	M	Yes__ No__	
301	Intranet Layer Protocol	5.4.1	M	Yes__ No__	
302	Subnetwork Dependent Convergence Function (SNDCF)	5.4.2	M	Yes__ No__	
303	Lower layer protocol network settings	5.5	O	Yes__ No__	

A.4 Physical Layer DPRL.

Item	Protocol Feature	Reference	Status	Support	Notes
100	Physical Layer	5.1	M	Yes__ No__	
100.a	The physical layer (PL) shall provide the control functions required to activate, maintain, and deactivate the connections between communications systems	5.1	M	Yes__ No__	
101	Transmission Channel Interfaces	5.1.1 APPENDIX L	M	Yes__ No__	
102	Physical Layer Protocol	5.2	M	Yes__ No__	

A.4.1 Transmission Channel Interfaces.

Item	Protocol Feature	Reference	Status	Support	Notes
101	Transmission Channel Interfaces	5.1.1 APPENDIX L	M	Yes__ No__	

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A.4.2 Physical Layer Protocol.

Item	Protocol Feature	Reference	Status	Support	Notes
102	Physical Layer Protocol	5.2	M	Yes__ No__	
102.1	Physical Layer PDU	5.2.1	M	Yes__ No__	
102.1.a	The transmission frame shall be the basic PDU of the PL	5.2.1	M	Yes__ No__	
102.1.b	DMTD subsystems or applicable C4I systems shall support the Synchronous Mode of transmission as a minimum for joint interoperability purposes	5.2.1	M	Yes__ No__	
102.1.c	DMTD subsystems or applicable C4I systems may support the Asynchronous Mode of transmission at this standard interface	5.2.1	O	Yes__ No__	
102.1.d	DMTD subsystems or applicable C4I systems may support the Packet Mode of transmission at this standard interface	5.2.1	O	Yes__ No__	
102.1.1	Communication Security Preamble and Postamble	5.2.1.1	O	Yes__ No__	
102.1.1.a	COMSEC preamble field shall be used to achieve cryptographic synchronization over the link	5.2.1.1	102.1.1:M	Yes__ No__	
102.1.1.b	COMSEC postamble field shall be used to provide an end-of-transmission flag to the COMSEC equipment at the receiving station	5.2.1.1	102.1.1:M	Yes__ No__	
102.1.2	Phasing	5.2.1.2	O	Yes__ No__	
102.1.2.a	Phasing shall be a string of alternating ones and zeros, beginning with a one, sent by DTE	5.2.1.2	102.1.2:M	Yes__ No__	
102.1.2.b	For Packet Mode interfaces, the length of this field shall be 0 (zero)	5.2.1.2	412.1.1.6:M	Yes__ No__	
102.1.3	Transmission Synchronization Field	5.2.1.3	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
102.1.3.a	SFS shall be used to achieve synchronization when implementing the mandatory Synchronous Mode of Transmission	5.2.1.3	102.1.b :M	Yes__ No__	
102.1.3.b	SFS shall be used to achieve synchronization when implementing the optional Asynchronous Mode of Transmission	5.2.1.3	102.1.c :M	Yes__ No__	
102.1.3.c	RFS shall be used to achieve synchronization when implementing the optional Robust Communication Protocol (RCP) in the both Synchronous mode and Asynchronous mode	5.2.1.3	102.1.3.d:M	Yes__ No__	
102.1.3.d	The RCP, available in some radios is optional for both the Asynchronous and Synchronous modes	5.2.1.3	102.1.b and 102.1.c:O	Yes__ No__	
102.1.3.1	Synchronous Mode Transmission Synchronization Field	5.2.1.3.1	102.1.b :M	Yes__ No__	
102.1.3.1.1	Frame Synchronization subfield	5.2.1.3.1.1	102.1.3.1:M	Yes__ No__	
102.1.3.1.1.a	Frame synchronization subfield shall consist of one-of-two fixed 64-bit synchronization pattern as shown in FIGURE 6 or FIGURE 7.	5.2.1.3.1.1	102.1.3.1:M	Yes__ No__	
102.1.3.1.1.b	The receiver shall correlate for the frame synchronization pattern	5.2.1.3.1.1	102.1.3.1:M	Yes__ No__	
102.1.3.1.1.c	A pattern shall be detected if 13 or fewer bits are in error with non-inverted or inverted data	5.2.1.3.1.1	102.1.3.1:M	Yes__ No__	
102.1.3.1.1.d	If the correlation detects an inverted synchronization pattern, all received data shall be inverted before any other received processing is performed	5.2.1.3.1.1	102.1.3.1:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
102.1.3.1.1.e	If the standard frame synchronization subfield is detected before the robust frame synchronization subfield, the receiver shall assume the optional RCP processing is not requested for this transmission	5.2.1.3.1.1	102.1.3.1:M	Yes__ No__	
102.1.3.1.1.f	If the robust frame synchronization pattern is detected before the standard frame synchronization subfield, the receiver shall assume the optional RCP processing is requested for this transmission	5.2.1.3.1.1	102.1.3.c and 102.1.3.d:M	Yes__ No__	
102.1.3.1.1.g	If the robust frame synchronization pattern is detected, the robust frame format subfield shall be used to determine what physical level processing is required for data reception	5.2.1.3.1.1	102.1.3.1.f:M	Yes__ No__	
102.1.3.1.1.h	If the robust frame synchronization pattern is used, the standard frame synchronization pattern shall not be used	5.2.1.3.1.1	102.1.3.1:M	Yes__ No__	
102.1.3.1.2	Robust Frame Format subfield	5.2.1.3.1.2	102.1.3.c and 102.1.3.1.1.g :M	Yes__ No__	
102.1.3.1.2.a	The robust frame format subfield shall be used only with the robust frame synchronization subfield for RCP processing	5.2.1.3.1.2	102.1.3.1.2: M	Yes__ No__	
102.1.3.1.2.b	The robust frame format subfield shall be formatted with multi-dwell majority vote 3 out of 5 BCH (15,7) coding with no scrambling and no convolutional encoding.	5.2.1.3.1.2	102.1.3.1.2: M	Yes__ No__	
102.1.3.1.3	Message Indicator	5.2.1.3.1.3	102.1.1:O	Yes__ No__	
102.1.3.1.4	TWC subfield	5.2.1.3.1.4	102.1.3.1:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
102.1.3.1.4.a	The TWC calculation shall include the length of the TWC and data field	5.2.1.3.1.4	102.1.3.1.4: M	Yes__ No__	
102.1.3.1.4.b	If the number of bits in the data field will not be evenly divisible by 16, the word count shall be rounded to the next higher integer and a variable number of zeros, 0 to 15, shall be appended after the final link layer frame in order to make the Transmission Unit an integral number of 16-bit words	5.2.1.3.1.4	102.1.3.1.4: M	Yes__ No__	
102.1.3.1.4.c	These zeros shall not be subject to FEC or TDC	5.2.1.3.1.4 G.3.7.1.3	102.1.3.1.4: M	Yes__ No__	
102.1.3.2	Asynchronous Mode Transmission Synchronization Field	5.2.1.3.2	102.1.c:M	Yes__ No__	
102.1.3.2.1	Frame Synchronization subfield	5.2.1.3.2.1 5.2.1.3.1.1	102.1.3.2:M	Yes__ No__	
102.1.3.2.2	Robust Frame Format subfield	5.2.1.3.2.2 5.2.1.3.1.2	102.1.3.2:M	Yes__ No__	
102.1.3.2.3	Message Indicator	5.2.1.3.2.3 5.2.1.3.1.3	102.1.1:O	Yes__ No__	
102.1.3.2.4	TWC subfield	5.2.1.3.2.4 5.2.1.3.1.4	102.1.3.2:M	Yes__ No__	
102.1.3.3	Packet Mode Transmission Synchronization Field	5.2.1.3.3	102.1.d :O	Yes__ No__	
102.1.3.3.a	When a DTE has data to send to the radio (DCE) it shall transmit flags on the ‘T’ lead until flags are received from the radio (DCE) on the ‘R’ lead, then data shall be sent to the radio (DCE) on the ‘T’ lead	5.2.1.3.3	102.1.3.3:M	Yes__ No__	
102.1.3.3.b	A variable number (at least one) of lead flags shall be transmitted prior to the actual data	5.2.1.3.3	102.1.3.3:M	Yes__ No__	
102.1.3.3.c	On the receive side, the radio (DCE) shall send at least one flag prior to the data it sends to the DTE	5.2.1.3.3	102.1.3.3:M	Yes__ No__	
102.1.3.4	Robust Communication Protocol (RCP)	5.2.1.3.4	102.1.3.d:O	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
102.1.4	Data field	5.2.1.4	M	Yes__ No__	
102.1.4.a	The data field shall contain the string of bits, comprising the Transmission Header and concatenated data link frames, created by the data link layer following the procedures for framing, zero bit insertion, concatenation, FEC, TDC, and scrambling.	5.2.1.4	M	Yes__ No__	
102.1.5	Bit Synchronization field	5.2.1.5	102.1.3.1:O	Yes__ No__	
102.1.5.a	This field shall be used to provide the receiver a signal for re-establishing bit synchronization	5.2.1.5	102.1.5:M	Yes__ No__	
102.1.5.b	The bit synchronization field shall be a 64-bit pattern that consists of alternating ones and zeros, beginning with a one.	5.2.1.5	102.1.5 and 209.4:M	Yes__ No__	
102.2	NAC related indications	5.2.2	M	Yes__ No__	
102.2.a	Upon detection of a net busy, the net busy indicator shall be set	5.2.2	M	Yes__ No__	
102.2.b	The net busy sensing indicator shall be reset when neither digital data nor voice is detected by the net busy sensing function	5.2.2 C.4.1	M	Yes__ No__	
102.3	PL to upper layer interactions	5.2.3	M	Yes__ No__	
102.3.a	PL-Unitdata Request data/data length	5.2.3.a	102.3:O	Yes__ No__	
102.3.b	PL-Unitdata Indication data/data length	5.2.3.b	102.3:O	Yes__ No__	
102.3.c	PL-Status Indication net activity	5.2.3.c	102.3:O	Yes__ No__	

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A.5 Data Link Layer DPRL.

Item	Protocol Feature	Reference	Status	Support	Notes
200	Data Link Layer	5.3	M	Yes__ No__	
200.a	The data link layer shall provide the control functions to ensure the transfer of information over established physical paths, to provide framing requirements for data, and to provide for error control	5.3	M	Yes__ No__	
201	Transmission Header	5.3.1	M	Yes__ No__	
202	Network Access Control (NAC)	5.3.2	M	Yes__ No__	
203	Types of Procedures	5.3.3	M	Yes__ No__	
204	Data Link Frame	5.3.4	M	Yes__ No__	
205	Operational Parameters	5.3.5	M	Yes__ No__	
206	Commands and Responses	5.3.6	M	Yes__ No__	
207	Description of Procedures by Type	5.3.7	M	Yes__ No__	
208	Data Link Initialization	5.3.8	M	Yes__ No__	
209	Frame Transfer	5.3.9	M	Yes__ No__	
210	Flow Control	5.3.10	M	Yes__ No__	
211	Acknowledgment and Response	5.3.11	M	Yes__ No__	
212	Invalid Frame	5.3.12	M	Yes__ No__	
213	Retransmission	5.3.13	M	Yes__ No__	
214	Error Detection and Correction (not used in packet mode)	5.3.14	102.1.3.1:M 102.1.3.2:M 102.1.3.3:X	Yes__ No__ Yes__ No__ No	
215	Data Scrambling (not used in packet mode)	5.3.15	O	Yes__ No__	
216	Data Link Layer Interactions	5.3.16	O	Yes__ No__	

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A.5.1 Transmission Header.

Item	Protocol Feature	Reference	Status	Support	Notes
201	Transmission Header	5.3.1	M	Yes__ No__	
201.a	The TWC, MI and Transmission Header shall have Golay FEC applied when operating in the Asynchronous and Synchronous modes	5.3.1	M	Yes__ No__	
201.b	TDC (7x24) bit interleaving shall be applied in unison with the FEC on the TWC and Transmission Header	5.3.1	M	Yes__ No__	
201.c	The data shall be formatted into a TDC block composed of seven (7) 24-bit Golay (24,12) codewords in a manner analogous to 5.3.14.3	5.3.1, 5.3.14.3	M	Yes__ No__	
201.1	Selection Bits	5.3.1.1	M	Yes__ No__	
201.1.a	Scrambling, if used, shall be applied before any FEC and TDC is applied. FEC, TDC and scrambling are not applied when the Packet Mode Interface described in L.4.1.6 is used at the PL.	5.3.1.1	102.1.3.1:O 102.1.3.2:O 102.1.3.3:X	Yes__ No__ Yes__ No__ No	
201.2	MIL-STD-188-220 Version	5.3.1.2	M	Yes__ No__	
201.2.a	This subfield shall identify the MIL-STD-188-220 Version used to generate this message	5.3.1.2	M	Yes__ No__	
201.2.b	MIL-STD-188-220D compliant systems shall use the value “1” for all transmitted messages	5.3.1.2	M	Yes__ No__	
201.2.c	Received DL PDUs with a MIL-STD-188-220 Version field value that is not equal to 1 shall be discarded by stations that implement only MIL-STD-188-220D	5.3.1.2	M	Yes__ No__	

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201.2.d	A DL-Error Indication shall be generated indicating that an unsupported MIL-STD-188-220 Version field value was received.	5.3.1.2	M	Yes__ No__	
201.3	Transmission Queue Field	5.3.1.3	M	Yes__ No__	
201.3.1	T-bits	5.3.1.3.1	M	Yes__ No__	
201.3.1.a	If the T-bits are “00”, the transmission queue subfield does not contain information and is ignored	5.3.1.3.1	M	Yes__ No__	
201.3.1.b	If the T-bits are “01”, the transmission queue subfield is used in conjunction with RE-NAD.	5.3.1.3.1	202.4.4:M	Yes__ No__	
201.3.1.c	If the T-bits are “10”, the transmission queue subfield is used in conjunction with DAP-NAD and DAV-NAD.	5.3.1.3.1	202.4.5:M	Yes__ No__	
201.3.1.d	If the T-bits are “11”, this bit sequence is invalid and shall be ignored. Data link frame(s) after this header shall be processed normally.	5.3.1.3.1	M	Yes__ No__	
201.3.2	Queue Precedence	5.3.1.3.2	202.4.4:M	Yes__ No__	
201.3.3	Queue Length	5.3.1.3.3	202.4.4:M	Yes__ No__	
201.3.4	Data link Precedence	5.3.1.3.4	202.4.5:M	Yes__ No__	
201.3.4.a	It shall contain the value 0 if an urgent message is in the frame, 1 if a priority but no urgent message is in the frame and 2 if neither an urgent nor priority message is in the frame	5.3.1.3.4	201.3.4:M	Yes__ No__	
201.3.4.b	Undefined precedence values shall be handled as routine	5.3.1.3.4	201.3.4:M	Yes__ No__	
201.3.5	First Station Number	5.3.1.3.5	202.4.5:M	Yes__ No__	
201.4	Flag Sequence	5.3.4.2.1	M	Yes__ No__	
201.5	Frame Check Sequence	5.3.4.2.5	M	Yes__ No__	

A.5.2 Net Access Control (NAC).

Item	Protocol Feature	Reference	Status	Support	Notes
202	NAC	5.3.2	M	Yes__ No__	
202.a	As a minimum, DAP-NAD and R-NAD shall be available to regulate transmission opportunities for all participants when the network is operating in Synchronous Mode.	5.3.2	M	Yes__ No__	
202.1	Network Busy Sensing Function	APPENDIX C	M	Yes__ No__	
202.2	Response Hold Delay (RHD)	APPENDIX C	M	Yes__ No__	
202.3	Timeout Period (TP)	APPENDIX C	M	Yes__ No__	
202.4	NAD	APPENDIX C	M	Yes__ No__	
202.4.1	R-NAD	APPENDIX C	M	Yes__ No__	
202.4.2	P-NAD	APPENDIX C	O	Yes__ No__	
202.4.3	H-NAD	APPENDIX C	O	Yes__ No__	
202.4.4	RE-NAD	APPENDIX C	O	Yes__ No__	
202.4.5	DAP-NAD	APPENDIX C	102.1.3.2:M	Yes__ No__	
202.4.6	DAV-NAD	APPENDIX C	O	Yes__ No__	
202.5	Scheduler	5.3.2.1, C.4.4.4.1.1 C.4.4.4.1.5 C.4.4.4.1.6	202.4.4:M	Yes__ No__	
202.5.a	When a station has data to transmit, it shall calculate the scheduler timer as indicated in APPENDIX C	5.3.2.1 C.4.4.4.1	202.5:M	Yes__ No__	
202.5.b	When this timer expires, the link layer shall first determine that the previous frame concatenation was transmitted by the PL	5.3.2.1	202.5:M	Yes__ No__	
202.5.c	If the frame concatenation was not transmitted, the link layer shall request its transmission	5.3.2.1	202.5:M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
202.5.d	If a higher precedence individual frame becomes available for transmission, the concatenated frames shall be re-built to include the higher precedence frame	5.3.2.1	202.5:M	Yes__ No__	
202.5.e	If the previous frame concatenation was transmitted, the link layer shall build a new frame concatenation. This frame concatenation shall then be passed to the PL for transmission	5.3.2.1	202.5:M	Yes__ No__	

A.5.3 Types of Procedures.

Item	Protocol Feature	Reference	Status	Support	Notes
203	Types of Procedures	5.3.3	M	Yes__ No__	
203.1	Type 1 Operation (unacknowledged connectionless)	5.3.3.1	M	Yes__ No__	
203.2	Type 2 Operation (connection-mode)	5.3.3.2	O	Yes__ No__	
203.2.a	With Type 2 operation, a data link connection shall be established between two systems prior to any exchange of information bearing PDUs	5.3.3.2	203.2:M	Yes__ No__	
203.2.b	The connection normally shall remain open until a station leaves the net	5.3.3.2	203.2:M	Yes__ No__	
203.2.c	The normal communications cycle between Type 2 systems shall consist of transferring PDUs from the source to the destination, and acknowledging receipt of these PDUs in the opposite direction	5.3.3.2	203.2:M	Yes__ No__	
203.3	Type 3 Operation (acknowledged connectionless)	5.3.3.3	M	Yes__ No__	
203.4	Type 4 Operation (decoupled acknowledged connectionless)	5.3.3.4	O	Yes__ No__	
203.5	Station Class	5.3.3.5	M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
203.5.a	Class A	5.3.3.5	203.5:O.<4>	Yes__ No__	
203.5.b	Class B	5.3.3.5	203.5:O.<4>	Yes__ No__	
203.5.c	Class C	5.3.3.5	203.5:O.<4>	Yes__ No__	
203.5.d	Class D	5.3.3.5	203.5:O.<4>	Yes__ No__	

A.5.4 Data Link Frame.

Item	Protocol Feature	Reference	Status	Support	Notes
204	Data Link Frame	5.3.4	M	Yes__ No__	
204.a	The data link frame shall be the basic PDU of the link layer	5.3.4	M	Yes__ No__	
204.1	Types of Frames	5.3.4.1	M	Yes__ No__	
204.1.1	Unnumbered Frame (U-PDU) Type 1 operations Type 2 operations Type 3 operations Type 4 operations	5.3.4.1.1	203.1:M 203.2:M 203.3:M 203.4:M	Yes__ No__ Yes__ No__ Yes__ No__ Yes__ No__	
204.1.2	Information Frame (I-PDU) Type 1 operations Type 2 operations Type 3 operations Type 4 operations	5.3.4.1.2	X 203.2:M X X	No Yes__ No__ No No	
204.1.3	Supervisory Frame (S-PDU) Type 1 operations Type 2 operations Type 3 operations Type 4 operations	5.3.4.1.3	X 203.2:M X 203.4:M	No Yes__ No__ No Yes__ No__	
204.2	Data Link Frame Structure	5.3.4.2	M	Yes__ No__	
204.2.a	The basic elements of the data link frame shall be the opening flag sequence, the address field, the control field, the information field, the FCS, and the closing flag sequence	5.3.4.2	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
204.2.b	Each Type 1, Type 2, Type 3 and Type 4 data link frame shall be structured as shown in the data link frame portion of FIGURE 12	5.3.4.2	M	Yes__ No__	
204.2.1	Flag Sequence	5.3.4.2.1	M	Yes__ No__	
204.2.1.a	All frames shall start and end with the 8-bit flag sequence of one 0 bit, six 1 bits, and one 0 bit (01111110)	5.3.4.2.1	M	Yes__ No__	
204.2.1.b	The flag shall be used for data link frame synchronization	5.3.4.2.1	M	Yes__ No__	
204.2.2	Address Fields	5.3.4.2.2	M	Yes__ No__	
204.2.2.a	These fields shall identify the link addresses of the source and destinations	5.3.4.2.2	M	Yes__ No__	
204.2.2.1	Address Format	5.3.4.2.2.1	M	Yes__ No__	
204.2.2.1.a	Single octet addressing shall be mandatory for any system using IPv4 or N-Layer Pass-Through at the Network Layer for synchronous, asynchronous, and packet modes of operation.	5.3.4.2.2.1	M	Yes__ No__	
204.2.2.1.b	Four octet and six octet addressing shall be optional for any system using IPv4 or N-Layer Pass-Through at the Network Layer for synchronous, asynchronous, and packet modes of operation.	5.3.4.2.2.1	M	Yes__ No__	
204.2.2.1.c	Six octet addressing shall be mandatory for any system using IPv6 at the Network Layer for synchronous, asynchronous, and packet modes of operation.	5.3.4.2.2.1	M	Yes__ No__	
204.2.2.1.d	Any system transmitting messages using IPv6 at the Network Layer shall only use six octets addressing at the Data Link Layer for Individual Addresses.	5.3.4.2.2.1	M	Yes__ No__	

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204.2.2.1.e	Single octet, four octets, and six octets addressing for individual addresses (see paragraph 5.3.4.2.2.2.2.5) shall not be mixed in the same net	5.3.4.2.2.1	M	Yes__ No__	
204.2.2.1.1	Single Octet Addressing	5.3.4.2.2.1.1	M	Yes__ No__	
204.2.2.1.1.a	Each address in the address fields shall consist of a single octet	5.3.4.2.2.1.1	M	Yes__ No__	
204.2.2.1.1.b	The source address octet shall consist of a command/response (C/R) designation bit (the LSB) followed by a 7-bit address representing the source	5.3.4.2.2.1.1	M	Yes__ No__	
204.2.2.1.1.c	Each destination octet shall consist of an extension bit (the LSB) followed by the 7-bit destination address. The destination address uses a modification of the HDLC extended addressing format	5.3.4.2.2.1.1	M	Yes__ No__	
204.2.2.1.1.d	The destination address shall be extended by setting the extension bit of a destination address octet to 0, indicating that the following octet is another destination address	5.3.4.2.2.1.1	M	Yes__ No__	
204.2.2.1.1.e	The destination address field shall be terminated by an octet that has the extension bit set to 1	5.3.4.2.2.1.1	M	Yes__ No__	
204.2.2.1.1.f	The destination address field shall be extendible from 1 address octet to 16 address octets	5.3.4.2.2.1.1	M	Yes__ No__	
204.2.2.1.1.g	The format of the address fields shall be in the extended address field format	5.3.4.2.2.1.1	M	Yes__ No__	
204.2.2.1.2	Four Octets Addressing	5.3.4.2.2.1.2	O	Yes__ No__	
204.2.2.1.2.a	Each address in the address fields shall consist of four octets, except for special, global multicast and group multicast addresses which are a single octet	5.3.4.2.2.1.2	204.2.2.1.2: M	Yes__ No__	

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204.2.2.1.2.b	The four octets of address space shall be preceded by a single octet 32-bit marker subfield	5.3.4.2.2.1.2	204.2.2.1.2: M	Yes__ No__	
204.2.2.1.2.c	In the source address field the 32-bit marker subfield shall consist of a command/response (C/R) designation bit (the LSB) followed by a 7-bit value=126	5.3.4.2.2.1.2	204.2.2.1.2: M	Yes__ No__	
204.2.2.1.2.d	In the destination address field the 32-bit marker subfield shall consist of an extension bit (the LSB) followed by the 7-bit value=126	5.3.4.2.2.1.2	204.2.2.1.2: M	Yes__ No__	
204.2.2.1.2.e	The destination address field shall be extended by setting the extension bit of the 32-bit marker subfield of a destination address octet to 0. This subsequent address may be formatted in either four octets or a single octet (i.e. special, group multicast or global multicast).	5.3.4.2.2.1.2	204.2.2.1.2: M	Yes__ No__	
204.2.2.1.2.f	The destination address field shall be terminated by an octet (either a valid address or the 32-bit marker subfield) that has the extension bit set to 1	5.3.4.2.2.1.2	204.2.2.1.2: M	Yes__ No__	
204.2.2.1.2.g	The destination address field shall be extendible from 1 address to 16 addresses	5.3.4.2.2.1.2	204.2.2.1.2: M	Yes__ No__	
204.2.2.1.3	Six Octets Addressing	5.3.4.2.2.1.3	204.2.2.1.c: M	Yes__ No__	
204.2.2.1.3.a	Each address in the address fields shall consist of six octets, except for special, global multicast and group multicast addresses which are a single octet	5.3.4.2.2.1.3	204.2.2.1.3: M	Yes__ No__	
204.2.2.1.3.b	The six octets of address space shall be preceded by a single octet 48-bit marker subfield	5.3.4.2.2.1.3	204.2.2.1.3: M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
204.2.2.1.3.c	In the source address field the 48-bit marker subfield shall consist of a command/response (C/R) designation bit (the LSB) followed by a 7-bit value=125	5.3.4.2.2.1.3	204.2.2.1.3: M	Yes__ No__	
204.2.2.1.3.d	In the destination address field the 32-bit marker subfield shall consist of an extension bit (the LSB) followed by the 7-bit value=125	5.3.4.2.2.1.3	204.2.2.1.3: M	Yes__ No__	
204.2.2.1.3.e	If the destination address field is extended, it shall be indicated by setting the extension bit of the 48-bit marker subfield of the destination address octet to 0. This subsequent address may be formatted in either six octets or a single octet (i.e. special, group multicast or global multicast).	5.3.4.2.2.1.3	204.2.2.1.3: M	Yes__ No__	
204.2.2.1.3.f	The destination address field shall be terminated by an octet (either a valid address or the 48-bit marker subfield) that has the extension bit set to 1	5.3.4.2.2.1.3	204.2.2.1.3: M	Yes__ No__	
204.2.2.1.3.g	The destination address field shall be extendible from 1 address to 16 addresses	5.3.4.2.2.1.3	204.2.2.1.3: M	Yes__ No__	
204.2.2.1.3.1.a	Guaranteed Uniqueness of Six Octet Address when using IPv6	5.3.4.2.2.1.3.1	M	Yes__ No__	
204.2.2.1.3.1.b	Systems using IPv6 at the Network Layer shall only use six octet addressing and shall ensure that they have a universally unique six octet Data Link Layer address.	5.3.4.2.2.1.3.1	M	Yes__ No__	
204.2.2.1.3.1.c	This universally unique six octet Data Link Layer address shall be static and shall not change while a system is an active participant on an IPv6 network.	5.3.4.2.2.1.3.1	M	Yes__ No__	
204.2.2.2	Addressing Convention	5.3.4.2.2.2	M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
204.2.2.2.a	The following addressing conventions shall be implemented in the 7 address bits of each address octet, 32-bit marker octet, or 48-bit marker octet.	5.3.4.2.2.2	M	Yes__ No__	
204.2.2.2.1	Source and Destination	5.3.4.2.2.2.1	M	Yes__ No__	
204.2.2.2.1.1	Source Address	5.3.4.2.2.2.1.1	M	Yes__ No__	
204.2.2.2.1.1.a	The C/R designation bit shall be set to 0 for commands and 1 for responses.	5.3.4.2.2.2.1.1	M	Yes__ No__	
204.2.2.2.1.2	Destination Address(es)	5.3.4.2.2.2.1.2	M	Yes__ No__	
204.2.2.2.2	Types of Addresses	5.3.4.2.2.2.2	M	Yes__ No__	
204.2.2.2.2.1	Reserved Address	5.3.4.2.2.2.2.1	M	Yes__ No__	
204.2.2.2.2.1.a	A station receiving a value of 0 in the destination address field shall ignore the address and continue processing any remaining addresses	5.3.4.2.2.2.2.1	M	Yes__ No__	
204.2.2.2.2.2	Special Addresses	5.3.4.2.2.2.2.2	Send: O Recv: M	Send: Yes__ No__ Recv: Yes__ No__	
204.2.2.2.2.3	32-bit Marker Subfield	5.3.4.2.2.2.2.3	204.2.2.1.2: M	Yes__ No__	
204.2.2.2.2.4	48-bit Marker Subfield	5.3.4.2.2.2.2.4	204.2.2.1.3: M	Yes__ No__	
204.2.2.2.2.5	Individual Addresses	5.3.4.2.2.2.2.5	M	Yes__ No__	
204.2.2.2.2.5.a	Individual single octet addresses shall be assigned within the address range 4 to 95	5.3.4.2.2.2.2.5	M	Yes__ No__	
204.2.2.2.2.5.b	Individual four octets addresses shall be assigned within the address range 0.0.0.0 to 255.255.255.255 in dot notation	5.3.4.2.2.2.2.5	M	Yes__ No__	

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204.2.2.2.2.5.c	Individual six octet address shall be assigned within the address range 0 to 248-1 (00-00-00-00-00-00 to FF-FF-FF-FF-FF-FF in hex notation).	5.3.4.2.2.2.2.5	M		Yes__ No__		
204.2.2.2.2.5.d	If IPv6 is used at the Network Layer, Individual Addresses shall be six octets.	5.3.4.2.2.2.2.5	M		Yes__ No__		
204.2.2.2.2.5.e	Stations shall be capable of sending and receiving 1 to 16 individual destination addresses in a single data link frame	5.3.4.2.2.2.2.5	M		Yes__ No__		
204.2.2.2.2.5.f	Sending stations shall use any individual address just once in a data link frame	5.3.4.2.2.2.2.5	M		Yes__ No__		
204.2.2.2.2.5.g	When individual address(es) are present, a receiving station shall receive all addresses, search for its unique individual address, and follow the media access procedures described in APPENDIX C	5.3.4.2.2.2.2.5 APPENDIX C	M		Yes__ No__		
204.2.2.2.2.6	Group Multicast Addresses	5.3.4.2.2.2.2.6	Send: O	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.6.a	The valid address range shall be 96 to 124	5.3.4.2.2.2.2.6	Send: O	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.6.b	While the use of link group multicast addresses is optional, all stations shall be capable of recognizing received group addresses	5.3.4.2.2.2.2.6	Send: O	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.6.c	If a receiving station does not implement group addressing procedures, it shall still process all received addresses, but ignore the group addresses (that is, recognize range 96 to 124 as group addresses)	5.3.4.2.2.2.2.6	Send: O	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	

Item	Protocol Feature	Reference	Status		Support		Notes
204.2.2.2.2.6.d	When group addressing is implemented, a station shall be capable of sending and receiving 1 to 16 destination group addresses	5.3.4.2.2.2.2.6	Send: O	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.6.e	Coupled data link acknowledgment of group multicast addresses using the F-bit shall not be allowed	5.3.4.2.2.2.2.6	Send: O	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.6.f	An uncoupled TEST response PDU with its F-bit set to zero shall be sent in response to a TEST command PDU addressed to a group multicast address when the receiving station is a member of the specified group	5.3.4.2.2.2.2.6	Send: O	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.7	Individual, Special and Multicast Addresses Mixed	5.3.4.2.2.2.2.7	Send: 204.2.2.2.4:M	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.7.a	All stations shall be capable of sending and receiving Special, Individual, and optionally Multicast (group and global) addresses "mixed" in a destination address subfield	5.3.4.2.2.2.2.7	Send: 204.2.2.2.4:M	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.7.b	All stations shall be capable of receiving mixed addresses	5.3.4.2.2.2.2.7	Send: 204.2.2.2.4:M	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.7.c	The reception and acknowledgment procedures shall be for all stations even those that do not implement multicast addressing procedures	5.3.4.2.2.2.2.7	Send: 204.2.2.2.4:M	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.7.d	The total number of destination addresses shall not exceed 16	5.3.4.2.2.2.2.7.a	Send: 204.2.2.2.4:M	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.7.e	All individual and special addresses shall precede multicast addresses	5.3.4.2.2.2.2.7.c	Send: 204.2.2.2.4:M	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	

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204.2.2.2.2.7.f	The special address 3, if used, shall follow all individual, reserved, and other special addresses	5.3.4.2.2.2.2.7.d	Send: 204.2.2.2.2.4:M	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.7.g	The special address 3, if used, may precede group or global addresses, but shall not precede individual, reserved or other special addresses	5.3.4.2.2.2.2.7.d	Send: 204.2.2.2.2.4:M	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.7.h	Only one type of multicast (group or global) shall be mixed in a destination address subfield	5.3.4.2.2.2.2.7.e	Send: 204.2.2.2.2.4:M	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.7.i	If multicast, special and individual addresses are mixed, only the individual and special addresses shall be acknowledged when indicated	5.3.4.2.2.2.2.7.f	Send: 204.2.2.2.2.4:M	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.7.j	Multicast addresses shall not be acknowledged but a data link response (using a TEST Response PDU) is allowed in the case where a TEST message is received with a multicast address in the destination field and the poll bit is set to 0	5.3.4.2.2.2.2.7.g	Send: 204.2.2.2.2.4:M	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.7.k	A station that optionally implements multicast (group and global) addressing shall also be capable of sending and receiving multicast, special and individual addresses “mixed” in a destination subfield	5.3.4.2.2.2.2.7.h	Send: 204.2.2.2.2.4:M	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.7.l	Stations shall treat single, four, and six octet addresses as separate and distinct addresses	5.3.4.2.2.2.2.7.i	Send: 204.2.2.2.2.4:M	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.7.m	Reserved, Special, Group and Global Multicast Addresses, and the 32-bit and 48-bit Markers shall always be single octet addresses.	5.3.4.2.2.2.2.7.j	Send: 204.2.2.2.2.4:M	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	

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204.2.2.2.2.7.n	Only single octet addresses shall represent Reserved, Special, Group and Global Multicast Addresses, and the 32-bit and 48-bit Makers.	5.3.4.2.2.2.2.7.j	Send: 204.2.2.2.2.4:M	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
204.2.2.2.2.8	Global Multicast Addressing	5.3.4.2.2.2.2.8	M		Yes__ No__		
204.2.2.2.2.8.a	Global multicast addressing, used when broadcasting messages to all systems on a broadcast subnetwork, shall be implemented through the unique bit pattern 1111111 (127)	5.3.4.2.2.2.2.8	M		Yes__ No__		
204.2.2.2.2.8.b	This global multicast address shall be used to indicate broadcasting at the Data Link Layer, independent of the Upper Layer Protocol addressing mechanism being used to request the Global Multicast	5.3.4.2.2.2.2.8	M		Yes__ No__		
204.2.2.2.2.8.c	If the global address is used, it shall be the only multicast destination address, but individual addresses are allowed with the global address	5.3.4.2.2.2.2.8	M		Yes__ No__		
204.2.2.2.2.8.d	All broadcast stations shall be capable of receiving and sending this address, and all stations will process the information contained within the frame	5.3.4.2.2.2.2.8	M		Yes__ No__		
204.2.2.2.2.8.e	Data link acknowledgment of the global address shall not be allowed, although the TEST response PDU is allowed in the case where a TEST message is received with the global address in the destination field and the poll bit is set to 0	5.3.4.2.2.2.2.8	M		Yes__ No__		
204.2.2.2.2.8.f	Coupled data link acknowledgment of the global address using the F-bit shall not be allowed	5.3.4.2.2.2.2.8	M		Yes__ No__		

Item	Protocol Feature	Reference	Status	Support	Notes
204.2.2.2.2.8.g	An uncoupled TEST response PDU with its F-bit set to zero shall be sent in response to a TEST command PDU addressed to the global address	5.3.4.2.2.2.2.8	M	Yes__ No__	
204.2.2.3	Mapping	5.3.4.2.2.3	M	Yes__ No__	
204.2.3	Control Field	5.3.4.2.3	M	Yes__ No__	
204.2.3.1	Type 1 Operations	5.3.4.2.3.1	M	Yes__ No__	
204.2.3.2	Type 2 Operations	5.3.4.2.3.2	203.2:M	Yes__ No__	
204.2.3.2.a	The Type 2 control field shall be repeated if more than one destination address is present	5.3.4.2.3.2	203.2:M	Yes__ No__	
204.2.3.2.b	Each destination address field shall have a corresponding control field	5.3.4.2.3.2	203.2:M	Yes__ No__	
204.2.3.2.c	Each of the corresponding control fields (when repeated) shall be identical except for the P/F bit and sequence numbers	5.3.4.2.3.2	203.2:M	Yes__ No__	
204.2.3.3	Type 3 Operations	5.3.4.2.3.3	M	Yes__ No__	
204.2.3.4	Type 4 Operations	5.3.4.2.3.4	203.4:M	Yes__ No__	
204.2.3.5	P/F Bit Type 1 Type 2 Type 3 Type 4	5.3.4.2.3.5	 M 203.2:M M X	 Yes__ No__ Yes__ No__ Yes__ No__ No	
204.2.3.5.a	The P-bit set to 1 shall be used to solicit a response PDU, with the F-bit set to 1	5.3.4.2.3.5	M	Yes__ No__	
204.2.3.5.b	On a data link, at most one PDU with P-bit set to 1 shall be outstanding in a given direction at a given time Type 1 Type 2 Type 3 Type 4	5.3.4.2.3.5	 203.1:M 203.2:M 203.3:M X	 Yes__ No__ Yes__ No__ Yes__ No__ No	

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Item	Protocol Feature	Reference	Status	Support	Notes
204.2.3.5.c	Before a station issues another PDU with the P-bit set to 1 to a particular destination, it shall have received a response PDU from that remote station with the F-bit set to 1 or have timed out waiting for that response PDU	5.3.4.2.3.5	M	Yes__ No__	
204.2.3.6	Sequence Numbers	5.3.4.2.3.6	203.2:M	Yes__ No__	
204.2.3.6.a	The Type 2 I and S PDUs shall contain sequence numbers	5.3.4.2.3.6	203.2:M	Yes__ No__	
204.2.3.6.b	The sequence numbers shall be in the range of 0-127	5.3.4.2.3.6	203.2:M	Yes__ No__	
204.2.3.7	Identification Numbers	5.3.4.2.3.7	203.4:M	Yes__ No__	
204.2.3.7.a	The Type 4 DIA and DRR/DRNR response S PDUs shall contain an identification number	5.3.4.2.3.7	203.4:M	Yes__ No__	
204.2.3.7.b	The identification numbers shall be in the range of 1-255	5.3.4.2.3.7	203.4:M	Yes__ No__	
204.2.3.7.c	The identification number of an S PDU command (bits 9-16) shall be filled with zeroes	5.3.4.2.3.7	203.4:M	Yes__ No__	
204.2.3.8	Precedence	5.3.4.2.3.8	203.4:M	Yes__ No__	
204.2.4	Information field	5.3.4.2.4	M	Yes__ No__	
204.2.4.a	The length of the information field shall be a multiple of 8 bits, not to exceed 3345 octets	5.3.4.2.4	M	Yes__ No__	
204.2.4.b	If the data is not a multiple of 8 bits, 1 to 7 fill bits (0) shall be added to meet this requirement	5.3.4.2.4	M	Yes__ No__	
204.2.5	FCS	5.3.4.2.5	M	Yes__ No__	
204.2.5.a	For error detection, all frames shall include a 32-bit FCS prior to the closing flag sequence	5.3.4.2.5	M	Yes__ No__	

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204.2.5.b	FCS generation shall be in accordance with the paragraph entitled “32-bit Frame Checking Sequence” in ISO 3309, and implemented in a manner that provides a unique remainder when a frame is received without bit errors incurred during transmission	5.3.4.2.5	M	Yes__ No__	
204.2.5.c	When the FCS is implemented via a 32-bit shift register, the shift register shall be initialized to all ones before checking or calculation of the FCS	5.3.4.2.5	M	Yes__ No__	
204.2.5.d	If the FCS of a received frame proves the frame to be invalid, the frame shall be discarded	5.3.4.2.5	M	Yes__ No__	
204.3	Data link PDU Construction	5.3.4.3	M	Yes__ No__	
204.3.1	Order-of-Bit Transmission	5.3.4.3.1	M	Yes__ No__	
204.3.1.a	The Information Field and control field(s) shall be transmitted LSB of each octet first	5.3.4.3.1	M	Yes__ No__	
204.3.1.b	The flag shall be transmitted LSB first	5.3.4.3.1	M	Yes__ No__	
204.3.1.c	For the FCS, the MSB shall be transmitted first	5.3.4.3.1	M	Yes__ No__	
204.3.1.d	For four octets addressing, the single octet 32-bit marker shall be transmitted first and the actual four octets link layer address shall be transmitted in the most significant to least significant octet order.	5.3.4.3.1	204.2.2.1.2: M	Yes__ No__	
204.3.1.e	The information field octets shall be transmitted in the same order as received from the upper layers, LSB of each octet first	5.3.4.3.1	M	Yes__ No__	
204.3.2	Zero-bit Insertion Algorithm	5.3.4.3.2	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
204.3.2.a	The occurrence of a spurious flag sequence within a frame or Transmission Header shall be prevented by employing a 0-bit insertion algorithm	5.3.4.3.2	M	Yes__ No__	
204.3.2.b	After the entire frame has been constructed, the transmitter shall always insert a 0 bit after the appearance of five 1's in the frame (with the exception of the flag fields)	5.3.4.3.2	M	Yes__ No__	
204.3.2.c	After detection of an opening flag sequence, the receiver shall search for a pattern of five 1's.	5.3.4.3.2	M	Yes__ No__	
204.3.2.d	When the pattern of five 1's appears, the sixth bit shall be examined	5.3.4.3.2	M	Yes__ No__	
204.3.2.e	If the sixth bit is a 0, the 5 bits shall be passed as data, and the 0 shall be deleted	5.3.4.3.2	M	Yes__ No__	
204.3.2.f	If the sixth bit is a 1, the receiver shall inspect the seventh bit	5.3.4.3.2	M	Yes__ No__	
204.3.2.g	If the seventh bit is a 0, a flag sequence has been received. If the seventh bit is a 1, an invalid message has been received and shall be discarded	5.3.4.3.2	M	Yes__ No__	

A.5.5 Operational Parameters.

Item	Protocol Feature	Reference	Status	Support	Notes
205	Operational Parameters	5.3.5	M	Yes__ No__	
205.1	Type 1 Operational Parameters	5.3.5.1	M	Yes__ No__	
205.1.1	The Poll (P) bit shall be set to 0 for all Type 1 PDUs.	5.3.5.1.1	M	Yes__ No__	
205.1.2	The Topology Update ID field of this PDU shall contain the full 8-bit Topology Update ID used in the most recent Topology Update	5.3.5.1.2	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
205.1.3	The CANTPRO Version Number subfield of the PDU Control field shall contain the unsupported Version from the received PDU	5.3.5.1.3	M	Yes__ No__	
205.1.4	The Preferred Version Number subfield of the PDU Control field shall contain the preferred Version for future communications	5.3.5.1.4	M	Yes__ No__	
205.2	Type 2 Operational Parameters	5.3.5.2	203.2:M	Yes__ No__	
205.2.1	Modulus	5.3.5.2.1	203.2:M	Yes__ No__	
205.2.1.a	Each I PDU shall be sequentially numbered with a numeric value between 0 and MODULUS minus ONE (where MODULUS is the modulus of the sequence numbers)	5.3.5.2.1	203.2:M	Yes__ No__	
205.2.1.b	MODULUS shall equal 128 for the Type 2 control field format	5.3.5.2.1	203.2:M	Yes__ No__	
205.2.1.c	The sequence numbers shall cycle through the entire range	5.3.5.2.1	203.2:M	Yes__ No__	
205.2.1.d	The maximum number of sequentially numbered I PDUs that may be outstanding (that is, unacknowledged) in a given direction of a data link connection at any given time shall never exceed one less than the modulus of the sequence numbers	5.3.5.2.1	203.2:M	Yes__ No__	
205.2.2	PDU State Variables and Sequence Numbers	5.3.5.2.2	203.2:M	Yes__ No__	
205.2.2.a	A station shall maintain a V(S) for the I PDUs it sends and a V(R) for the I PDUs it receives on each data link connection	5.3.5.2.2	203.2:M	Yes__ No__	
205.2.2.b	The operation of V(S) shall be independent of the operation of V(R)	5.3.5.2.2	203.2:M	Yes__ No__	
205.2.2.1	Send-state Variable V(S)	5.3.5.2.2.1	203.2:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
205.2.2.1.a	The V(S) shall denote the sequence number of the next in-sequence I PDU to be sent on a specific data link connection	5.3.5.2.2.1	203.2:M	Yes__ No__	
205.2.2.1.b	The V(S) shall take on a value between 0 and MODULUS minus ONE	5.3.5.2.2.1	203.2:M	Yes__ No__	
205.2.2.1.c	The value of V(S) shall be incremented by one with each successive I PDU transmission on the associated data link connection, but shall not exceed receive sequence number N(R) of the last received PDU by more than MODULUS minus ONE	5.3.5.2.2.1	203.2:M	Yes__ No__	
205.2.2.2	Send-sequence Number N(S)	5.3.5.2.2.2	203.2:M	Yes__ No__	
205.2.2.2.a	Only I PDUs shall contain N(S), the send sequence number of the sent PDU	5.3.5.2.2.2	203.2:M	Yes__ No__	
205.2.2.2.b	Prior to sending an I PDU, the value of the N(S) shall be set equal to the value of the V(S) for that data link connection, except for group or global addresses	5.3.5.2.2.2	203.2:M	Yes__ No__	
205.2.2.2.c	The value for N(S) shall be set to 0 for group or global addresses and the P-bit shall be set to 0	5.3.5.2.2.2	203.2:M	Yes__ No__	
205.2.2.3	Receive-state Variable V(R)	5.3.5.2.2.3	203.2:M	Yes__ No__	
205.2.2.3.a	The V(R) shall denote the sequence number of the next in-sequence I PDU to be received on a specific data link connection	5.3.5.2.2.3	203.2:M	Yes__ No__	
205.2.2.3.b	The V(R) shall take on a value between 0 and MODULUS minus ONE	5.3.5.2.2.3	203.2:M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
205.2.2.3.c	The value of the V(R) associated with a specific data link connection shall be incremented by one whenever an error-free I PDU is received whose N(S) equals the value of the V(R) for the data link connection	5.3.5.2.2.3	203.2:M	Yes__ No__	
205.2.2.4	Receive-sequence Number N(R)	5.3.5.2.2.4	203.2:M	Yes__ No__	
205.2.2.4.a	All I and S PDUs shall contain N(R), the expected sequence number of the next received I PDU on the specified data link connection	5.3.5.2.2.4	203.2:M	Yes__ No__	
205.2.2.4.b	Prior to sending an I or S PDU, the value of N(R) shall be set equal to the current value of the associated V(R) for that data link connection	5.3.5.2.2.4	203.2:M	Yes__ No__	
205.2.2.4.c	N(R) shall indicate that the station sending the N(R) has received correctly all I PDUs numbered up through N(R)-1 on the specified data link connection, except when the group or global address is utilized	5.3.5.2.2.4	203.2:M	Yes__ No__	
205.2.2.4.d	When a group or global address is used, the associated N(R) shall be set to 0	5.3.5.2.2.4	203.2:M	Yes__ No__	
205.2.2.4.e	N(R) shall indicate that the station sending the N(R) has received correctly all I PDUs numbered up through N(R)-1 on the specified data link connection, except for the N(R) associated with a group or global address	5.3.5.2.2.4	203.2:M	Yes__ No__	
205.2.2.4.f	Group and global addresses provide no indication regarding correctly received PDUs	5.3.5.2.2.4	203.2:M	Yes__ No__	
205.2.3	P/F bit	5.3.5.2.3	203.2:M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
205.2.3.a	The P/F bit shall serve a function in Type 2 operation in both command and response PDUs	5.3.5.2.3	203.2:M	Yes__ No__	
205.2.3.b	In command PDUs the P/F bit shall be referred to as the P-bit	5.3.5.2.3	203.2:M	Yes__ No__	
205.2.3.c	In response PDUs it shall be referred to as the F-bit	5.3.5.2.3	203.2:M	Yes__ No__	
205.2.3.1	Poll-bit Functions	5.3.5.2.3.1	203.2:M	Yes__ No__	
205.2.3.1.a	A command PDU with the P-bit set to 1 shall be used to solicit (poll) a response PDU with the F-bit set to 1 from the addressed station on a data link connection	5.3.5.2.3.1	203.2:M	Yes__ No__	
205.2.3.1.b	Only one Type 2 PDU with a P-bit set to 1 shall be outstanding in a given direction at a given time on the data link connection between any specified pair of stations	5.3.5.2.3.1	203.2:M	Yes__ No__	
205.2.3.1.c	Before a station issues another PDU on the same data link connection with the P-bit set to 1, the station shall have received a response PDU with the F-bit set to 1 from the addressed station	5.3.5.2.3.1	203.2:M	Yes__ No__	
205.2.3.1.d	If no valid response PDU is received within a system-defined P-bit timer time-out period, the resending of a command PDU with the P-bit set to 1 shall be permitted for error recovery purposes	5.3.5.2.3.1	203.2:M	Yes__ No__	
205.2.3.2	Final-bit Functions	5.3.5.2.3.2	203.2:M	Yes__ No__	
205.2.3.2.a	The F-bit set to 1 shall be used to respond to a command PDU with the P-bit set to 1	5.3.5.2.3.2	203.2:M	Yes__ No__	
205.2.3.2.b	Following the receipt of a command PDU with the P-bit set to 1, the station shall send a response PDU with the F-bit set to 1 on the appropriate data link connection at the first possible opportunity	5.3.5.2.3.2	203.2:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
205.2.3.2.c	The response PDU shall be assigned an URGENT precedence	5.3.5.2.3.2	203.2:M	Yes__ No__	
205.2.3.2.d	The station shall be permitted to send appropriate response PDUs with the F-bit set to 0 at any net access opportunity without the need for a command PDU	5.3.5.2.3.2	203.2:M	Yes__ No__	
205.3	Type 3 Operational Parameters	5.3.5.3	M	Yes__ No__	
205.3.a	The P-bit shall be set to 1 to solicit (poll) an immediate correspondent response PDU with the F-bit set to 1 from the addressed station	5.3.5.3	M	Yes__ No__	
205.3.b	The response with F-bit set to 1 shall be transmitted in accordance with the RHD procedures defined in APPENDIX C	5.3.5.3 C.4.2	M	Yes__ No__	
205.4	Type 4 Operational Parameters	5.3.5.4	203.4:M	Yes__ No__	
205.4.1	Identification Number	5.3.5.4.1	203.4:M	Yes__ No__	
205.4.1.a	Each station shall keep a number for originating PDUs	5.3.5.4.1	203.4:M	Yes__ No__	
205.4.1.b	Duplicate frame identification numbers from the same originator shall not be used for more than one outstanding (unacknowledged) DIA PDU	5.3.5.4.1	203.4:M	Yes__ No__	
205.4.2	Type 4 duplicate frame detection	5.3.5.4.2	203.4:M	Yes__No__	
205.4.2a	Each station shall maintain historical information about recently received Type 4 DIA command frames	5.3.5.4.2	203.4:M	Yes__No__	
205.4.2b	This historical information shall include, as a minimum, the source address, destination address, Identification number, FCS value, number of octets of user data and the number of times the DIA Command Frame has been received	5.3.5.4.2	203.4:M	Yes__No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
205.4.2c	The history shall not contain any more than 255 entries for any sending station	5.3.5.4.2	203.4:M	Yes__No__	
205.4.2d	When a station receives a Type 4 DIA command frame, it shall compare the frame against historical information about any DIA command in the history with the same Identification number that was previously received from the same sender	5.3.5.4.2	203.4:M	Yes__No__	
205.4.2e	The DIA command frame shall be declared a non-duplicate if no matching history entry is found	5.3.5.4.2	203.4:M	Yes__No__	
205.4.2f	If a matching history is found, the DIA command frame shall be declared a duplicate if both DIA command frames have the same number of octets of user data and the DIA command frame has been received fewer than seven times and either the just received DIA command frame has fewer non-reserved destination addresses, or it has the same number of non-reserved destination addresses and the two frames have identical FCSs	5.3.5.4.2	203.4:M	Yes__No__	
205.4.2g	If a matching history is found and the DIA command frame is not declared a duplicate, or whenever an XNP Hello or XNP Goodbye message is received from the sending station, all history entries associated with the sending station shall be discarded	5.3.5.4.2	203.4:M	Yes__No__	

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A.5.6 Commands and Responses.

Item	Protocol Feature	Reference	Status	Support	Notes
206	Commands and Responses	5.3.6	M	Yes__ No__	
206.a	A single multi-addressed frame shall not contain different PDU types nor contain the same individual address more than once	5.3.6	M	Yes__ No__	
206.b	The control field for all addresses in a single multi-addressed frame shall be the same except for the P/F bit and sequence number	5.3.6	M	Yes__ No__	
206.c	Response PDUs requiring "earliest opportunity" transmission shall be queued ahead of all other PDUs, except those queued for "first possible opportunity" for transmission during the next network access opportunity	5.3.6	M	Yes__ No__	
206.d	The response PDU shall assume the precedence level of the highest PDU queued or the mid (PRIORITY) level, whichever is greater	5.3.6	M	Yes__ No__	
206.e	The Type 4 DRR response PDU shall assume the precedence of the DIA frame it is acknowledging	5.3.6	M	Yes__ No__	
206.1	Type 1 Operation Commands and indications	5.3.6.1	M	Yes__ No__	
206.1.1	UI Command	5.3.6.1.1	M	Yes__ No__	
206.1.1.a	The UI PDU shall be used to send information to one or more stations	5.3.6.1.1	M	Yes__ No__	
206.1.1.b	The UI PDU shall be addressed to individual, special, group or global addresses	5.3.6.1.1	M	Yes__ No__	
206.1.1.c	The source address shall be the individual address of the transmitting station	5.3.6.1.1	M	Yes__ No__	
206.1.2	URR Command	5.3.6.1.2	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
206.1.2.a	The URR command PDU shall be transmitted to one or more stations to indicate that the sending station is ready to receive I, DIA and UI PDUs.	5.3.6.1.2	M	Yes__ No__	
206.1.2.b	The URR PDU shall be addressed to individual, group or global addresses	5.3.6.1.2	M	Yes__ No__	
206.1.2.c	The source address shall be the individual address of the transmitting station	5.3.6.1.2	M	Yes__ No__	
206.1.3	URNR Command	5.3.6.1.3	M	Yes__ No__	
206.1.3.a	The URNR command PDU shall be transmitted to one or more stations to indicate that the sending station is busy and cannot receive I, DIA or UI PDUs	5.3.6.1.3	M	Yes__ No__	
206.1.3.b	The URNR PDU shall be addressed to individual, group or global addresses	5.3.6.1.3	M	Yes__ No__	
206.1.3.c	The source address shall be the individual address of the transmitting station	5.3.6.1.3	M	Yes__ No__	
206.1.4	Topology Update ID indication	5.3.6.1.4	M	Yes__ No__	
206.1.4.a	The Type 1 Topology Update ID indication PDU, with P-bit set to 0, shall be periodically transmitted to the global broadcast address (single octet 127) to indicate the most recent Topology Update ID in accordance with APPENDIX H, if and only if Topology Updates are used (see 5.4.1.2)	5.3.6.1.4	M	Yes__ No__	
206.1.4.b	If no Topology Updates have been issued on the current network, this PDU shall not be transmitted	5.3.6.1.4	M	Yes__ No__	
206.1.5	Version CANTPRO indication	5.3.6.1.5	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
206.1.5.a	The Type 1 Version CANTPRO indication PDU, with P-bit set to 0, shall be transmitted to a single station upon receipt of an incoming PDU with an unsupported MIL-STD-188-220 Version indicated in the subfield of the received Transmission Information header field.	5.3.6.1.5	M	Yes__ No__	
206.1.5.b	The PDU shall be transmitted to the station indicated in the originator address of the received PDU with the unsupported Version subfield	5.3.6.1.5	M	Yes__ No__	
206.1.5.c	The "C" bits of the PDU Control field (see FIGURE 15) shall contain the received unsupported Version subfield	5.3.6.1.5	M	Yes__ No__	
206.1.5.d	The "P" bits of the PDU Control field (see FIGURE 15) shall contain the preferred Version for future communications	5.3.6.1.5	M	Yes__ No__	
206.1.6	TEST Command	5.3.6.1.6	M	Yes__ No__	
206.1.6.a	The TEST command shall be used to cause the destination station to respond with the TEST response at the earliest opportunity, thus performing a basic test of the transmission path	5.3.6.1.6	M	Yes__ No__	
206.1.6.b	If an information field is present, the received information field shall be returned, if possible, by the addressed station in the TEST response PDU	5.3.6.1.6	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
206.1.6.c	The TEST command, with the P-bit set to 0 shall cause each destination station (including members of group and global addresses) to respond with a TEST response (with information field) with the F-bit set to 0 at the earliest opportunity	5.3.6.1.6	M	Yes__ No__	
206.1.6.d	The TEST command PDU shall be addressed to an individual and/or group or global destination addresses	5.3.6.1.6	M	Yes__ No__	
206.1.6.e	The source address shall be an individual address	5.3.6.1.6	M	Yes__ No__	
206.1.7	TEST Response	5.3.6.1.7	M	Yes__ No__	
206.1.7.a	The TEST response, with the F-bit set to 0, shall be used by all addresses (individual, group and global) to reply to the TEST command with the P-bit set to 0 at the earliest opportunity	5.3.6.1.7	M	Yes__ No__	
206.1.7.b	If an information field was present in the TEST command PDU that had the P-bit set to 0, the TEST response PDU shall contain the same information field contents	5.3.6.1.7	M	Yes__ No__	
206.1.7.c	The source and destination addresses shall be an individual address	5.3.6.1.7	M	Yes__ No__	
206.2	Type 2 Operation Commands and Responses	5.3.6.2	203.2:M	Yes__ No__	
206.2.1	Information-Transfer-Format Command and Response	5.3.6.2.1	203.2:M	Yes__ No__	
206.2.1.a	The function of the I command and response shall be to transfer sequentially numbered PDUs that contain an information field across a data link connection	5.3.6.2.1	203.2:M	Yes__ No__	

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206.2.1.b	N(S) and N(R) associated with group and global addresses shall be set to zero by the transmitter and ignored by the receiver and are not acknowledged	5.3.6.2.1	203.2:M	Yes__ No__	
206.2.1.c	The encoding of the I PDU control field for Type 2 operation shall be as listed in FIGURE 17	5.3.6.2.1	203.2:M	Yes__ No__	
206.2.1.d	The I PDU control field shall contain two sequence number subfields: N(S), which shall indicate the sequence number associated with the I PDU; and N(R), which shall indicate the sequence number (as of the time the PDU is sent) of the next expected I PDU to be received, and, consequently, shall indicate that the I PDUs numbered up through N(R)-1 have been received correctly	5.3.6.2.1	203.2:M	Yes__ No__	
206.2.2	Supervisory-Format Commands and Responses	5.3.6.2.2	203.2:M	Yes__ No__	
206.2.2.a	S PDUs shall be used to perform numbered supervisory functions such as acknowledgments, temporary suspension of information transfer, or error recovery	5.3.6.2.2	203.2:M	Yes__ No__	
206.2.2.b	S PDUs shall not contain an information field and, therefore, shall not increment the V(S) at the sender or the V(R) at the receiver	5.3.6.2.2	203.2:M	Yes__ No__	
206.2.2.c	Encoding of the S PDU control field for Type 2 operation shall be as shown in FIGURE 18	5.3.6.2.2	203.2:M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
206.2.2.d	An S PDU shall contain an N(R), which shall indicate, at the time of sending, the sequence number of the next expected I PDU to be received. This shall acknowledge that all I PDUs numbered up through N(R)-1 have been received correctly, except in the case of the selective reject (SREJ) PDU.	5.3.6.2.2	203.2:M	Yes__ No__	
206.2.2.1	RR Command and Response	5.3.6.2.2.1	203.2:M	Yes__ No__	
206.2.2.1.a	The RR PDU shall be used by a station to indicate it is ready to receive I PDUs	5.3.6.2.2.1	203.2:M	Yes__ No__	
206.2.2.1.b	I PDUs numbered up through N(R)-1 shall be considered as acknowledged	5.3.6.2.2.1	203.2:M	Yes__ No__	
206.2.2.1.c	When the RR command is transmitted using the group or global address, the receive sequence number in the control field associated with that group/global address shall be set to 0 and the P-bit shall be set to 0	5.3.6.2.2.1	203.2:M	Yes__ No__	
206.2.2.2	REJ Command and Response	5.3.6.2.2.2	203.2:M	Yes__ No__	
206.2.2.2.a	The REJ PDU shall be used by a station to request the resending of I PDUs, starting with the PDU numbered N(R)	5.3.6.2.2.2	203.2:M	Yes__ No__	
206.2.2.2.b	I PDUs numbered up through N(R)-1 shall be considered as acknowledged	5.3.6.2.2.2	203.2:M	Yes__ No__	
206.2.2.2.c	It shall be possible to send additional I PDUs awaiting initial sending after the resent I PDUs	5.3.6.2.2.2	203.2:M	Yes__ No__	
206.2.2.2.d	With respect to each direction of sending on a data link connection, only one “sent REJ” condition shall be established at any given time	5.3.6.2.2.2	203.2:M	Yes__ No__	

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206.2.2.2.e	The "sent REJ" condition shall be cleared upon receipt of an I PDU with an N(S) equal to the N(R) of the REJ PDU	5.3.6.2.2.2	203.2:M	Yes__ No__	
206.2.2.2.f	Receipt of a REJ PDU shall indicate the clearance of a busy condition except as noted in 5.3.7.2.5.8	5.3.6.2.2.2 5.3.7.2.5.8	203.2:M	Yes__ No__	
206.2.2.3	RNR Command and Response	5.3.6.2.2.3	203.2:M	Yes__ No__	
206.2.2.3.a	The RNR PDU shall be used by a station to indicate a busy condition (a temporary inability to accept subsequent I PDUs)	5.3.6.2.2.3	203.2:M	Yes__ No__	
206.2.2.3.b	I PDUs numbered up through N(R)-1 shall be considered as acknowledged	5.3.6.2.2.3	203.2:M	Yes__ No__	
206.2.2.3.c	I PDUs numbered N(R) and any subsequent I PDUs received shall not be considered as acknowledged; the acceptance status of these PDUs shall be indicated in subsequent exchanges	5.3.6.2.2.3	203.2:M	Yes__ No__	
206.2.2.3.d	When the RNR command is transmitted using the group or global address, the receive sequence number in the control field associated with that group/global address shall be set to 0, and the P-bit shall be set to 0	5.3.6.2.2.3	203.2:M	Yes__ No__	
206.2.2.4	SREJ Command and Response	5.3.6.2.2.4	203.2:M	Yes__ No__	
206.2.2.4.a	If the P/F-bit in the SREJ PDU is set to 1, then I PDUs numbered up to N(R)-1 shall be considered acknowledged. If the P/F bit is set to 0, then the N(R) of the SREJ PDU does not indicate acknowledgment of any I PDUs	5.3.6.2.2.4	203.2:M	Yes__ No__	

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206.2.2.4.b	Each SREJ exception condition shall be cleared (reset) upon receipt of an I PDU with an N(S) equal to the N(R) of the SREJ PDU	5.3.6.2.2.4	203.2:M	Yes__ No__	
206.2.2.4.c	I PDUs that have been transmitted following the I PDU designated by the SREJ PDU shall not be retransmitted as the result of receiving the SREJ PDU	5.3.6.2.2.4	203.2:M	Yes__ No__	
206.2.3	U Commands and Responses	5.3.6.2.3	203.2:M	Yes__ No__	
206.2.3.a	U commands and responses shall be used in Type 2 operations to extend the number of data link connection control functions	5.3.6.2.3	203.2:M	Yes__ No__	
206.2.3.b	The U PDUs shall not increment the state variables on the data link connection at either the sending or the receiving station	5.3.6.2.3	203.2:M	Yes__ No__	
206.2.3.c	Encoding of the U PDU control field shall be as in FIGURE 19	5.3.6.2.3	203.2:M	Yes__ No__	
206.2.3.1	SABME Command	5.3.6.2.3.1	203.2:M	Yes__ No__	
206.2.3.1.a	The SABME command PDU shall be used to establish a data link connection to the destination station in the ABM	5.3.6.2.3.1	203.2:M	Yes__ No__	
206.2.3.1.b	No information shall be permitted with the SABME command PDU	5.3.6.2.3.1	203.2:M	Yes__ No__	
206.2.3.1.c	The destination station shall confirm receipt of the SABME command PDU by sending a UA response PDU on that data link connection at the earliest opportunity	5.3.6.2.3.1	203.2:M	Yes__ No__	
206.2.3.1.d	Upon acceptance of the SABME command PDU, the destination station V(S)s and V(R)s shall be set to 0	5.3.6.2.3.1	203.2:M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
206.2.3.1.e	If the UA response PDU is received correctly, then the initiating station shall also assume the ABM with its corresponding V(S)s and V(R)s set to 0	5.3.6.2.3.1	203.2:M	Yes__ No__	
206.2.3.1.f	Previously sent I PDUs that are unacknowledged when this command is executed shall remain unacknowledged	5.3.6.2.3.1	203.2:M	Yes__ No__	
206.2.3.2	DISC Command	5.3.6.2.3.2	203.2:M	Yes__ No__	
206.2.3.2.a	The DISC command PDU shall be used to terminate an ABM previously set by a SABME command PDU	5.3.6.2.3.2	203.2:M	Yes__ No__	
206.2.3.2.b	It shall be used to inform the destination station that the source station is suspending operation of the data link connection and the destination station should assume the logically disconnected mode	5.3.6.2.3.2	203.2:M	Yes__ No__	
206.2.3.2.c	No information field shall be permitted with the DISC command PDU	5.3.6.2.3.2	203.2:M	Yes__ No__	
206.2.3.2.d	Prior to executing the command, the destination station shall confirm the acceptance of the DISC command PDU by sending a UA response PDU on that data link connection	5.3.6.2.3.2	203.2:M	Yes__ No__	
206.2.3.2.e	Previously sent I PDUs that are unacknowledged when this command is executed shall remain unacknowledged	5.3.6.2.3.2	203.2:M	Yes__ No__	
206.2.3.3	RSET Command	5.3.6.2.3.3	203.2:M	Yes__ No__	
206.2.3.3.a	The RSET command PDU shall be used by a station in an operational mode to reset the V(R) in the addressed station	5.3.6.2.3.3	203.2:M	Yes__ No__	
206.2.3.3.b	No information field shall be permitted with the RSET command PDU	5.3.6.2.3.3	203.2:M	Yes__ No__	

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206.2.3.3.c	The addressed station shall confirm acceptance of the RSET command by transmitting a UA response PDU at the earliest opportunity	5.3.6.2.3.3	203.2:M	Yes__ No__	
206.2.3.3.d	Upon acceptance of this command, the V(R) of the addressed station shall be set to 0	5.3.6.2.3.3	203.2:M	Yes__ No__	
206.2.3.3.e	If the UA response PDU is received correctly, the initializing station shall reset its V(S) to 0	5.3.6.2.3.3	203.2:M	Yes__ No__	
206.2.3.4	UA Response	5.3.6.2.3.4	203.2:M	Yes__ No__	
206.2.3.4.a	The UA response PDU shall be used by a station on a data link connection to acknowledge receipt and acceptance of the SABME, DISC and RSET command PDUs	5.3.6.2.3.4	203.2:M	Yes__ No__	
206.2.3.4.b	These received command PDUs shall not be executed until the UA response PDU is sent	5.3.6.2.3.4	203.2:M	Yes__ No__	
206.2.3.4.c	No information field shall be permitted with the UA response PDU	5.3.6.2.3.4	203.2:M	Yes__ No__	
206.2.3.5	DM Response	5.3.6.2.3.5	203.2:M	Yes__ No__	
206.2.3.5.a	The DM response PDU shall be used to report status indicating that the station is logically disconnected from the data link connection and is in ADM	5.3.6.2.3.5	203.2:M	Yes__ No__	
206.2.3.5.b	No information field shall be permitted with the DM response PDU	5.3.6.2.3.5	203.2:M	Yes__ No__	
206.2.3.6	FRMR Response	5.3.6.2.3.6	203.2:M	Yes__ No__	

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206.2.3.6.a	The FRMR response PDU shall be used by the station in the ABM to report that one of the following conditions, which is not correctable by resending the identical PDU, resulted from the receipt of a PDU from the remote station:	5.3.6.2.3.6	203.2:M	Yes__ No__	
206.2.3.6.a.1	The receipt of a command PDU or a response PDU that is invalid or not implemented	5.3.6.2.3.6.a	206.2.3.6.a:O.<4>	Yes__ No__	
206.2.3.6.a.2	The receipt of an I PDU with an information field that exceeded the established maximum information field length that can be accommodated by the receiving station for that data link connection.	5.3.6.2.3.6.b	206.2.3.6.a:O.<4>	Yes__ No__	
206.2.3.6.a.3	The receipt of an invalid N(R) from the remote station. An invalid N(R) shall be defined as one that signifies an I PDU that has previously been sent and acknowledged, or one that signifies an I PDU that has not been sent and is not the next sequential I PDU waiting to be sent.	5.3.6.2.3.6.c	206.2.3.6.a:O.<4>	Yes__ No__	
206.2.3.6.a.4	The receipt of an invalid N(S) from the remote station. An invalid N(S) shall be defined as an N(S) that is greater than or equal to the last sent N(R)+ k, where k is the maximum number of outstanding I PDUs. The parameter k is the window size indicated in the XNP message.	5.3.6.2.3.6.d APPENDIX E	206.2.3.6.a:O.<4>	Yes__ No__	
206.2.3.6.b	The responding station shall send the FRMR response PDU at the earliest opportunity	5.3.6.2.3.6	203.2:M	Yes__ No__	
206.2.3.6.c	An information field shall be returned with the FRMR response PDU to provide the reason for the PDU rejection	5.3.6.2.3.6	203.2:M	Yes__ No__	

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206.2.3.6.d	The information field shall contain the fields shown in FIGURE 20	5.3.6.2.3.6	203.2:M		Yes__ No__		
206.2.3.6.e	The station receiving the FRMR response PDU shall be responsible for initiating the appropriate mode setting or resetting corrective action by initializing one or both directions of transmission on the data link connection, using the SABME, RSET or DISC command PDUs, as applicable	5.3.6.2.3.6	203.2:M		Yes__ No__		
206.3	Type 3 Operation Commands and Responses	5.3.6.3	M		Yes__ No__		
206.3.1	UI Command	5.3.6.3.1	M		Yes__ No__		
206.3.1.a	The UI PDU shall be used to send information to one or more stations	5.3.6.3.1	M		Yes__ No__		
206.3.1.b	The UI PDU shall be addressed to individual, special, group or global addresses	5.3.6.3.1	M		Yes__ No__		
206.3.1.c	The source address shall be the individual address of the transmitting station	5.3.6.3.1	M		Yes__ No__		
206.3.2	URR Response	5.3.6.3.2	M		Yes__ No__		
206.3.2.a	The URR response shall be used to acknowledge a Type 3 UI command	5.3.6.3.2	M		Yes__ No__		
206.3.2.b	The URR response shall be the first PDU sent by the receiving station upon receiving a UI command after the appropriate RHD period	5.3.6.3.2 C.4.2	M		Yes__ No__		
206.3.2.c	The source and destination shall be individual addresses	5.3.6.3.2	M		Yes__ No__		
206.3.3	URNR Response	5.3.6.3.3	Send: O	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	

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206.3.3.a	The URNR response PDU shall be used to reply to a Type 3 UI command, if the UI command cannot be processed due to a busy condition	5.3.6.3.3	206.3.3:M	Yes__ No__	
206.3.3.b	If used, the URNR response shall be the first PDU transmitted by the receiving station, upon receiving a UI command, after the appropriate RHD period	5.3.6.3.3 and C.4.2	206.3.3:M	Yes__ No__	
206.3.3.c	The URNR response shall have the F-bit set to 1 and shall be addressed to the source of the UI command	5.3.6.3.3	M	Yes__ No__	
206.3.4	TEST Command	5.3.6.3.4	M	Yes__ No__	
206.3.4.a	The TEST command shall be used to cause the destination station to respond with the TEST response at the earliest opportunity, thus performing a basic test of the transmission path	5.3.6.3.4	M	Yes__ No__	
206.3.4.b	If an information field is present, the received information field shall be returned, if possible, by the addressed station in the TEST response PDU	5.3.6.3.4	M	Yes__ No__	
206.3.4.c	The TEST command, with the P-bit set to 1, shall cause the individually addressed destination station(s) to respond with a TEST response PDU (with no information field), with the F-bit set to 1, after the appropriate RHD period.	5.3.6.3.4 C.4.2	M	Yes__ No__	
206.3.4.d	The TEST command PDU shall be addressed to an individual and/or group or global destination addresses	5.3.6.3.4	M	Yes__ No__	
206.3.4.e	The source address shall be an individual address	5.3.6.3.4	M	Yes__ No__	
206.3.5	TEST Response	5.3.6.3.5	M	Yes__ No__	

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206.3.5.a	The TEST response, with F-bit set to 1, without an information field shall be used by individual addresses to reply to the TEST command with the P-bit set to 1	5.3.6.3.5	M	Yes__ No__	
206.3.5.b	The TEST response shall be the first PDU sent by the receiving station upon receiving a TEST command PDU, after the appropriate RHD period	5.3.6.3.5 C.4.2	M	Yes__ No__	
206.3.5.c	The source and destination addresses shall be an individual address	5.3.6.3.5	M	Yes__ No__	
206.4	Type 4 Operation Commands and Responses	5.3.6.4	203.4:M	Yes__ No__	
206.4.1	Unnumbered Information (DIA) Transfer Format Command	5.3.6.4.1	203.4:M	Yes__ No__	
206.4.1.a	The function of the Type 4 DIA commands shall be to transfer PDUs that contain an identification number and an information field across a connectionless link	5.3.6.4.1	203.4:M	Yes__ No__	
206.4.1.b	The encoding of the PDU control field for Type 4 operation shall be as listed in FIGURE 22	5.3.6.4.1	203.4:M	Yes__ No__	
206.4.1.1	DIA PDU Acknowledgment	5.3.6.4.1.1	203.4:M	Yes__ No__	
206.4.2	Supervisory Format Commands and Responses	5.3.6.4.2	203.4:M	Yes__ No__	
206.4.2.a	The S PDUs shall be used to convey link acknowledgment of a DIA PDU and whether or not a station is ready to receive Type 4 PDUs	5.3.6.4.2	203.4:M	Yes__ No__	
206.4.2.b	The command S PDU level of precedence shall be set to the highest precedence while response S PDUs shall use the precedence of the DIA PDU which they are acknowledging	5.3.6.4.2	203.4:M	Yes__ No__	

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206.4.2.c	The encoding of the S PDU control field for Type 4 operation shall be as listed in FIGURE 23	5.3.6.4.2	203.4:M	Yes__ No__	

A.5.7 Description of Procedures by Type.

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207	Description of Procedures by Type	5.3.7	M	Yes__ No__	
207.1	Description of Type 1 Procedures	5.3.7.1	M	Yes__ No__	
207.1.a	Stations will combine network status information (URR/URNR) for Type 1 and Type 3 communication procedures	5.3.7.1	M	Yes__ No__	
207.1.1	Modes of Operation	5.3.7.1.1	M	Yes__ No__	
207.1.1.a	A station using Type 1 procedures shall support the entire procedure set whenever it is operational on the network	5.3.7.1.1	M	Yes__ No__	
207.1.2	Procedure for Addressing	5.3.7.1.2	M	Yes__ No__	
207.1.2.a	The address fields shall be used to indicate the source and destinations of the transmitted PDU	5.3.7.1.2	M	Yes__ No__	
207.1.2.b	The first bit in the source address field shall be used to identify whether a command or a response is contained in the PDU	5.3.7.1.2	M	Yes__ No__	
207.1.2.c	Individual, group, special and global addressing shall be supported for destination addresses in command PDUs	5.3.7.1.2	M	Yes__ No__	
207.1.2.d	The source address field shall contain an individual or special address	5.3.7.1.2	M	Yes__ No__	
207.1.3	Procedure for Using the P/F Bit	5.3.7.1.3	M	Yes__ No__	
207.1.3.a	The P-bit shall always be set to 0 for Type 1 communications	5.3.7.1.3	M	Yes__ No__	

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207.1.4	Procedures for Logical Data Link Set-up and Disconnection	5.3.7.1.4	M	Yes__ No__	
207.1.5	Procedures for Information Transfer	5.3.7.1.5	M	Yes__ No__	
207.1.5.1	Sending UI Command PDUs	5.3.7.1.5.1	M	Yes__ No__	
207.1.5.1.a	Information transfer from an initiating station to a responding station shall be accomplished by sending the UI command PDU	5.3.7.1.5.1	M	Yes__ No__	
207.1.5.1.b	Transmission of UI commands to stations detected as busy (due to receipt of a URNR Command or Response) shall be discontinued until the busy state is cleared	5.3.7.1.5.1	M	Yes__ No__	
207.1.5.2	Receiving UI Command PDUs	5.3.7.1.5.2	M	Yes__ No__	
207.1.5.2.a	Reception of the UI command PDU with P-bit set to 0 shall not be acknowledged	5.3.7.1.5.2	M	Yes__ No__	
207.1.5.3	Sending URNR Command PDUs	5.3.7.1.5.3	M	Yes__ No__	
207.1.5.4	Receiving URNR Command PDUs	5.3.7.1.5.4	M	Yes__ No__	
207.1.5.5	Sending URR Command PDUs	5.3.7.1.5.5	M	Yes__ No__	
207.1.5.6	Receiving URR Command PDUs	5.3.7.1.5.6	M	Yes__ No__	
207.1.5.7	Using TEST Command and Response PDUs	5.3.7.1.5.7	M	Yes__ No__	
207.1.5.7.a	Any TEST command PDU received in error shall be discarded and no response PDU sent	5.3.7.1.5.7	M	Yes__ No__	
207.1.5.10.b	In the event of a test failure, it shall be the responsibility of the TEST function initiator to determine any future actions	5.3.7.1.5.7	M	Yes__ No__	
207.2	Description of Type 2 Procedures	5.3.7.2	203.2:M	Yes__ No__	
207.2.1	Modes of Operation	5.3.7.2.1	203.2:M	Yes__ No__	
207.2.1.1	Operational Mode	5.3.7.2.1.1	203.2:M	Yes__ No__	
207.2.1.1.a	The operational mode shall be the ABM	5.3.7.2.1.1	203.2:M	Yes__ No__	

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207.2.1.1.b	Either station shall be able to send commands at any time and initiate response transmissions without receiving explicit permission from the other station	5.3.7.2.1.1	203.2:M	Yes__ No__	
207.2.1.1.c	Such an asynchronous transmission shall contain one or more PDUs that shall be used for information transfer and to indicate status changes in the station (for example, the number of the next expected I PDU; transition from a ready to a busy condition, or vice versa; occurrence of an exception condition)	5.3.7.2.1.1	203.2:M	Yes__ No__	
207.2.1.1.d	A station in ABM receiving a DISC command PDU shall respond with the UA response PDU if it is capable of executing the command	5.3.7.2.1.1	203.2:M	Yes__ No__	
207.2.1.2	Non-Operational Mode	5.3.7.2.1.2	203.2:M	Yes__ No__	
207.2.1.2.a	The non-operational mode shall be the ADM	5.3.7.2.1.2	203.2:M	Yes__ No__	
207.2.1.2.b	ADM differs from ABM in that the data link connection is logically disconnected from the physical medium such that no information (user data) shall be sent or accepted	5.3.7.2.1.2	203.2:M	Yes__ No__	
207.2.1.2.c	A data link connection shall be system-predefined as to the conditions that cause it to assume ADM	5.3.7.2.1.2	203.2:M	Yes__ No__	

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207.2.1.2.d	A station on a data link connection in ADM shall be required to monitor transmissions received from its PL to accept and respond to one of the mode-setting command PDUs (SABME, DISC), or to send a DM response PDU at a medium access opportunity, when required	5.3.7.2.1.2	203.2:M	Yes__ No__	
207.2.1.2.e	A station in ADM receiving a DISC command PDU or any I or S PDU shall respond with the DM response PDU	5.3.7.2.1.2	203.2:M	Yes__ No__	
207.2.1.2.f	A station in ADM shall not establish a FRMR exception condition	5.3.7.2.1.2	203.2:M	Yes__ No__	
207.2.2	Procedure for Addressing	5.3.7.2.2	203.2:M	Yes__ No__	
207.2.2.a	The address fields for a PDU shall be used to indicate the individual source and up to 16 destinations	5.3.7.2.2	203.2:M	Yes__ No__	
207.2.2.b	The first bit in the source address field shall be used to identify whether a command or response is contained in the PDU	5.3.7.2.2	203.2:M	Yes__ No__	
207.2.3	Procedures for Using the P/F Bit	5.3.7.2.3	203.2:M	Yes__ No__	
207.2.3.a	An individually addressed station receiving a command PDU (SABME, DISC, RR, RNR, REJ, or I) with the P-bit set to 1 shall send a response PDU with the F-bit set to 1	5.3.7.2.3	203.2:M	Yes__ No__	
207.2.3.b	The response PDU returned by a station to a RSET, SABME or DISC command PDU with the P-bit set to 1 shall be a UA or DM response PDU with the F-bit set to 1	5.3.7.2.3	203.2:M	Yes__ No__	

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207.2.3.c	The response PDU returned by a station to an I, RR or REJ command PDU with the P-bit set to 1 shall be an I, RR, REJ, RNR, DM or FRMR response PDU with the F-bit set to 1	5.3.7.2.3	203.2:M	Yes__ No__	
207.2.3.d	The response PDU returned by a station to an RNR command PDU with the P-bit set to 1 shall be an RR, REJ, RNR, DM or FRMR response PDU with the F-bit set to 1	5.3.7.2.3	203.2:M	Yes__ No__	
207.2.3.e	The response PDU returned by a station to a SREJ with the P-bit set to one shall be the requested I PDU (response) with the F-bit set to one	5.3.7.2.3	203.2:M	Yes__ No__	
207.2.4	Procedures for Logical Data Link Set-up and Disconnection	5.3.7.2.4	203.2:M	Yes__ No__	
207.2.4.1	Data Link Connection Phase	5.3.7.2.4.1	203.2:M	Yes__ No__	
207.2.4.1.a	Either station shall be able to take the initiative to initialize the data link connection	5.3.7.2.4.1	203.2:M	Yes__ No__	
207.2.4.1.1	Initiator Action	5.3.7.2.4.1.1	203.2:M	Yes__ No__	
207.2.4.1.1.a	When the station wishes to initialize the link, it shall send the SABME command PDU to one or more individual addresses and start the acknowledgment timer(s)	5.3.7.2.4.1.1	203.2:M	Yes__ No__	
207.2.4.1.1.b	Upon receipt of the UA response PDU, the station shall reset both the V(S) and V(R) to 0 for the corresponding data link connection, shall stop the acknowledgment timer and shall enter the information transfer phase	5.3.7.2.4.1.1	203.2:M	Yes__ No__	

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207.2.4.1.1.c	When receiving the DM response PDU, the station that originated the SABME command PDU shall stop the acknowledgment timers for that link, shall not enter the information transfer phase for that station, and shall report to the higher layer for appropriate action	5.3.7.2.4.1.1	203.2:M	Yes__ No__	
207.2.4.1.1.d	Should any acknowledgment timer run out before receiving all UA or DM response PDUs, the station shall resend the SABME command PDU, after deleting the address and control fields corresponding to the received UAs or DMs, and restart the acknowledgment timers	5.3.7.2.4.1.1	203.2:M	Yes__ No__	
207.2.4.1.1.e	After resending the SABME command PDU N2 times, the station shall stop sending the SABME command PDU, may report to the higher layer protocol and may initiate other error recovery action	5.3.7.2.4.1.1	203.2:M	Yes__ No__	
207.2.4.1.1.f	Other Type 2 PDUs received (commands and responses) while attempting to connect shall be ignored by the station	5.3.7.2.4.1.1	203.2:M	Yes__ No__	
207.2.4.1.2	Respondent Action	5.3.7.2.4.1.2	203.2:M	Yes__ No__	
207.2.4.1.2.a	When a SABME command PDU is received, and the connection is desired, the station shall return a UA response PDU to the remote station, set both the V(S) and V(R) to 0 for the corresponding data link connection, and enter the information transfer phase	5.3.7.2.4.1.2	203.2:M	Yes__ No__	
207.2.4.1.2.b	The return of the UA response PDU shall take precedence over any other response PDU that may be pending at the station for that data link connection	5.3.7.2.4.1.2	203.2:M	Yes__ No__	

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207.2.4.1.2.c	It shall be possible to follow the UA response PDU with additional PDUs, if pending	5.3.7.2.4.1.2	203.2:M	Yes__ No__	
207.2.4.1.2.d	If the connection is not desired, the station shall return a DM response PDU to the remote station and remain in the link disconnected mode	5.3.7.2.4.1.2	203.2:M	Yes__ No__	
207.2.4.2	Information Transfer Phase	5.3.7.2.4.2	203.2:M	Yes__ No__	
207.2.4.2.a	After having sent the UA response PDU to an SABME command PDU or having received the UA response PDU to a sent SABME command PDU, the station shall accept and send I and S PDUs according to the procedures described in 5.3.7.2.5	5.3.7.2.4.2 5.3.7.2.5	203.2:M	Yes__ No__	
207.2.4.2.b	When receiving an SABME command PDU while in the information transfer phase, the station shall conform to the resetting procedure described in 5.3.7.2.6	5.3.7.2.4.2 5.3.7.2.6	203.2:M	Yes__ No__	
207.2.4.2.c	When receiving an RSET command PDU while in the information transfer phase, the station shall conform to the resetting procedure described in 5.3.7.2.7	5.3.7.2.4.2 5.3.7.2.7	203.2:M	Yes__ No__	
207.2.4.3	Data Link Disconnection Phase	5.3.7.2.4.3	203.2:M	Yes__ No__	
207.2.4.3.a	During the information transfer phase, either station shall be able to initiate disconnecting of the data link connection by sending a DISC command PDU and starting the acknowledgment timer	5.3.7.2.4.3 5.3.8.1.3.a	203.2:M	Yes__ No__	
207.2.4.3.b	When receiving a DISC command PDU, the station shall return a UA response PDU and enter the data link disconnected phase	5.3.7.2.4.3	203.2:M	Yes__ No__	

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207.2.4.3.c	The return of the UA response PDU shall take precedence over any other response PDU that may be pending at the station for that data link connection	5.3.7.2.4.3	203.2:M	Yes__ No__	
207.2.4.3.d	Upon receipt of the UA or DM response PDU from a remote station, the station shall stop its acknowledgment timer for that link, and enter the link disconnected mode	5.3.7.2.4.3	203.2:M	Yes__ No__	
207.2.4.3.e	Should the acknowledgment timer run out before receiving the UA or DM response PDU for a particular link, the station shall send another DISC command PDU and restart the acknowledgment timer	5.3.7.2.4.3	203.2:M	Yes__ No__	
207.2.4.3.f	After sending the DISC command PDU N2 times, the sending station shall stop sending the DISC command PDU, shall enter the data link disconnected phase, and shall report to the higher layer for the appropriate error recovery action.	5.3.7.2.4.3 5.3.8.1.3.d	203.2:M	Yes__ No__	
207.2.4.4	Data Link Disconnected Phase	5.3.7.2.4.4	203.2:M	Yes__ No__	
207.2.4.4.a	After having received a DISC command PDU from the remote station and returned a UA response PDU, or having received the UA response PDU to a sent DISC command PDU, the station shall enter the data link disconnected phase	5.3.7.2.4.4	203.2:M	Yes__ No__	
207.2.4.4.b	In the disconnected phase, the station shall react to the receipt of an SABME command PDU, as described in 5.3.7.2.4.1, and shall send a DM response PDU in answer to a received DISC command PDU	5.3.7.2.4.4 5.3.7.2.4.1	203.2:M	Yes__ No__	

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207.2.4.4.c	When receiving any other Type 2 command, I or S PDU, the station in the disconnected phase shall send a DM response PDU	5.3.7.2.4.4	203.2:M	Yes__ No__	
207.2.4.4.d	In the disconnected phase, the station shall be able to initiate a data link connection	5.3.7.2.4.4	203.2:M	Yes__ No__	
207.2.4.5	Contention of Unnumbered Mode-Setting Command PDUs	5.3.7.2.4.5	203.2:M	Yes__ No__	
207.2.4.5.a	A contention situation on a data link connection shall be resolved in the following way: If the sent and received mode-setting command PDUs are the same, each station shall send the UA response PDU at the earliest opportunity	5.3.7.2.4.5	203.2:M	Yes__ No__	
207.2.4.5.b	Each station shall enter the indicated phase either after receiving the UA response PDU, or after its acknowledgment timer expires	5.3.7.2.4.5	203.2:M	Yes__ No__	
207.2.4.5.c	If the sent and received mode-setting command PDUs are different, each station shall enter the data link disconnected phase and shall issue a DM response PDU at the earliest opportunity	5.3.7.2.4.5	203.2:M	Yes__ No__	
207.2.5	Procedures for Information Transfer	5.3.7.2.5	203.2:M	Yes__ No__	
207.2.5.1	Sending I PDUs	5.3.7.2.5.1	203.2:M	Yes__ No__	
207.2.5.1.a	When the station has an I PDU to send (that is, an I PDU not already sent), it shall send the I PDU with an N(S) equal to its current V(S) and an N(R) equal to its current V(R) for that data link connection	5.3.7.2.5.1	203.2:M	Yes__ No__	
207.2.5.1.b	At the end of sending the I PDU, the station shall increment its V(S) by 1	5.3.7.2.5.1	203.2:M	Yes__ No__	

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207.2.5.1.c	If the acknowledgment timer is not running at the time that an I PDU is sent, the acknowledgment timer shall be started	5.3.7.2.5.1	203.2:M	Yes__ No__	
207.2.5.1.d	If the data link connection V(S) is equal to the last value of N(R) received plus k (where k is the maximum number of outstanding I PDUs), the station shall not send any new I PDUs on that data link connection, but shall be able to resend an I PDU	5.3.7.2.5.1 5.3.8.1.3.e 5.3.7.2.5.6 5.3.7.2.5.9	203.2:M	Yes__ No__	
207.2.5.1.e	Upon sending an I PDU that causes the number of outstanding I PDUs to be equal to the k2 value for that connection, the station shall send an RR (or RNR) command to the destination station	5.3.7.2.5.1	203.2:M	Yes__ No__	
207.2.5.1.f	The destination station shall respond with a RR Response with the N(R) indicating the last received I PDU	5.3.7.2.5.1	203.2:M	Yes__ No__	
207.2.5.1.g	When a local station on a data link connection is in the busy condition, the station shall still be able to send I PDUs, provided that the remote station on this data link connection is not also busy	5.3.7.2.5.1	203.2:M	Yes__ No__	
207.2.5.1.h	When the station is in the FRMR exception condition for a particular data link connection, it shall stop transmitting I PDUs on that data link connection	5.3.7.2.5.1	203.2:M	Yes__ No__	
207.2.5.1.i	When a station is in the timer recovery condition, it shall not send any new I PDUs on that data link connection	5.3.7.2.5.1 5.3.7.2.5.11	203.2:M	Yes__ No__	
207.2.5.2	Receiving I PDU	5.3.7.2.5.2	203.2:M	Yes__ No__	

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207.2.5.2.a	When the station is not in a busy condition and receives an I PDU whose N(S) is equal to its V(R), the station shall accept the information field of this PDU, increment by 1 its V(R), and act as follows:	5.3.7.2.5.2	207.2.5.2:M	Yes__ No__	
207.2.5.2.a.1	If an I PDU is available to be sent, the station shall be able to act as in 5.3.7.2.5.1 and acknowledge the received I PDU by setting N(R) in the control field of the next sent I PDU to the value of its V(R). The station shall also be able to acknowledge the received I PDU by sending an RR PDU with the N(R) equal to the value of its V(R).	5.3.7.2.5.2.a 5.3.7.2.5.1	207.2.5.2.a:O.<3>	Yes__ No__	
207.2.5.2.a.2	If no I PDU is available to be sent by the station, then the station shall either:	5.3.7.2.5.2.b	207.2.5.2.a:O.<3>	Yes__ No__	
207.2.5.2.a.2.a	If the received I PDU is a command PDU with the P-bit set to 1, then send an S PDU with its F-bit set to 1 and its N(R) equal to the current value of V(R) at the first possible opportunity (this transmission is time critical to maintaining the connection), and stop the Response Delay Timer	5.3.7.2.5.2.b(1)	207.2.5.2.a.2:O.<2>	Yes__ No__	
207.2.5.2.a.2.b	If the received I PDU is not a command PDU with the P-bit set to 1, then the station shall	5.3.7.2.5.2.b(2)	207.2.5.2.a.2:O.<2>	Yes__ No__	
207.2.5.2.a.2.b.1	If the number of outstanding I PDUs received since the last I PDU for which an acknowledgment was sent is equal to or greater than *k3*, then send an S PDU with its N(R) equal to the current value of V(R) at the earliest opportunity, and stop the Response Delay Timer	5.3.7.2.5.2.b(2)(a) 5.3.8.1.3.g	207.2.5.2.a.2.b:O.<2>	Yes__ No__	

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207.2.5.2.a.2.b.2	If the number of outstanding I PDUs received since the last I PDU for which an acknowledgment was sent is less than *k3*, and if the Response Delay Timer is not already running, then start the Response Delay Timer. When the Response Delay Timer is running then the station shall:	5.3.7.2.5.2.b(2)(b) 5.3.8.1.3.g	207.2.5.2.a.2.b:O.<2>	Yes__ No__	
207.2.5.2.a.2.b.2(i)	If an I PDU is sent back to the originator of the recently received I PDU before the Response Delay Timer expires, then stop the Response Delay Timer. The N(R) in the outgoing I frame will acknowledge any recently received correct in sequence I PDU frames as described in 5.3.7.2.5.1 (No S PDU needs to be sent)	5.3.7.2.5.2.b(2)(b)(i) 5.3.7.2.5.1	207.2.5.2.a.2.b.2:O.<3>	Yes__ No__	
207.2.5.2.a.2.b.2(ii)	If another PDU of any type that can be concatenated is transmitted to any destination and adequate space exists to concatenate additional frames, then concatenate onto this PDU an S PDU with its N(R) equal to the current value of V(R) addressed to the originator of the recently received I PDU, and stop the Response Delay Timer	5.3.7.2.5.2.b(2)(b)(ii)	207.2.5.2.a.2.b.2:O.<3>	Yes__ No__	
207.2.5.2.a.2.b.2(iii)	If the Response Delay Timer expires, then at the earliest opportunity, send an S PDU with its N(R) equal to the current value of V(R). (Note that S PDUs to other destinations may be concatenated with this frame as described in the preceding paragraph.)	5.3.7.2.5.2.b(2)(b)(iii)	207.2.5.2.a.2.b.2:O.<3>	Yes__ No__	

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207.2.5.2.a.3	If receipt of the I PDU caused the station to go into the busy condition with regard to any subsequent I PDUs, the station shall send an RNR PDU with the N(R) equal to the value of its V(R). If I PDUs are available to send, the station shall be able to send them (as in 5.3.7.2.5.1) prior to or following the sending of the RNR PDU.	5.3.7.2.5.2.c 5.3.7.2.5.1	207.2.5.2.a:O.<3>	Yes__ No__	
207.2.5.2.b	When the station is in a busy condition, the station shall be able to ignore the information field contained in any received I PDU on that data link connection	5.3.7.2.5.2 5.3.7.2.5.10	207.2.5.2:M	Yes__ No__	
207.2.5.3	Receiving Incorrect PDUs	5.3.7.2.5.3	203.2:M	Yes__ No__	
207.2.5.3.a	When the station receives an invalid PDU or a PDU with an incorrect source address, the entire PDU shall be discarded	5.3.7.2.5.3	203.2:M	Yes__ No__	
207.2.5.4	Receiving Out-of-Sequence PDUs	5.3.7.2.5.4	203.2:M	Yes__ No__	
207.2.5.4.a	When the station receives one or more I PDUs whose N(S)s are not in the expected sequence, that is, not equal to the current V(R) but is within the receive window, the station shall respond by sending a REJ or a SREJ PDU as described in either 5.3.7.2.5.4.1or 5.3.7.2.5.4.2	5.3.7.2.5.4 5.3.7.2.5.4.1 5.3.7.2.5.4.2	203.2:M	Yes__ No__	
207.2.5.4.1	Reject Response	5.3.7.2.5.4.1	203.2:M	Yes__ No__	

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207.2.5.4.1.a	When an I PDU has been received out-of-sequence and more than one frame is missing, the station may discard the information field of the I PDU and send a REJ PDU with the N(R) set to the value of V(R). The station shall then discard the information field of all I PDUs until the expected I PDU is correctly received	5.3.7.2.5.4.1	203.2:M	Yes__ No__	
207.2.5.4.1.b	When receiving the expected I PDU, the station shall acknowledge the PDU	5.3.7.2.5.4.1 5.3.7.2.5.2	203.2:M	Yes__ No__	
207.2.5.4.1.c	The station shall use the N(R) and P-bit indications in the discarded I PDU	5.3.7.2.5.4.1	203.2:M	Yes__ No__	
207.2.5.4.1.d	On a given data link connection, only one "sent REJ" exception condition from a given station to another given station shall be established at a time	5.3.7.2.5.4.1	203.2:M	Yes__ No__	
207.2.5.4.1.e	A "sent REJ" condition shall be cleared when the requested I PDU is received	5.3.7.2.5.4.1	203.2:M	Yes__ No__	
207.2.5.4.1.f	The "sent REJ" condition shall be able to be reset when a REJ timer time-out function runs out	5.3.7.2.5.4.1	203.2:M	Yes__ No__	
207.2.5.4.1.g	When the station perceives by REJ timer time-out that the requested I PDU will not be received, because either the requested I PDU or the REJ PDU was in error or lost, the station shall be able to resend the REJ PDU up to N2 times to reestablish the "sent REJ" condition	5.3.7.2.5.4.1 5.3.8.1.3.d	203.2:M	Yes__ No__	
207.2.5.4.2	Selective Reject Response	5.3.7.2.5.4.2	203.2:M	Yes__ No__	
207.2.5.4.2.a	A SREJ PDU shall not be transmitted if an earlier REJ condition has not been cleared	5.3.7.2.5.4.2	203.2:M	Yes__ No__	

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207.2.5.4.2.b	When the station perceives by the REJ timer time-out that the request I PDU will not be received, because either the requested I PDU or the SREJ PDU was in error or lost, the station shall be able to resend all outstanding SREJ PDUs in order to reestablish the “sent SREJ” condition up to N2 times	5.3.7.2.5.4.2 5.3.8.1.3.d	203.2:M	Yes__ No__	
207.2.5.5	Receiving Acknowledgment	5.3.7.2.5.5	203.2:M	Yes__ No__	
207.2.5.5.a	When correctly receiving an I or S PDU, even in the busy condition, the receiving station shall consider the N(R) contained in this PDU as an acknowledgment for all the I PDUs it has sent on this data link connection with an N(S) up to and including the received N(R) minus one	5.3.7.2.5.5 5.3.7.2.5.10	203.2:M	Yes__ No__	
207.2.5.5.b	The station shall reset the acknowledgment timer when it correctly receives an I or Type 2 S PDU with the N(R) higher than the last received N(R) (actually acknowledging some I PDUs)	5.3.7.2.5.5	203.2:M	Yes__ No__	
207.2.5.5.c	If the timer has been reset and there are outstanding I PDUs still unacknowledged on this data link connection, the station shall restart the acknowledgment timer	5.3.7.2.5.5	203.2:M	Yes__ No__	
207.2.5.5.d	If the timer then runs out, the station shall follow the procedures in 5.3.7.2.5.11with respect to the unacknowledged I PDUs	5.3.7.2.5.5 5.3.7.2.5.11	203.2:M	Yes__ No__	
207.2.5.6	Receiving SREJ PDU	5.3.7.2.5.6	203.2:M	Yes__ No__	
207.2.5.6.a	If the received transmission is an SREJ command or response PDU, the I PDU corresponding to the N(R) being rejected shall be retransmitted	5.3.7.2.5.6	203.2:M	Yes__ No__	

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207.2.5.7	Receiving RSET PDU	5.3.7.2.5.7	203.2:M	Yes__ No__	
207.2.5.7.a	Upon the receipt of the RSET command PDU, the receiving station shall reply with a UA response PDU and shall then set its V(R) to 0 for the initiating station	5.3.7.2.5.7	203.2:M	Yes__ No__	
207.2.5.8	Receiving REJ PDU	5.3.7.2.5.8	203.2:M	Yes__ No__	
207.2.5.8.a	When receiving an REJ PDU, the station shall set its V(S) to the N(R) received in the REJ PDU control field	5.3.7.2.5.8	203.2:M	Yes__ No__	
207.2.5.8.b	The station shall resend the corresponding I PDU as soon as it is available	5.3.7.2.5.8	203.2:M	Yes__ No__	
207.2.5.8.c	If other unacknowledged I PDUs had already been sent on that data link connection following the one indicated in the REJ PDU, then those I PDUs shall be resent by the station following the resending of the requested I PDU	5.3.7.2.5.8	203.2:M	Yes__ No__	
207.2.5.8.d	If retransmission beginning with a particular PDU occurs while waiting acknowledgment and an REJ PDU is received, which would also start retransmission with the same I PDU [as identified by the N(R) in the REJ PDU], the retransmission resulting from the REJ PDU shall be inhibited	5.3.7.2.5.8 5.3.7.2.5.11	203.2:M	Yes__ No__	
207.2.5.9	Receiving RNR PDU	5.3.7.2.5.9	203.2:M	Yes__ No__	

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207.2.5.9.a	A station receiving an RNR PDU shall, with one exception described below, stop sending I PDUs on the indicated data link connection at the earliest possible time and shall start the busy-state timer, if not already running. **EXCEPTION**: A station may include a busy destination in a PDU that is addressed to multiple destination addresses if at least one of the multiple destinations is not busy.	5.3.7.2.5.9	203.2:M	Yes__ No__	
207.2.5.9.b	When the busy-state timer runs out, the station shall follow the procedure described in 5.3.7.2.5.11	5.3.7.2.5.9 5.3.7.2.5.11	203.2:M	Yes__ No__	
207.2.5.9.c	In any case, the station shall not send any other I PDUs on that data link connection before receiving an RR or REJ PDU, or before receiving an I response PDU with the F-bit set to 1, or before the completion of a resetting procedure on that data link connection	5.3.7.2.5.9	203.2:M	Yes__ No__	
207.2.5.10	Station-Busy Condition	5.3.7.2.5.10	203.2:M	Yes__ No__	
207.2.5.10.a	A station shall enter the busy condition on a data link connection when it is temporarily unable to receive or continue to receive I PDUs due to internal constraints	5.3.7.2.5.10	203.2:M	Yes__ No__	
207.2.5.10.b	When the station enters the busy condition, it shall send an RNR PDU at the first possible opportunity	5.3.7.2.5.10	203.2:M	Yes__ No__	
207.2.5.10.c	It shall be possible to send I PDUs waiting to be sent on that data link connection prior to or following the sending of the RNR PDU	5.3.7.2.5.10	203.2:M	Yes__ No__	

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207.2.5.10 .d	While in the busy condition, the station shall accept and process supervisory PDUs and return an RNR response PDU with the F-bit set to 1 if it receives an S or I command PDU with the P-bit set to 1 on the affected data link connection	5.3.7.2.5.10	203.2:M	Yes__ No__	
207.2.5.10 .e	To indicate the clearance of a busy condition on a data link connection, the station shall send an I response PDU with the F-bit set to 1 if a P-bit set to 1 is outstanding, an REJ response PDU, or an RR response PDU on the data link connection with N(R) set to the current V(R), depending on whether or not the station discarded information fields of correctly received I PDUs	5.3.7.2.5.10	203.2:M	Yes__ No__	
207.2.5.10 .f	The sending of a SABME command PDU or a UA response PDU shall indicate the clearance of a busy condition at the sending station on a data link connection	5.3.7.2.5.10	203.2:M	Yes__ No__	
207.2.5.11	Waiting Acknowledgment	5.3.7.2.5.11	203.2:M	Yes__ No__	
207.2.5.11 .a	The station maintains an internal retransmission count variable for each data link connection, which shall be set to 0 when the station receives or sends a UA response PDU to a SABME command PDU, when the station receives an RNR PDU, or when the station correctly receives an I or S PDU with the N(R) higher than the last received N(R) (actually acknowledging some outstanding I PDUs)	5.3.7.2.5.11	203.2:M	Yes__ No__	

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207.2.5.11 .b	If the acknowledgment timer, busy-state timer, or the P-bit timer runs out, the station on this data link connection shall enter the timer recovery condition and add 1 to its retransmission count variable	5.3.7.2.5.11	203.2:M	Yes__ No__	
207.2.5.11 .c	When a station is in the timer recovery condition, the station shall not send any new I PDUs to the destination station	5.3.7.2.5.11	203.2:M	Yes__ No__	
207.2.5.11 .d	The station shall then start the P-bit timer and send an S command PDU with the P-bit set to 1	5.3.7.2.5.11	203.2:M	Yes__ No__	
207.2.5.11 .e	The timer recovery condition shall be cleared on the data link connection when the station receives a valid I or S PDU from the remote station with the F-bit set to 1	5.3.7.2.5.11	203.2:M	Yes__ No__	
207.2.5.11 .f	If, while in the timer recovery condition, the station correctly receives a valid I or S PDU with one of the following:	5.3.7.2.5.11	203.2:M	Yes__ No__	
207.2.5.11 .f.1	The F-bit set to 1 and the N(R) within the range from the last value of N(R) received to the current V(S) inclusive, the station shall clear the timer recovery condition, set its V(S) to the received N(R), stop the P-bit timer, and resend any unacknowledged PDUs	5.3.7.2.5.11.a	207.2.5.11.f: O.<2>	Yes__ No__	
207.2.5.11 .f.2	The P/F bit set to 0 and the N(R) within the range from the last value of N(R) received to the current V(S) inclusive, the station shall not clear the timer recovery condition but shall treat the N(R) value received as an acknowledgment for the indicated previously transmitted I PDUs	5.3.7.2.5.11.b 5.3.7.2.5.5	207.2.5.11.f: O.<2>	Yes__ No__	

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207.2.5.11.g	If the P-bit timer runs out in the timer recovery condition, the station shall add 1 to its retransmission count variable	5.3.7.2.5.11	203.2:M	Yes__ No__	
207.2.5.11.h	If the retransmission count variable is less than N2, the station shall resend an S PDU with the P-bit set to 1 and restarts its P-bit timer	5.3.7.2.5.11 5.3.8.1.3.d	203.2:M	Yes__ No__	
207.2.5.11.i	If the retransmission count variable is equal to N2, the station shall initiate a resetting procedure, by sending a SABME command PDU	5.3.7.2.5.11 5.3.8.1.3.d 5.3.7.2.6	203.2:M	Yes__ No__	
207.2.6	Procedures for Mode Resetting	5.3.7.2.6	203.2:M	Yes__ No__	
207.2.6.a	The resetting phase shall apply only during ABM	5.3.7.2.6	203.2:M	Yes__ No__	
207.2.6.b	Either station shall be able to initiate a resetting of both directions by sending a SABME command PDU and starting its acknowledgment timer	5.3.7.2.6	203.2:M	Yes__ No__	
207.2.6.1	Receiver Action	5.3.7.2.6.1	203.2:M	Yes__ No__	
207.2.6.1.a	After receiving a SABME command PDU, the station shall return one of two types of responses, at the earliest opportunity: 5.3.7.2.6.1.a or 5.3.7.2.6.1.b	5.3.7.2.6.1	203.2:M	Yes__ No__	
207.2.6.1.a.1	A UA response PDU and reset its V(S) and V(R) to 0 to reset the data link connection	5.3.7.2.6.1.a	207.2.6.1.a:O.<2>	Yes__ No__	
207.2.6.1.a.2	A DM response PDU if the data link connection is to be terminated	5.3.7.2.6.1.b	207.2.6.1.a:O.<2>	Yes__ No__	
207.2.6.1.b	The return of the UA or DM response PDU shall take precedence over any other response PDU for that data link connection that may be pending at the station	5.3.7.2.6.1	203.2:M	Yes__ No__	

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207.2.6.1.c	It shall be possible to follow the UA PDU with additional PDUs, if pending	5.3.7.2.6.1	203.2:M	Yes__ No__	
207.2.6.2	Initiator Action	5.3.7.2.6.2	203.2:M	Yes__ No__	
207.2.6.2.a	If the UA PDU is received correctly by the initiating station, it shall reset its V(S) and V(R) to 0 and stop its acknowledgment timer	5.3.7.2.6.2	203.2:M	Yes__ No__	
207.2.6.2.b	This shall also clear all exception conditions that might be present at either of the stations involved in the reset	5.3.7.2.6.2	203.2:M	Yes__ No__	
207.2.6.2.c	The exchange shall also indicate clearance of any busy condition that may have been present at either station involved in the reset	5.3.7.2.6.2	203.2:M	Yes__ No__	
207.2.6.2.d	If a DM response PDU is received, the station shall enter the data link disconnected phase, shall stop its acknowledgment timer, and shall report to the higher layer for appropriate action	5.3.7.2.6.2	203.2:M	Yes__ No__	
207.2.6.2.e	If the acknowledgment timer runs out before a UA or DM response PDU is received, the SABME command PDU shall be resent and the acknowledgment timer shall be started	5.3.7.2.6.2	203.2:M	Yes__ No__	
207.2.6.2.f	After the timer runs out N2 times, the sending station shall stop sending the SABME command PDU, and shall enter the ADM, may report to the higher layer protocol and may initiate other error recovery actions	5.3.7.2.6.2 5.3.8.1.3.d	203.2:M	Yes__ No__	
207.2.6.2.g	Other Type 2 PDUs, with the exception of the SABME and DISC command PDUs, received by the station before completion of the reset procedure shall be discarded	5.3.7.2.6.2	203.2:M	Yes__ No__	

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207.2.6.3	Resetting with the FRMR PDU	5.3.7.2.6.3	203.2:M	Yes__ No__	
207.2.6.3.a	Under certain FRMR exception conditions, it shall be possible for the initiating station, by sending a FRMR response PDU, to ask the remote station to reset the data link connection	5.3.7.2.6.3 5.3.7.2.8	203.2:M	Yes__ No__	
207.2.6.3.b	Upon receiving the FRMR response PDU (even during a FRMR exception condition), the remote station shall either initiate a resetting procedure, by sending a SABME or RSET command PDU, or initiate a disconnect procedure, by sending a DISC command PDU	5.3.7.2.6.3	203.2:M	Yes__ No__	
207.2.6.3.c	After sending an FRMR response PDU, the initiating station shall enter the FRMR exception condition	5.3.7.2.6.3	203.2:M	Yes__ No__	
207.2.6.3.d	The FRMR exception condition shall be cleared when the station receives or sends a SABME or DISC command PDU, DM response PDU or RSET command PDU	5.3.7.2.6.3	203.2:M	Yes__ No__	
207.2.6.3.e	Any other Type 2 command PDU received while in the FRMR exception condition shall cause the station to resend the FRMR response PDU with the same information field as originally sent	5.3.7.2.6.3	203.2:M	Yes__ No__	
207.2.6.3.f	In the FRMR exception condition, additional I PDUs shall not be sent, and received I and S PDUs shall be discarded by the station	5.3.7.2.6.3	203.2:M	Yes__ No__	
207.2.6.3.g	It shall be possible for the station to start its acknowledgment timer on the sending of the FRMR response PDU	5.3.7.2.6.3	203.2:M	Yes__ No__	

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207.2.6.3.h	If the timer runs out before the reception of a SABME or DISC command PDU from the remote station, it shall be possible for the station to resend the FRMR response PDU and restart its acknowledgment timer	5.3.7.2.6.3	203.2:M	Yes__ No__	
207.2.6.3.i	After the acknowledgment timer has run out N2 times, the station shall reset the data link connection by sending a SABME command PDU	5.3.7.2.6.3 5.3.8.1.3.d	203.2:M	Yes__ No__	
207.2.6.3.j	When an additional FRMR response PDU is sent while the acknowledgment timer is running, the timer shall not be reset or restarted	5.3.7.2.6.3	203.2:M	Yes__ No__	
207.2.7	Procedures for Sequence Number Resetting	5.3.7.2.7	203.2:M	Yes__ No__	
207.2.7.a	The addressed station shall confirm acceptance of the RSET command by transmission of a UA response at the earliest opportunity	5.3.7.2.7	203.2:M	Yes__ No__	
207.2.7.b	Upon acceptance of this command, the addressed station V(R) shall be set to 0	5.3.7.2.7	203.2:M	Yes__ No__	
207.2.7.c	If the UA response is received correctly, the initialization station shall reset its V(S) to 0	5.3.7.2.7	203.2:M	Yes__ No__	
207.2.7.d	The RSET command shall reset all PDU rejection conditions in the addressed station, except for an invalid N(R) sequence number condition which the addressed station has reported by FRMR	5.3.7.2.7	203.2:M	Yes__ No__	
207.2.7.e	To clear an invalid N(R) frame rejection condition with an RSET command, the RSET command shall be transmitted by the station that detects the invalid N(R)	5.3.7.2.7	203.2:M	Yes__ No__	
207.2.8	FRMR Exception Conditions	5.3.7.2.8	203.2:M	Yes__ No__	

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207.2.8.a	The station shall request a resetting procedure by sending an FRMR response PDU, after receiving, during the information transfer phase, a PDU with one of the conditions identified in 5.3.6.2.3.6	5.3.7.2.8 5.3.7.2.6.3 5.3.6.2.3.6	203.2:M	Yes__ No__	
207.2.8.b	The other station shall initiate a resetting procedure by sending a SABME or RSET command PDU, after receiving the FRMR response PDU	5.3.7.2.8 5.3.7.2.6	203.2:M	Yes__ No__	
207.3	Description of Type 3 Procedures	5.3.7.3	M	Yes__ No__	
207.3.a	Stations will combine network status information (URR/URNR) for Type 1 and Type 3 communication procedures	5.3.7.3	M	Yes__ No__	
207.3.1	Modes of Operation	5.3.7.3.1	M	Yes__ No__	
207.3.1.a	A station using Type 3 procedures shall support the entire procedure set whenever it is operational on the network	5.3.7.3.1	M	Yes__ No__	
207.3.2	Procedure for Addressing	5.3.7.3.2	M	Yes__ No__	
207.3.2.a	The address fields shall be used to indicate the source and destinations of the transmitted PDU	5.3.7.3.2	M	Yes__ No__	
207.3.2.b	The first bit in the source address field shall be used to identify whether a command or a response is contained in the PDU	5.3.7.3.2	M	Yes__ No__	
207.3.2.c	Individual, group, special and global addressing shall be supported for destination addresses in command PDUs	5.3.7.3.2	M	Yes__ No__	
207.3.2.d	The source address field shall contain an individual or special address	5.3.7.3.2	M	Yes__ No__	
207.3.3	Procedure for Using the P/F Bit	5.3.7.3.3	M	Yes__ No__	

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207.3.3.a	The P-bit shall always be set to 1 for Type 3 communications.	5.3.7.3.3	M	Yes__ No__	
207.3.4	Procedures for Logical Data Link Set-up and Disconnection	5.3.7.3.4	M	Yes__ No__	
207.3.5	Procedures for Information Transfer	5.3.7.3.5	M	Yes__ No__	
207.3.5.1	Sending UI Command PDUs	5.3.7.3.5.1	M	Yes__ No__	
207.3.5.1.a	Information transfer from an initiating station to a responding station shall be accomplished by sending the UI command PDU	5.3.7.3.5.1	M	Yes__ No__	
207.3.5.1.b	When a sending station sends a UI command PDU with the P-bit set to 1, it shall start an acknowledgment timer for that transmission and initialize the internal transmission count variable to zero	5.3.7.3.5.1	M	Yes__ No__	
207.3.5.1.c	If all expected URR and URNR response PDUs are not received before the timer runs out, the sending station shall resend the UI command PDU, increment the internal transmission count variable, and restart the acknowledgment timer	5.3.7.3.5.1	M	Yes__ No__	
207.3.5.1.d	Prior to resending the UI command PDU, the group and global addresses shall be removed as well as individual and special addresses from which a response (URR or URNR) was received	5.3.7.3.5.1	M	Yes__ No__	
207.3.5.1.e	The special address 3, if used, shall not be removed prior to retransmission unless it is the only address remaining	5.3.7.3.5.1	M	Yes__ No__	
207.3.5.1.f	No retransmission shall be attempted unless an individual or special address other than 3 remains	5.3.7.3.5.1	M	Yes__ No__	

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207.3.5.1.g	If a URR response PDU is still not received, this resending procedure shall be repeated until the value of the internal transmission count variable is equal to the value of the logical link parameter N4, at which time a DL-Status-Indication shall be reported to the upper layer indicating an acknowledgment failure	5.3.7.3.5.1 5.3.8.1.4.c	M	Yes__ No__	
207.3.5.1.h	An internal transmission count shall be maintained for each UI information exchange (where P-bit = 1) between a pair of sending and receiving stations	5.3.7.3.5.1	M	Yes__ No__	
207.3.5.1.i	Both the acknowledgment timer and internal transmission count, for that exchange, shall not affect the information exchange with other receiving stations	5.3.7.3.5.1	M	Yes__ No__	
207.3.5.1.j	If a URNR response PDU is received in response to a UI command with the P-bit set to 1, the receiving station shall designate the sending station as busy	5.3.7.3.5.1	M	Yes__ No__	
207.3.5.1.k	The retransmission of the UI command shall follow the rules for the busy condition	5.3.7.3.5.1	M	Yes__ No__	
207.3.5.1.l	Transmission of the UI commands to that station shall be discontinued until the busy state is cleared	5.3.7.3.5.1	M	Yes__ No__	
207.3.5.2	Receiving UI Command PDUs	5.3.7.3.5.2	M	Yes__ No__	
207.3.5.2.a	A station shall acknowledge the receipt of a valid UI command PDU, which has the P-bit set to 1 and contains the station individual address, by sending a URR response PDU to the originator of the command UI PDU	5.3.7.3.5.2	M	Yes__ No__	

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207.3.5.2. b	If the receiving station is unable to accept UI PDUs due to a busy condition, it may respond with a URNR response PDU	5.3.7.3.5.2	O	Yes__ No__	
207.3.5.3	Sending URR Response PDUs	5.3.7.3.5.3	M	Yes__ No__	
207.3.5.3. a	A URR response PDU, with the F-bit set to 1, shall be sent only upon receipt of a UI command PDU, with the P-bit set to 1	5.3.7.3.5.3	M	Yes__ No__	
207.3.5.3. b	The URR response PDU shall be sent to the originator of the associated UI command PDU	5.3.7.3.5.3	M	Yes__ No__	
207.3.5.4	Sending URNR Response PDUs	5.3.7.3.5.4	206.1.9:M	Yes__ No__	
207.3.5.4. a	A URNR response PDU, with the F-bit set to 1, may be sent by the remote station to advise the originator of the associated UI command PDU that it is experiencing a busy condition and is unable to accept UI PDUs	5.3.7.3.5.4	O	Yes__ No__	
207.3.5.5	Receiving UI Acknowledgment	5.3.7.3.5.5	M	Yes__ No__	
207.3.5.5. a	After sending a UI command PDU with the P-bit set to 1, the sending station shall expect to receive an acknowledgment in the form of a URR response PDU from the station to which the command PDU was sent	5.3.7.3.5.5	M	Yes__ No__	
207.3.5.5. b	No acknowledgment shall be expected from group or global addresses or from the special address 3	5.3.7.3.5.5	M	Yes__ No__	
207.3.5.5. c	Upon receiving such a response PDU, the station shall stop the acknowledgment timer associated with the transmission for which the acknowledgment was received and reset the associated internal transmission count to zero	5.3.7.3.5.5	M	Yes__ No__	

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207.3.5.6	Using TEST Command and Response PDUs	5.3.7.3.5.6	M	Yes__ No__	
207.3.5.6.a	Any TEST command PDU received in error shall be discarded and no response PDU sent	5.3.7.3.5.6	M	Yes__ No__	
207.3.5.6.b	In the event of a test failure, it shall be the responsibility of the TEST function initiator to determine any future actions	5.3.7.3.5.6	M	Yes__ No__	
207.4	Description of Type 4 Procedures	5.3.7.4	203.4:M	Yes__ No__	
207.4.1	Modes of Operation	5.3.7.4.1	203.4:M	Yes__ No__	
207.4.1.a	A station using Type 4 procedures shall support the entire set whenever it is operational on the network	5.3.7.4.1	203.4:M	Yes__ No__	
207.4.2	Procedure for Addressing	5.3.7.4.2	203.4:M	Yes__ No__	
207.4.2.a	The address field shall be used to indicate the source and destinations of the transmitted PDU	5.3.7.4.2	203.4:M	Yes__ No__	
207.4.2.b	The first bit in the source address shall be used to identify whether a command or a response is contained in the PDU	5.3.7.4.2	203.4:M	Yes__ No__	
207.4.2.c	Individual, group, and global addressing shall be supported for the destination addresses in command PDUs	5.3.7.4.2	203.4:M	Yes__ No__	
207.4.2.d	The source address shall contain an individual address	5.3.7.4.2	203.4:M	Yes__ No__	
207.4.3	Procedure for Using the P/F Bit	5.3.7.4.3	X	---	
207.4.4	Procedures for Logical Data Link Set-up and Disconnection	5.3.7.4.4	203.4:M	Yes__ No__	
207.4.4.a	All stations shall advance to the information transfer state	5.3.7.4.4	203.4:M	Yes__ No__	
207.4.5	Procedures for Information Transfer	5.3.7.4.5	203.4:M	Yes__ No__	
207.4.5.1	Sending DIA Command Frames	5.3.7.4.5.1	203.4:M	Yes__ No__	
207.4.5.2	DRNR Procedure	5.3.7.4.5.2	203.4:M	Yes__ No__	

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207.4.5.2.1	Sending DRNR Command PDU	5.3.7.4.5.2.1	203.4:M	Yes__ No__	
207.4.5.2.2	Receiving DRNR Command PDU	5.3.7.4.5.2.2	203.4:M	Yes__ No__	
207.4.5.2.2.a	Upon receipt of a DRNR PDU a station shall, with one exception described below, inhibit transmission of DIA PDUs to the station which originated the DRNR command by updating the station status table to reflect this busy condition. **EXCEPTION**: A station may include a busy destination in a PDU that is addressed to multiple destination addresses if at least one of the multiple destinations is not busy	5.3.7.4.5.2.2	203.4:M	Yes__ No__	
207.4.5.2.2.b	The DRNR PDU shall not change the Quiet Mode status of a station	5.3.7.4.5.2.2	203.4:M	Yes__ No__	
207.4.5.2.2.c	Any PDUs in the retransmission queue addressed to the busy station shall be modified to delete (null) the busy station from the destination address list	5.3.7.4.5.2.2	203.4:M	Yes__ No__	
207.4.5.2.2.d	Normal transmission of DIA PDUs to that station shall resume upon receipt of a DRR command from the station	5.3.7.4.5.2.2	203.4:M	Yes__ No__	
207.4.5.2.3	Sending DRNR Response PDU	5.3.7.4.5.2.3	203.4:M	Yes__ No__	
207.4.5.2.3.a	A station shall generate and transmit a DRNR response PDU after it has sent a DRNR command PDU (if its Quiet Mode is disabled) while it is processing frames in its receive queues in the busy condition	5.3.7.4.5.2.3	203.4:M	Yes__ No__	
207.4.5.2.4	Receiving DRNR Response PDU	5.3.7.4.5.2.4	203.4:M	Yes__ No__	

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207.4.5.2.4.a	Upon receipt of a DRNR response PDU, a station shall search the destination addresses associated with the identification number in the DRNR response PDU	5.3.7.4.5.2.4	203.4:M	Yes__ No__	
207.4.5.2.4.b	The response PDU originator's address shall be deleted from the destination address field (if it is still there) of the DIA being acknowledged	5.3.7.4.5.2.4	203.4:M	Yes__ No__	
207.4.5.3	DRR Procedures	5.3.7.4.5.3	203.4:M	Yes__ No__	
207.4.5.3.1	Sending a DRR PDU	5.3.7.4.5.3.1	203.4:M	Yes__ No__	
207.4.5.3.1.a	A station shall generate and transmit a DRR PDU if its Quiet Mode is disabled and one of the following conditions exist:	5.3.7.4.5.3.1	203.4:M	Yes__ No__	
207.4.5.3.1.a.1	The station is no longer busy and had previously sent a DRNR command PDU	5.3.7.4.5.3.1.a	207.3.5.3.1.a: O.<3>	Yes__ No__	
207.4.5.3.1.a.2	The station is not busy and the station received a DIA PDU from a transmitting station which requires acknowledgment	5.3.7.4.5.3.1.b	207.3.5.3.1.a: O.<3>	Yes__ No__	
207.4.5.3.1.a.3	If directed by the user interface	5.3.7.4.5.3.1.c	207.3.5.3.1.a: O.<3>	Yes__ No__	
207.4.5.3.1.1	Sending a DRR Command PDU	5.3.7.4.5.3.1.1	203.4:M	Yes__ No__	
207.4.5.3.1.2	Sending a DRR Response PDU	5.3.7.4.5.3.1.2	203.4:M	Yes__ No__	
207.4.5.3.2	Receiving DRR Response PDU	5.3.7.4.5.3.2	203.4:M	Yes__ No__	
207.4.5.3.2.a	Upon receipt of a DRR response PDU a station shall search the destination addresses associated with the identification number in the DRR response PDU	5.3.7.4.5.3.2	203.4:M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
207.4.5.3.2.b	The DRR response PDU originator's address shall be deleted from the destination address field of the DIA being acknowledged	5.3.7.4.5.3.2	203.4:M	Yes__ No__	

A.5.8 Data Link Initialization.

Item	Protocol Feature	Reference	Status	Support	Notes
208	Data Link Initialization	5.3.8	M	Yes__ No__	
208.a	The Join Request is sent to the default NETCON destination address, which shall be the station assigned to perform NETCON station responsibilities	5.3.8	O	Yes__ No__	
208.1	List of Data Link Parameters	5.3.8.1	M	Yes__ No__	
208.1.a	The maximum number of octets in the information field of a UI, I or DIA PDU is an adjustable data link parameter in the range of 708 – 3345	5.3.8.1.1	M	Yes__ No__	
208.1.1	Type 1 Logical Data Link Parameters	5.3.8.1.2	M	Yes__ No__	
208.1.1.a	The logical data link parameters for Type 1 operation shall be as follows:	5.3.8.1.2	M	Yes__ No__	
208.1.1.a.1	The busy-state timer is a data link parameter that defines the time interval following receipt of the URNR command PDU during which the station shall wait for the other station to clear the busy condition. Default value is 120 seconds.	5.3.8.1.2.a	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
208.1.1.a.2	The minimum-length valid data link PDU shall contain 2 flags, 2 addresses, one 8-bit control field, and the FCS. The minimum number of octets in a valid data link PDU shall be 9.	5.3.8.1.2.b	M	Yes__ No__	
208.1.1.a.3	If the TTTL time expires and the TEST Response frame has not been transmitted then the TEST Response frame shall be deleted from the queue.	5.3.8.1.2.c	M	Yes__ No__	
208.1.1.a.4	A value of 0 indicates that the message shall not time out (see E.4.3.3).	5.3.8.1.2.c	M	Yes__ No__	
208.1.2	Type 2 Logical Data Link Parameters	5.3.8.1.3	203.2:M	Yes__ No__	
208.1.2.a	The logical data link connection parameters for Type 2 operation shall be as follows:	5.3.8.1.3	208.1.2:M	Yes__ No__	
208.1.2.a.1	The acknowledgment timer is a data link connection parameter that shall define the time interval during which the station shall expect to receive acknowledgment to one or more outstanding I PDUs or an expected response to a sent U command PDU. The acknowledgment timer should not be activated until the corresponding PDU has been transmitted. Time values are established at protocol initialization and are in the range of 10 to 1800 seconds in one-second increments. Default is 120 seconds.	5.3.8.1.3.a	203.2:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
208.1.2.a.2	The P-bit timer is a data link connection parameter that defines the time interval during which the station shall expect to receive a frame with the F-bit set to 1 in response to a sent Type 2 command with the P-bit set to 1. The P-bit timer should not be activated until the corresponding PDU has been transmitted. Time values are established at protocol initialization and are in the range of 10 to 60 seconds in increments of 1 second. Default is 10 seconds.	5.3.8.1.3.b	203.2:M	Yes__ No__	
208.1.2.a.3	The REJ timer is a data link connection parameter that defines the time interval during which the station shall expect to receive a reply to a sent REJ or SREJ PDU. The REJ timer value shall be equal to or less than twice the acknowledgment timer. The REJ timer should not be activated until the corresponding PDU has been transmitted.	5.3.8.1.3.c	203.2:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
208.1.2.a.4	N2 is a data link connection parameter that indicates the maximum number of times that a PDU (including the S command PDU that is sent as a result of the acknowledgment P-bit or REJ timer expiring) is sent, following the running out of the acknowledgment timer, the P-bit timer, or the REJ timer. The maximum number of times that a PDU is retransmitted following the expiration of the timers is established at protocol initialization. This value is in the range of 0 through 5 and defaults to 2. The retransmission of PDUs may be overridden by the Quiet Mode parameter, which is described in 5.3.11.2.	5.3.8.1.3.d 5.3.11.2	203.2:M	Yes__ No__	
208.1.2.a.5	The maximum number (*k*) of sequentially numbered I PDUs that the sending station may have outstanding (i.e. unacknowledged) on a single data link connection simultaneously. The value of this parameter is in the range 1 through 127. (This value of this parameter may be established through the use of the Type 2 *k* Window field of an XNP message as described in APPENDIX E, "Type 2 Parameters".)	5.3.8.1.3.e APPENDIX E	203.2:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
208.1.2.a.6	The maximum number (*k2*) of outstanding (i.e. unacknowledged) I PDUs that can be sent by a source station on a data link connection before the station requests acknowledgment. When this threshold is reached the sending station sends an S PDU that both acknowledges received I frames and causes an S PDU to be sent in return to acknowledge outstanding I PDUs. The value of this parameter is in the range 1 through 127, but would normally be less than or equal to the value of parameter *k*.	5.3.8.1.3.f	203.2:M	Yes__ No__	
208.1.2.a.7	The maximum number (*k3*) of correct in sequence I PDUs received on a data link connection since the last I PDU received on the data link connection was acknowledged. When this threshold is reached the receiving station generates an S PDU to acknowledge received frames. The value of this parameter is in the range 1 through 127, but would normally be less than or equal to the value of parameter *k*.	5.3.8.1.3.g	203.2:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
208.1.2.a.8	The amount of time, as a percent of Type 2 Acknowledgment Timer seconds, that a station waits after an I PDU Response or an I PDU Command with its P-bit set to 0 is received until it is acknowledged by transmission of an S PDU in the case that no other frames are available for transmission. The value of this parameter is in the range of 0 - 99%. (The value of this parameter may be established by the Type 2 Acknowledgment Timer and Response Timer fields of an XNP Parameter Update message as described in APPENDIX E, “Type 2 Parameters” or from the Protocol Parameters Table.)	5.3.8.1.3.h APPENDIX E	203.2:M	Yes__ No__	
208.1.2.a.9	A minimum-length valid data link PDU shall contain exactly 2 flags, 2 address fields, 1 control field and the FCS. Thus, the minimum number of octets in a valid data link PDU shall be 9 or 10, depending on whether the PDU is a U PDU, or an I or S PDU, respectively.	5.3.8.1.3.i	203.2:M	Yes__ No__	
208.1.3	Type 3 Logical Data Link Parameters	5.3.8.1.4	M	Yes__ No__	
208.1.3.a	The logical data link parameters for Type 3 operation shall be as follows:	5.3.8.1.4	M	Yes__ No__	
208.1.3.a.1	The acknowledgment timer is a data link parameter that shall define the timeout period (TP) during which the sending station shall expect an acknowledgment from a specified destination station. The acknowledgment timer should not be activated until the corresponding PDU has been transmitted.	5.3.8.1.4.a	M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
208.1.3.a.2	TP shall take into account any delay introduced by the physical sublayer. The value of TP is described in APPENDIX C (C.4.3).	5.3.8.1.4.a C.4.3	M	Yes__ No__	
208.1.3.a.3	The busy-state timer is a data link parameter that defines the time interval following receipt of the URNR command PDU during which the station shall wait for the other station to clear the busy condition. Default value is 120 seconds.	5.3.8.1.4.b	M	Yes__ No__	
208.1.3.a.4	N4 is a data link parameter that indicates the maximum number of times that an UI or TEST command PDU is retransmitted by a station trying to accomplish a successful information exchange. Normally, N4 is set large enough to overcome the loss of a PDU due to link error conditions. The maximum number of times that a PDU is retransmitted following the expiration of the acknowledgment timer is established at protocol initialization. This value is in the range of 0 through 5 and defaults to 2. The retransmission of PDUs may be overridden by the Quiet Mode parameter, which is described in 5.3.11.2.	5.3.8.1.4.c 5.3.11.2	M	Yes__ No__	
208.1.3.a.5	The minimum-length valid data link PDU shall contain 2 flags, 2 addresses, one 8-bit control field, and the FCS. The minimum number of octets in a valid data link PDU shall be 9.	5.3.8.1.4.d	M	Yes__ No__	
208.1.4	Type 4 Logical Data Link Parameters	5.3.8.1.5	203.4:M	Yes__ No__	
208.1.4.a	The logical data link parameters for Type 4 operation shall be as follows:	5.3.8.1.5	208.1.3:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
208.1.4.a.1	The T1 timer is the maximum time a station shall wait for an acknowledgment of a transmitted DIA PDU before that PDU is retransmitted	5.3.8.1.5.a	203.4:M	Yes__ No__	
208.1.4.a.2	The value of T1 shall be in the range of 5-120 seconds in increments of 0.2 seconds	5.3.8.1.5.a	203.4:M	Yes__ No__	
208.1.4.a.3	Each DIA PDU transmitted shall be assigned a T1 timer	5.3.8.1.5.a	203.4:M	Yes__ No__	
208.1.4.a.4	When the T1 timer expires for DIA PDU, that DIA PDU shall be retransmitted in the next transmission opportunity for that precedence, assuming the N2 count has not been reached	5.3.8.1.5.a	203.4:M	Yes__ No__	
208.1.4.a.5	DIA PDUs with only one destination will be discarded if the destination replied with a DRNR or DRR response PDU	5.3.8.1.5.a	203.4:M	Yes__ No__	
208.1.4.a.6	If the DIA PDU is multi-addressed, the receive station is removed (nulled) from the destination address field	5.3.8.1.5.a	203.4:M	Yes__ No__	
208.1.4.a.7	This timer shall be paused whenever the net is busy with voice. This timer is resumed when voice transmission has completed.	5.3.8.1.5.a	203.4:M	Yes__ No__	
208.1.4.a.8	The N2 parameter shall indicate the maximum number of retransmission attempts to complete the successful transmission of a DIA PDU	5.3.8.1.5.b	203.4:M	Yes__ No__	
208.1.4.a.9	The value of N2 shall be the maximum retransmit value (range = 0-5)	5.3.8.1.5.b	203.4:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
208.1.4.a.10	The value of *k* indicates the maximum number of DIA PDUs that a station may have outstanding (awaiting acknowledgment) to all stations at any given time. The value of *k* ranges from 5 - 20 DIA PDUs.	5.3.8.1.5.c	203.4:M	Yes__ No__	
208.1.4.a.11	A minimum-length valid data link PDU shall contain exactly 2 flags, 2 address fields, one (1) 16-bit control field, and the FCS	5.3.8.1.5.d	203.4:M	Yes__ No__	
208.1.4.a.12	The minimum number of octets in a valid data link PDU shall be 10	5.3.8.1.5.d	203.4:M	Yes__ No__	
208.1.4.a.13	The number of Type 4 DIA frames remembered in the list used to detect and discard duplicates. The number in the list can range from 0 - 255. The value of "0" is used to turn off this detect capability.	5.3.8.1.5.e	203.4:M	Yes__ No__	

A.5.9 Frame Transfer.

Item	Protocol Feature	Reference	Status	Support	Notes
209	Frame Transfer	5.3.9	M	Yes__ No__	
209.a	The data link layer shall request the transmission of a frame by the PL	5.3.9	M	Yes__ No__	
209.1	PDU Transmission	5.3.9.1	M	Yes__ No__	
209.1.a	PDUs shall be queued for transmission in such a manner that the highest precedence PDUs are transmitted before lower precedence PDUs	5.3.9.1	M	Yes__ No__	
209.1.b	If a prioritized net access scheme is active, the precedence access level used shall be the precedence of the PDU that is to be transmitted next	5.3.9.1	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
209.1.c	Transmission units of the same precedence shall be in FIFO order	5.3.9.1	M	Yes__ No__	
209.1.d	Type 2 I PDUs for a particular connection shall be transmitted in the order of their sequence numbers	5.3.9.1	203.2:M	Yes__ No__	
209.2	Data Link Concatenation	5.3.9.2	M	Yes__ No__	
209.2.a	All receiving stations shall be able to de-concatenate the reception into separate PDUs	5.3.9.2	M	Yes__ No__	
209.2.b	Data link concatenation to add another interior data frame shall not be performed if the resulting frame would take longer to transmit than the maximum transmit time allowed for the network	5.3.9.2	M	Yes__ No__	
209.3	Physical Layer Concatenation	5.3.9.3	O	Yes__ No__	
209.3.a	The time to transmit the combined length of the transmission frame, shall not exceed the maximum transmit time allowed for the network	5.3.9.3	O	Yes__ No__	
209.3.b	The PL shall transmit each transmission unit following the complete PL procedures with no additional bits between Interior Transmission Units (except for bit synchronization when used in Asynchronous Mode)	5.3.9.3	O	Yes__ No__	
209.3.c	Note that the Phasing field shall precede the first Interior Transmission Unit only	5.3.9.3 5.2.1.2	O	Yes__ No__	
209.4	PDU Transmissions	5.3.9.4	M	Yes__ No__	
209.4.a	The PDU that did not allow concatenation shall be at the head of its appropriate queue for the next net access period	5.3.9.4	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
209.4.b	If the first PDU in the highest precedence level queue (or only queue) does not allow concatenation, it shall be the only PDU transmitted in that net access period	5.3.9.4	M	Yes__ No__	

A.5.10 Flow Control.

Item	Protocol Feature	Reference	Status	Support	Notes
210	Flow Control	5.3.10	M	Yes__ No__	
210.1.a	Stations will correlate Flow Control information for Type 1 and Type 3 communications	5.3.10.1	M	Yes__ No__	
210.1	Type 1 Flow Control	5.3.10.1	M	Yes__ No__	
210.2	Type 2 Flow Control	5.3.10.2	203.2:M	Yes__ No__	
210.2.a	The maximum number (k) of sequentially numbered I PDUs that may be outstanding (that is, unacknowledged) at any given time is a data link connection parameter, which shall never exceed 127	5.3.10.2	203.2:M	Yes__ No__	
210.3	Type 3 Flow Control	5.3.10.3	M	Yes__ No__	
210.3.a	Stations will correlate Flow Control information for Type 1 and Type 3 communications	5.3.10.3	M	Yes__ No__	
210.4	Type 4 Flow Control	5.3.10.4	203.4:M	Yes__ No__	

A.5.11 Acknowledgment and Response.

Item	Protocol Feature	Reference	Status	Support	Notes
211	Acknowledgment and Response	5.3.11	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
211.a	All UI, DIA or I PDUs that require an acknowledgment shall be acknowledged except for the following cases:	5.3.11	203.3:M 203.2:M 203.4:M	Yes__ No__ Yes__ No__ Yes__ No__	
211.a.1	The control field of the received PDU specifies that no acknowledgment is required	5.3.11.a	203.3:M 203.2:M 203.4:M	Yes__ No__ Yes__ No__ Yes__ No__	
211.a.2	The Quiet Mode (described in 5.3.11.2), has been set to ON	5.3.11.b 5.3.11.2	203.3:M 203.2:M 203.4:M	Yes__ No__ Yes__ No__ Yes__ No__	
211.a.3	The receiving station is a group (including global) addressee only	5.3.11.c	203.3:M 203.2:M 203.4:M	Yes__ No__ Yes__ No__ Yes__ No__	
211.a.4	The receiving station's individual address is not in the address field	5.3.11.d	203.3:M 203.2:M 203.4:M	Yes__ No__ Yes__ No__ Yes__ No__	
211.a.5	The PDU is invalid	5.3.11.e	203.3:M 203.2:M 203.4:M	Yes__ No__ Yes__ No__ Yes__ No__	
211.1	Acknowledgment	5.3.11.1	M	Yes__ No__	
211.1.1	Type 3 Acknowledgment	5.3.11.1.1	M	Yes__ No__	
211.1.1.a	Each Type 3 PDU, shall be responded to before another PDU is transmitted	5.3.11.1.1	M	Yes__ No__	
211.1.1.b	All Type 3 UI and TEST command PDUs shall be acknowledged	5.3.11.1.1	M	Yes__ No__	
211.1.1.c	The RHD procedures shall be followed by all stations on the network to allow each responding station an interval in which they can transmit their response	5.3.11.1.1 C.4.2	M	Yes__ No__	
211.1.2	Type 2 Acknowledgment	5.3.11.1.2	203.2:M	Yes__ No__	
211.1.2.a	Type 2 PDUs that require acknowledgment shall activate the acknowledgment timer	5.3.11.1.2	203.2:M	Yes__ No__	
211.1.3	Type 4 Acknowledgment	5.3.11.1.3	203.4:M	Yes__ No__	
211.1.3.a	The DIA PDU shall activate the acknowledgment timer	5.3.11.1.3	203.4:M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
211.2	Quiet Mode	5.3.11.2	M	Yes__ No__	
211.2.a	The protocol shall allow an operator to initiate Quite Mode as an override feature that, when invoked, prevents any transmission (including retransmission) without explicit permission from the operator	5.3.11.2	M	Yes__ No__	
211.2.b	As a security feature, the operator shall be able to turn off automatic transmission but still continue to receive	5.3.11.2	M	Yes__ No__	
211.2.c	Normal protocol exchange shall occur when the Quiet Mode is OFF	5.3.11.2	M	Yes__ No__	
211.2.d	The Quiet Mode shall override the Maximum Number of Retransmissions data link parameters	5.3.11.2	M	Yes__ No__	
211.2.e	UI, I or DIA PDUs received by a station with Quiet Mode ON shall be serviced in the normal way except nothing will be returned nor queued for later transmission	5.3.11.2	M	Yes__ No__	
211.3	Immediate Retransmission	5.3.11.3	O	Yes__ No__	
211.3.a	The sending station shall not include the special address 3 in its TP calculation and shall schedule any necessary retransmissions during the longer TP experienced by other stations	5.3.11.3	O	Yes__ No__	

A.5.12 Invalid Frame.

Item	Protocol Feature	Reference	Status	Support	Notes
212	Invalid Frame	5.3.12	M	Yes__ No__	
212.a	A frame is invalid if it has one or more of the following characteristics:	5.3.12	M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
212.a.1	Frame not bounded by a beginning and ending flag	5.3.12.a	M	Yes__ No__	
212.a.2	Frame is too short if it is < 9 bytes	5.3.12.b	M	Yes__ No__	
212.a.3	Frame is too long if it is > the maximum PDU length	5.3.12.c 5.3.8.1.1.a	M	Yes__ No__	
212.a.4	Frame has an invalid address or control field	5.3.12.d	M	Yes__ No__	
212.a.5	Frame has an FCS error	5.3.12.e	M	Yes__ No__	
212.b	Any invalid frame shall be discarded	5.3.12	M	Yes__ No__	

A.5.13 Retransmission.

Item	Protocol Feature	Reference	Status	Support	Notes
213	Retransmission	5.3.13	M	Yes__ No__	
213.a	The default number of retransmissions is 2, but the data link layer protocol may be initialized to automatically retransmit 0 to 5 times	5.3.13	M	Yes__ No__	
213.b	If the Quiet Mode is ON, no automatic retransmissions shall be made	5.3.13	M	Yes__ No__	

A.5.14 Error Detection and Correction.

Item	Protocol Feature	Reference	Status		Support		Notes
214	Error Detection and Correction	5.3.14	102.1.3.1:M 102.1.3.2:M 102.1.3.3:X		Yes__ No__ Yes__ No__ No		
214.a	If selected, the FEC process shall be used to encode the data link frame of 5.3.4	5.3.14 5.3.4	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.b	If selected, the TDC process shall be applied to the FEC-encoded data link frame and to the fill bits	5.3.14	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	

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Item	Protocol Feature	Reference	Status		Support		Notes
214.c	Three modes of EDC shall be supported: FEC OFF, FEC ON with TDC, and FEC ON without TDC (NOTE: FEC ON without TDC may be used when the transmission channel provides the TDC capability)	5.3.14	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.1	Forward-Error-Correction Coding (not used in packet mode)	5.3.14.1	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.1.a	When FEC is selected, the Golay (24,12) cyclic block code, described in detail in APPENDIX F, shall be used for FEC	5.3.14.1 APPENDIX F	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.1.b	The generator polynomial to obtain the 11 check bits shall be $g(x) = x^{11} + x^{10} + x^6 + x^5 + x^4 + x^2 + 1$ where g(x) is a factor of $x^{23} + 1$	5.3.14.1	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.2	FEC Preprocessing	5.3.14.2	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.2.a	When FEC is selected, data bits shall be divided into a sequence of 12-bit segments for Golay encoding	5.3.14.2	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.2.b	The total number of 12-bit segments shall be an integral number	5.3.14.2	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.2.c	If FEC/TDC is selected and a coupled acknowledgment of Type 3 URR, URNR and TEST Response frames with their F-bit set is being transmitted, the coupled acknowledgment frame shall be duplicated and then data link concatenated to the end of the original coupled acknowledgment frame. This shall not be applied when the four octets addressing, described in 5.3.4.2.2.1.2, is used.	5.3.14.2	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	

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Item	Protocol Feature	Reference	Status		Support		Notes
214.2.d	If the data bits do not divide into an integral number of 12-bit segments, after coupled acknowledgment duplication (as appropriate), then from 1 to 11 zeros (0's) shall be added at the end to form an integral number of 12-bit segments	5.3.14.2	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.3	Time-Dispersive Coding	5.3.14.3	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.3.a	When TDC is selected, data shall be formatted into a sequence of TDC blocks composed of sixteen 24-bit Golay (24,12) codewords (that is, there are 384 FEC-encoded bits per TDC block)	5.3.14.3	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.3.b	Each TDC block shall contain a total of 16 FEC codewords	5.3.14.3	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.3.c	If the last TDC block of a message contains less than 16 FEC codewords, fill codewords shall be added to complete the TDC block	5.3.14.3	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.3.d	These 24-bit fill codewords shall be created by Golay-encoding an alternating sequence of 12-bit data words, with the first word composed of 12 ones followed by a word composed of 12 zeros	5.3.14.3	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.3.e	The fill codewords shall alternate until the TDC block is filled	5.3.14.3	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.3.f	The TDC block shall be structured into a 16 x 24 matrix (the Golay codewords appear as rows)	5.3.14.3	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.3.g	Each TDC block matrix shall be rotated to form a 24 x 16 matrix	5.3.14.3	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.3.h	At the receiver, the TDC-encoded bit stream shall be structured into a 24 x 16 matrix	5.3.14.3	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	

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Item	Protocol Feature	Reference	Status		Support		Notes
214.3.i	Each received TDC block matrix shall be rotated to form the original 16 x 24 matrix	5.3.14.3	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	
214.3.j	The TDC decoder at the receiver shall perform the inverse of the TDC encoding process	5.3.14.3	Send: 214:O	Recv: 214: M	Send: Yes__ No__	Recv: Yes__ No__	

A.5.15 Data Scrambling.

Item	Protocol Feature	Reference	Status	Support	Notes
215	Data Scrambling	5.3.15	102.1.3.1:O 102.1.3.2:O 102.1.3.3:X	Yes__ No__ Yes__ No__ No	
215.a	Data scrambling shall be performed if the transmission medium does not have a DC response and there is the possibility that "long" strings of the NRZ ones and zeros are transmitted	5.3.15	215:M	Yes__ No__	
215.b	CCITT V.36 scrambling shall not be applied outside the FEC because bit errors at the receiver will be extended	5.3.15.b	215:M	Yes__ No__	
215.c	If CCITT V.36 scrambling/descrambling is used, the contents of the 20-state shift register shall be initialized to all ones prior to scrambling or descrambling data link frames in each interior transmission unit	5.3.15.b	O	Yes__ No__	
215.d	The adverse state detector (ASD) counter shall be initialized such that at least 32-bits will have been counted, starting from the first bit input to the 20-state shift register, when the first adverse state is detected	5.3.15.b	O	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
215.e	The operation of the scrambling/descrambling shall be as shown	5.3.15.b	O	Yes__ No__	

A.5.16 Data Link Layer Interactions.

Item	Protocol Feature	Reference	Status	Support	Notes
216	Data Link Layer Interactions	5.3.16	O	Yes__ No__	
216.a	DL Unitdata Request parameters	5.3.16.a	O	Yes__ No__	
216.b.1	DL-Unitdata Indication parameters	5.3.16.b	O	Yes__ No__	
216.b.2	DL-Status Indication parameters	5.3.16.b	O	Yes__ No__	
216.b.3	DL-Maximum Data Link Transmission Unit Indication	5.3.16.b	O	Yes__ No__	
216.b.4	DL-Address Indication	5.3.16.b	O	Yes__ No__	
216.c.1	Topology Update ID, in a DL-Unitdata Request, shall contain the most recent Topology Update ID sent from the upper layer	5.3.16.c(4)	O	Yes__ No__	
216.c.2	Topology Update ID, in a DL-Unitdata Indication, shall contain the Topology Update Identifier field from the Transmission Header	5.3.16.c(4)	O	Yes__ No__	
216.c.3	Precedence levels shall be mapped to the Intranet Sublayer of the Network Layer as shown in TABLE VIII	5.3.16.c(5)(a)	O	Yes__ No__	
216.c.4	Data Length parameter values that are larger than MDLTU shall be failed with the corresponding DL-Status Indication reflecting whether or not the message was transmitted as appropriate.	5.3.16.c(10)	O	Yes__ No__	
216.c.5	MDLTU values contained in the MIL-STD-188-220D Parameter Table shall be used when applicable for a specific net configuration.	5.3.16.c(10)	O	Yes__ No__	

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A.6 Network Layer DPRL.

Item	Protocol Feature	Reference	Status	Support	Notes
301	Intranet Protocol	5.4.1	M	Yes__ No__	
302	Subnetwork Dependent Convergence Function (SNDCF)	5.4.2	M	Yes__ No__	

A.6.1 Intranet Protocol.

Item	Protocol Feature	Reference	Status	Support	Notes
301	Intranet Protocol	5.4.1	M	Yes__ No__	
301.1	Intranet Header	5.4.1.1	M	Yes__ No__	
301.1.a	The Version Number, Message Type, Intranet Header Length (HLEN) and Type of Service (TOS) fields compose the mandatory fields of the Intranet Header and shall be present in the Intranet Header of all Intranet Data Packets	5.4.1.1	M	Yes__ No__	
301.1.b	When optional Intranet Fragmentation/Reassembly is utilized, the Message Identification Number, Total Number of Fragments, and Fragment Number fields shall be present in addition to the mandatory fields, and any other optional fields in use.	5.4.1.1	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
301.1.c	When optional Intranet Relaying is being utilized the Message Identification Number, Maximum Hop Count, Originator Address, and one to many Destination/Relay Status and Destination/Relay Address fields shall be present in the Intranet Header as appropriate based on the topology of the network in addition to the mandatory fields, and any other optional fields in use	5.4.1.1	M	Yes__ No__	
301.1.d	The Intranet Header and any associated data contained in the IL Data Packet shall be exchanged using Data Link Layer UI, I, and/or DIA PDUs	5.4.1.1	M	Yes__ No__	
301.1.1	Version Number	5.4.1.1.1	M	Yes__ No__	
301.1.1.a	The version number shall indicate which version of the intranet protocol is being used. The value of the Version Number for MIL-STD-188-220D shall be 1.	5.4.1.1.1	M	Yes__ No__	
301.1.1.b	Received IL PDUs with a Version field value that is not equal to 1 shall be discarded by MIL-STD-188-220D stations and an IL-Error Indication shall be generated indicating that an invalid Version field value was received, IL PDU source/originator, the Message Type, and the bad Version field value (which should be 0).	5.4.1.1.1	M	Yes__ No__	
301.1.2	Message Types	5.4.1.1.2	M	Yes__ No__	
301.1.2.a	MIL-STD-188-220 compliant systems shall support the upper layer interactions indicated in the message type field for transmit and receive as indicated in TABLE X	5.4.1.1.2	M	Yes__ No__	
301.1.2.b	Intranet Acknowledgment shall be message type 1	5.4.1.1.2 TABLE X	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
301.1.2.c	Topology Update shall be message type 2	5.4.1.1.2 TABLE X	M	Yes__ No__	
301.1.2.d	Topology Update Request shall be message type 3	5.4.1.1.2 TABLE X	M	Yes__ No__	
301.1.2.e	IPv4 Packets shall be message type 4	5.4.1.1.2 TABLE X	M	Yes__ No__	
301.1.2.f	ARP/RARP shall be message type 5	5.4.1.1.2 TABLE X	M	Yes__ No__	
301.1.2.f.1	All systems implementing IPv4 or N-Layer Pass-Through shall be able to respond to an ARP request in accordance with RFC 826	5.4.1.1.2.2	M	Yes__ No__	
301.1.2.f.2	For hardware type (ar$hrd) = 22 (CNR), the source hardware address (ar$sha) field shall contain the data link address	5.4.1.1.2.2 5.3.4.2.2	M	Yes__ No__	
301.1.2.f.3	The hardware address length (ar$hln) field value (specifying the number of octets in the hardware address field) shall be set to one octet when the net is configured for 7-bit addressing or to four octets when the net is configured for 32 bit addressing, or six octets when the net is configured for 48-bit addressing	5.4.1.1.2.2	M	Yes__ No__	
301.1.1.2.f.4	Any system implementing IPv6 shall implement both ICMPv6 and Neighbor Discovery. Systems shall not use ARP messages on IPv6 networks.	5.4.1.1.2.2	M	Yes__ No__	
301.1.2.g	XNP shall be message type 6	5.4.1.1.2 TABLE X APPENDIX E	M	Yes__ No__	
301.1.2.h	MIL-STD-2045-47001 Header (N-Layer Pass-Through) shall be message type 7	5.4.1.1.2 TABLE X	M	Yes__ No__	
301.1.2.i	Reserved Message Types shall be message types 0, 8, and 9.	5.4.1.1.2 TABLE X	M	Yes__ No__	
301.1.2.j	Segmentation/Reassembly shall be message type 10	5.4.1.1.2 TABLE X	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
301.1.2.k	IPv6 Packets shall be message type 11	5.4.1.1.2 TABLE X	M	Yes__ No__	
301.1.2.l	Note for TABLE X: M indicates Mandatory for compliant systems, O indicates optional for compliant systems, C indicates Conditionally Mandatory for compliant systems implementing Intranet Relaying, X indicates that compliant systems should neither transmit nor accept IL packets with this field value.	5.4.1.1.2 TABLE X	M	Yes__ No__	
301.1.2.1	Interoperability with Internet Protocols (IP Packets)	5.4.1.1.2.1	M	Yes__ No__	
301.1.2.1.a	Systems implementing the IP protocol at the Internet Sub-Layer of the Network Layer shall implement Intranet message type 4 (IPv4 Packets) and type 11 (IPv6 Packets) as defined in TABLE X at the Intranet Sub-Layer of the Network Layer.	5.4.1.1.2.1 TABLE X	M	Yes__ No__	
301.1.2.1.b	Systems implementing the IP protocol shall implement both IPv4 and IPv6 protocols as a dual stack.	5.4.1.1.2.1	M	Yes__ No__	
301.1.2.1.c	For each network attachment point, the system shall be able to configure that point to use either IPv4 or IPv6	5.4.1.1.2.1	M	Yes__ No__	
301.1.3	Intranet Header Length	5.4.1.1.3	M	Yes__ No__	
301.1.3.a	The HLEN field value shall indicate the number of octets in the Intranet Header only.	5.4.1.1.3	M	Yes__ No__	
301.1.3.b	The minimum HLEN value is 3 octets when no Intranet Fragmentation/ Reassembly or Intranet Relaying is utilized	5.4.1.1.3	M	Yes__ No__	
301.1.3.c	The minimum HLEN value is 5 octets when Intranet Fragmentation/Reassembly is used but Intranet Relaying is not used	5.4.1.1.3	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
301.1.3.d	The minimum HLEN value is 9 octets when Intranet Relaying is used	5.4.1.1.3	M	Yes__ No__	
301.1.4	Type of Service	5.4.1.1.4	M	Yes__ No__	
301.1.5	Message Identification Number	5.4.1.1.5	301.1.b:M	Yes__ No__	
301.1.5.a	The message identification number shall be a number, 0-255, assigned by the originating host for messages that require Intranet Fragmentation/Reassembly and/or that require Intranet Relaying	5.4.1.1.5	301.1.5:M	Yes__ No__	
301.1.5.b	For messages that require Intranet Fragmentation/Reassembly without Intranet Relaying, the source address contained in the DL-Unitdata Indication combined with the Message Identification Number field value shall uniquely identify fragments of the same message	5.4.1.1.5	301.1.5:M	Yes__ No__	
301.1.5.c	For messages that require Intranet Relay, the Originator Address field value combined with the Message Identification Number field value shall uniquely identify relayed fragments of the same message	5.4.1.1.5	301.1.5:M	Yes__ No__	
301.1.5.d	Sending/Originating stations shall insure that the Message Identification Number field value assigned to each pending message transmission is unique	5.4.1.1.5	301.1.5:M	Yes__ No__	
301.1.5.e	After all 256 of the Message Identification field values have been associated with a message transmission for the first time, the least recently used Message identification field value associated with a message transmission that is no longer pending shall be used for the next new message transmission	5.4.1.1.5	301.1.5:M	Yes__ No__	
301.1.6	Fragment Number	5.4.1.1.6	301.1.b:M 301.1.c:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
301.1.6.a	The Fragment Number field shall have a numeric value, from 1 to 15, that indicates the position of an intranet fragment relative to other intranet fragments generated by a source/originator for a single Message Identification Number	5.4.1.1.6	301.1.6:M	Yes__ No__	
301.1.6.b	The Fragment Number field value shall be less than or equal to the Total Number of Fragments field value	5.4.1.1.6	301.1.6:M	Yes__ No__	
301.1.6.c	The Sending station shall number the fragments contiguously starting with 1	5.4.1.1.6	301.1.6:M	Yes__ No__	
301.1.6.d	When Intranet Fragmentation is not required and Intranet Relaying is required, the Fragment Number field value shall be set to 1	5.4.1.1.6	301.1.6:M	Yes__ No__	
301.1.7	Total Number of Fragments	5.4.1.1.7	301.1.b:M 301.1.c:M	Yes__ No__	
301.1.7.a	The Total Number of Fragments field shall have a numeric value, from 1 to 15, that indicates the total number of intranet fragments generated by an originator for a specific Message Identification Number field value	5.4.1.1.7	301.1.7:M	Yes__ No__	
301.1.7.b	All intranet fragments associated with the same Message Identification Number field value shall have the same Total Number of Fragments field value	5.4.1.1.7	301.1.7:M	Yes__ No__	
301.1.7.c	The Total Number of Fragments field value shall be greater than or equal to the Fragment Number field value	5.4.1.1.7	301.1.7:M	Yes__ No__	
301.1.7.d	When Intranet Fragmentation is not required and Intranet Relaying is required, the Total Number of Fragments field value shall be set to 1, indicating that Intranet Fragmentation is not used	5.4.1.1.7	301.1.7:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
301.1.7.1	Sending IL Fragments	5.4.1.1.7.1	301.1.b:M	Yes__ No__	
301.1.7.1.a	When the number of octets contained in the Intranet Header combined with the number of data related octets needed to be sent exceeds the MDLTU, the Intranet Layer of the sending station shall break the data packet into fragments.	5.4.1.1.7.1	301.1.7.1:M	Yes__ No__	
301.1.7.1.b	The number of octets in each data fragment, when combined with the size of the Intranet Header, shall be less than or equal to the MDLTU	5.4.1.1.7.1	301.1.7.1:M	Yes__ No__	
301.1.7.1.c	An identical Intranet Header, except for the Fragment Number field value, shall be pre-appended to each data fragment to form an IL PDU fragment	5.4.1.1.7.1	301.1.7.1:M	Yes__ No__	
301.1.7.1.d	The amount of data contained in each IL PDU fragment shall be the same, except possibly for the last fragment, which may be smaller	5.4.1.1.7.1	301.1.7.1:M	Yes__ No__	
301.1.7.1.e	The Fragment Number field of the Intranet Header of each IL PDU fragment shall indicate the unique position of each data fragment relative to the other fragments associated with the same Message Identification Number field value.	5.4.1.1.7.1	301.1.7.1:M	Yes__ No__	
301.1.7.1.1	Sending IL fragments requiring ETE Acks	5.4.1.1.7.1.1	301.1.b:M 301.1.c:M	Yes__ No__	
301.1.7.1.1.a	The maximum size of the Intranet Header for the initial and any subsequent retries shall be determined based on the current topology and then be subtracted from the MDLTU in order to determine the size of the data fragments	5.4.1.1.7.1.1	301.1.7.1.1:M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
301.1.7.1.1.b	For a given topology the maximum Intranet Header size shall be bounded based on the maximum number of Intranet hops permitted and the ultimate number of destinations of the message	5.4.1.1.7.1.1	301.1.7.1.1:M	Yes__ No__	
301.1.7.2	Receiving IL Fragments	5.4.1.1.7.2	301.1.b:M	Yes__ No__	
301.1.7.2.a	When an IL fragment is received, a destination station shall attempt to reassemble it with any other previously received fragments from the same source/originator having the same Message Identification Number and Total Number of Segments field values	5.4.1.1.7.2	301.1.7.2:M	Yes__ No__	
301.1.7.2.b	Related fragments received over time at the destination stations shall be reassembled back into the original data packet	5.4.1.1.7.2	301.1.7.2:M	Yes__ No__	
301.1.7.2.c	The fragments shall be reassembled at the proper location based on their relative positions as indicated by the Fragment Number field value, Total Number of Fragments field value, and the fact that all fragments except possibly the last fragment contain the same amount of data	5.4.1.1.7.2	301.1.7.2:M	Yes__ No__	
301.1.7.2.1	Reassembly Logic	5.4.1.1.7.2.1	301.1.b:M	Yes__ No__	
301.1.7.2.1.a	The reassembly logic shall be able to handle segments received in an order different from the order they were offered for transmission by the source/originator to its local Data Link Layer	5.4.1.1.7.2.1	301.1.7.2.1:M	Yes__ No__	
301.1.7.2.1.b	The reassembly logic shall be able to handle the receipt of duplicate fragments, e.g. 2 of 15 is received a second time before 3 of 15 through 15 of 15 are received	5.4.1.1.7.2.1	301.1.7.2.1:M	Yes__ No__	

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301.1.7.2.1.c	When all of the related data fragments are received (e.g. segment 2 of 4 could be the last of the four segments received) and the message has been successfully reassembled by the destination, an IL-Data Indication shall be generated by the destination Intranet Layer	5.4.1.1.7.2.1	301.1.7.2.1: M	Yes__ No__	
301.1.7.2.1.d	If an ETE Acknowledgment was requested by the source/originator, it shall be generated as described below in 5.4.1.1.9.5 when the final segment is received	5.4.1.1.7.2.1	301.1.7.2.1: M	Yes__ No__	
301.1.7.2.2	Reassembly Inactivity Timer	5.4.1.1.7.2.2	301.1.b:M	Yes__ No__	
301.1.7.2.2.a	Each time a fragment is received that is associated with a partially reassembled message, the Reassembly Inactivity Timer shall be started/restarted for the given message	5.4.1.1.7.2.2	301.1.7.2.2: M	Yes__ No__	
301.1.7.2.2.b	The default value of the Reassembly Inactivity Timer shall be two times the ETE Intranet Acknowledgment Timer.	5.4.1.1.7.2.2	301.1.7.2.2: M	Yes__ No__	
301.1.7.2.2.c	There shall be one Reassembly Inactivity Timer for each partially reassembled message	5.4.1.1.7.2.2	301.1.7.2.2: M	Yes__ No__	
301.1.7.2.2.d	When the Reassembly Inactivity Timer expires, the memory associated with the partially reassembled message shall be deallocated.	5.4.1.1.7.2.2	301.1.7.2.2: M	Yes__ No__	
301.1.8	Maximum Hop Count	5.4.1.1.8	301.1.b:M	Yes__ No__	
301.1.8.a	The maximum hop count shall be the maximum number of times this intranet packet can be relayed on the radio net	5.4.1.1.8	301.1.8:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
301.1.8.b	If the maximum hop count is decremented to 0, the intranet packet shall not be forwarded any further, however it shall be processed locally if applicable	5.4.1.1.8	301.1.8:M	Yes__ No__	
301.1.9	Destination/Relay Status Byte	5.4.1.1.9	301.1.b:M	Yes__ No__	
301.1.9.a	The Destination/Relay Status Byte shall provide intranet routing information for each destination and/or relay address	5.4.1.1.9	301.1.9:M	Yes__ No__	
301.1.9.1	Distance	5.4.1.1.9.1	301.1.9:M	Yes__ No__	
301.1.9.2	REL	5.4.1.1.9.2	301.1.9:M	Yes__ No__	
301.1.9.3	Relay Type	5.4.1.1.9.3 APPENDIX I	301.1.9:M	Yes__ No__	
301.1.9.4	DES	5.4.1.1.9.4	301.1.9:M	Yes__ No__	
301.1.9.5	ACK	5.4.1.1.9.5	301.1.9:M	Yes__ No__	
301.1.9.5.1	Receiver generation of ETE Intranet ACK	5.4.1.1.9.5.1	301.1.9:M	Yes__ No__	
301.1.9.5.1.a	When a node has received all of the IL fragment(s) associated with the same source/originator and Message Identification Number and the ACK bit is set in the IL fragment(s), it shall return an Intranet Acknowledgment packet at the first possible opportunity	5.4.1.1.9.5.1	301.1.9:M	Yes__ No__	
301.1.9.5.1.b	The Intranet Acknowledgment packet shall have the same Message Identification Number as the received Intranet fragment(s)	5.4.1.1.9.5.1	301.1.9:M	Yes__ No__	
301.1.9.5.1.c	The path specified in the Intranet Acknowledgment packet shall be the reverse path specified in the most recently received Intranet fragment(s)	5.4.1.1.9.5.1	301.1.9:M	Yes__ No__	
301.1.9.5.1.d	The Intranet Acknowledgment packet shall specify exactly one destination, namely the originator of the received Intranet fragment(s)	5.4.1.1.9.5.1	301.1.9:M	Yes__ No__	

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301.1.9.5.2	ETE Intranet ACK Timer	5.4.1.1.9.5.2	301.1.9:M	Yes__ No__	
301.1.9.5.2.a	When an originator node sends an intranet fragment(s) with the ACK bit set, it shall start its ETE acknowledgment timer after the last fragment is sent	5.4.1.1.9.5.2	301.1.9:M	Yes__ No__	
301.1.9.5.2.b	The ETE acknowledgment timer is an intranet parameter that defines the period within which a sending station shall expect to receive an ETE acknowledgment for the associated IL fragment(s) from the destination(s)	5.4.1.1.9.5.2	301.1.9:M	Yes__ No__	
301.1.9.5.2.c	The value of the ETE acknowledgment timer shall be a fixed factor plus a factor proportional to the number of hops required for all destinations to receive the last fragment	5.4.1.1.9.5.2	301.1.9:M	Yes__ No__	
301.1.9.5.2.d	The default value for the fixed factor shall be 20 seconds	5.4.1.1.9.5.2	301.1.9:M	Yes__ No__	
301.1.9.5.2.e	The default value for the proportional factor shall be twice the value of the DL acknowledgment timer, multiplied by the number of hops to the furthest destination	5.4.1.1.9.5.2	301.1.9:M	Yes__ No__	
301.1.9.5.2.f	The maximum value for the ETE Intranet Acknowledgment Timer shall be 10 minutes (600 seconds)	5.4.1.1.9.5.2	301.1.9:M	Yes__ No__	
301.1.9.5.3	Receiving an Intranet ETE Acknowledgment	5.4.1.1.9.5.3	301.1.9:M	Yes__ No__	
301.1.9.5.3.a	When an Intranet Acknowledgment Packet is received, that destination shall be removed from the list of destinations from which an acknowledgment is required	5.4.1.1.9.5.3	301.1.9:M	Yes__ No__	

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301.1.9.5.3.b	If no destinations remain on the list, the ETE Intranet Acknowledgment Timer shall be stopped and an IL-Status Indication shall be generated indicating that all destinations did acknowledge.	5.4.1.1.9.5.3	301.1.9:M	Yes__ No__	
301.1.9.5.4	Expiration of the ETE Intranet ACK Timer	5.4.1.1.9.5.4	301.1.9:M	Yes__ No__	
301.1.9.5.4.a	When the ETE acknowledgment timer expires and the maximum number of Intranet retransmissions has not been reached, the sending station shall retry the transmission of all of the associated IL fragment(s) to any destinations that have not yet acknowledged the receipt of the fragment(s)	5.4.1.1.9.5.4	301.1.9:M	Yes__ No__	
301.1.9.5.4.b	The number of retries shall be a value between 1 and 4, with a default of 2	5.4.1.1.9.5.4	301.1.9:M	Yes__ No__	
301.1.9.5.4.c	If only one path exists to a destination, that path shall be used until either the acknowledgment is received or the maximum number of Intranet retransmissions is exhausted	5.4.1.1.9.5.4	301.1.9:M	Yes__ No__	
301.1.9.5.4.d	The size of the data contained in each IL fragment shall be the same for the initial and each subsequent retransmission for the same Message Identification Number.	5.4.1.1.9.5.4	301.1.9:M	Yes__ No__	
301.1.9.5.4.e	If an acknowledgment is not received from every destination after the maximum number of Intranet retransmissions, an IL-Status-Indication shall be sent to the upper layer specifying which destination(s) did and did not acknowledge the IL PDU	5.4.1.1.9.5.4	301.1.9:M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
301.1.9.5.4.f	The retransmitted packet shall have a recreated Intranet Header with the same TOS field and Message Identification Number	5.4.1.1.9.5.4	301.1.9:M	Yes__ No__	
301.1.9.5.4.g	The Intranet Header shall be recreated to specify an alternative path to the remaining destination(s) (if an alternate path exists) and the Intranet Header Length field value shall be updated correspondingly.	5.4.1.1.9.5.4	301.1.9:M	Yes__ No__	
301.1.9.5.4.h	This recreated Intranet Header shall not specify paths to nodes that have already acknowledged the message	5.4.1.1.9.5.4	301.1.9:M	Yes__ No__	
301.1.9.5.4.i	This recreated Intranet Header shall not specify paths to nodes from which an acknowledgment is not required	5.4.1.1.9.5.4	301.1.9:M	Yes__ No__	
301.1.9.5.4.j	This recreated Intranet Header shall include paths to all nodes from which an acknowledgment is required, but from which an acknowledgment has not yet been received	5.4.1.1.9.5.4	301.1.9:M	Yes__ No__	
301.1.10	Originator Address	5.4.1.1.10	301.1.b:M	Yes__ No__	
301.1.10.a	The originator address shall be the link layer address of the originating node	5.4.1.1.10	301.1.10:M	Yes__ No__	
301.1.10.b	The four octets of address space shall be preceded by a single octet 32-bit marker subfield, as per 5.3.4.2.2.2	5.4.1.1.10 5.3.4.2.2.2	301.1.10:M	Yes__ No__	
301.1.11	Destination/Relay Address	5.4.1.1.11	301.1.b:M	Yes__ No__	
301.1.11.a	The intranet destination/relay address shall be the link layer address	5.4.1.1.11	301.1.11:M	Yes__ No__	
301.1.11.b	The four octets of address space shall be preceded by a single octet 32-bit marker subfield, as per 5.3.4.2.2.2	5.4.1.1.11 5.3.4.2.2.2	301.1.11:M	Yes__ No__	
301.2	Topology Update	5.4.1.2	O	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
301.2.1	Topology Update Length	5.4.1.2.1	301.2:M	Yes__ No__	
301.2.1.a	Topology Update Length shall not exceed the MTU minus 8 octets	5.4.1.2.1	301.2:M	Yes__ No__	
301.2.2	Topology Update ID	5.4.1.2.2	301.2:M	Yes__ No__	
301.2.2.a	The Topology Update ID for the first topology update generated shall be 1	5.4.1.2.2	301.2:M	Yes__ No__	
301.2.3	Node Address	5.4.1.2.3	301.2:M	Yes__ No__	
301.2.4	Node Status Byte	5.4.1.2.4	301.2:M	Yes__ No__	
301.2.4.1	Link Quality	5.4.1.2.4.1	301.2.4:M	Yes__ No__	
301.2.4.2	Hop Length	5.4.1.2.4.2	301.2.4:M	Yes__ No__	
301.2.4.3	NR	5.4.1.2.4.3	301.2.4:M	Yes__ No__	
301.2.4.4	Quiet	5.4.1.2.4.4	301.2.4:M	Yes__ No__	
301.2.5	Node Predecessor Address	5.4.1.2.5	301.2:M	Yes__ No__	
301.3	Topology Update Request Message	5.4.1.3	301.2:M	Yes__ No__	
301.3.a	The maximum hop count and distance field shall be set to 1	5.4.1.3	301.2:M	Yes__ No__	
301.3.b	The Relay, Relay Type and ACK bit shall be always zero (0)	5.4.1.3	301.2:M	Yes__ No__	
301.3.c	The DES bit shall be always 1	5.4.1.3	301.2:M	Yes__ No__	
301.3.d	The destination address in the Intranet Header shall be the link layer address to which this request has been made	5.4.1.3	301.2:M	Yes__ No__	
301.4	Intranet Layer Interactions	5.4.1.4	O	Yes__ No__	
301.4.1	IL Unitdata Request parameters	5.4.1.4.a	O	Yes__ No__	
301.4.2	IL - Unitdata Indication parameters	5.4.1.4.b	O	Yes__ No__	
301.4.3	IL - Status Indication parameters	5.4.1.4.b	O	Yes__ No__	
301.4.4	IL – Data Length Indication parameters	5.4.1.4.b	O	Yes__ No__	
301.4.5	IL – Error Indication parameters	5.4.1.4.b	O	Yes__ No__	
301.4.6.a	Precedence shall be mapped from the TOS field	5.4.1.4.c.3(a) 5.4.1.1.4	301.4.3:M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
301.4.6.b	For IPv6 with Class Selector Codepoints (see RFC 2474), precedence shall be mapped from the Differentiated Services (DS) field as shown below	5.4.1.4.c.3(a) 5.4.1.1.4	301.4.3:M	Yes__ No__	
301.4.6.c	For IPv6 with other DS Codepoints, the IL precedence shall be selected to match the Per Hop Behavior (PHB) defined by the DS Codepoint	5.4.1.4.c.3(a) 5.4.1.1.4	301.4.3:M	Yes__ No__	
301.4.6.d	The other Quality of Service parameters shall be mapped from the TOS field	5.4.1.4.c.3(b) 5.4.1.1.4	301.4.3:M	Yes__ No__	
301.4.6.e	For IPv6, the DTR bits shown below will be set to match the PHB defined by the DS Codepoint in the DS field.	5.4.1.4.c.3(b) 5.4.1.1.4	301.4.3:M	Yes__ No__	
301.4.6.f	For IPv6 with Class Selector Codepoints (see RFC 2474), the D, T, and R bits shall be set to 0	5.4.1.4.c.3(b) 5.4.1.1.4	301.4.3:M	Yes__ No__	
301.4.6.g	The ETE intranet acknowledgment procedures shall be used when R=1, and relaying is used to deliver the message to any destination of the packet	5.4.1.4.c.3(c) 5.4.1.1.9.5	301.4.3:M	Yes__ No__	
301.4.6.h	IL-Unit Data Request with Data Length parameter values that are greater than the MTU shall not be honored by the IL resulting in the failure of the request without any attempt to send the data	5.4.1.4.c.10	301.4.3:M	Yes__ No__	
301.4.6.i	IL-Unit Data Request with the Data Length parameter value that are greater than the MTU Without IL Fragmentation and less than or equal to MTU shall be honored using IL Fragmentation.	5.4.1.4.c.11	301.4.3:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
301.4.6.j	IL-Unit Data Request with a Data Length parameter value that is less than or equal to the MTU Without IL Fragmentation shall be honored without the use of IL Fragmentation.	5.4.1.4.c.11	301.4.3:M	Yes__ No__	

A.6.2 Subnetwork Dependent Convergence Function (SNDCF).

Item	Protocol Feature	Reference	Status		Support		Notes
302	Subnetwork Dependent Convergence Function (SNDCF)	5.4.2	M		Yes__ No__		
302.a	If the IP protocol implementation does not provide the required information through an inter-layer interaction, the SNDCF shall examine the IP header fields to "learn" the destinations and TOS	5.4.2	302:M		Yes__ No__		
302.b	Selective Directed Broadcast for IPv4	5.4.2	Send: O	Recv: M	Send: Yes__ No__	Recv: Yes__ No__	
302.c	Selective Directed Broadcast for IPv6	5.4.2	Send: O	Recv: O	Send: Yes__ No__	Recv: Yes__ No__	
302.1	Determine Destination Function	5.4.2.1	M		Yes__ No__		
302.2	Address Mapping Function	5.4.2.2	M		Yes__ No__		
302.3	TOS Function	5.4.2.3	M		Yes__ No__		
302.4	Intranet Send Request	5.4.2.4	M		Yes__ No__		
302.5	Shall utilize/support UDP/IP for transmit and receive	5.4.3	M		Yes__ No__		
302.6	Shall be able to utilize/support MIL-STD-188-220 N-Layer pass through for the transmission and receipt of upper layer protocols	5.4.3	M		Yes__ No__		

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A.6.3 Standard network settings.

Item	Protocol Feature	Reference	Status	Support	Notes
303	Lower layer protocol network settings	5.5	O	Yes__ No__	
303.1	TABLE XIV describes a standard set of lower layer protocols that may be used by all systems to enhance interoperability.	5.5.2	O	Yes__ No__	

A.7 Appendixes.

Item	Protocol Feature	Reference	Status	Support	Notes
401	Abbreviations and Acronyms	APPENDIX A	NA	---	
402	Profile	APPENDIX B	M	Yes__ No__	
403	Network Access Control Algorithm (NAC)	APPENDIX C	M	Yes__ No__	
404	Communications Security Standards	APPENDIX D	O	Yes__ No__	
405	CNR Management Process	APPENDIX E	O	Yes__ No__	
406	Golay Coding Algorithm	APPENDIX F	102.1.3.1:M 102.1.3.2:M 102.1.3.3:X	Yes__ No__ Yes__ No__ No	
407	Packet Construction and Bit Ordering	APPENDIX G	M	Yes__ No__	
408	Intranet Topology Update	APPENDIX H	301.2:M	Yes__ No__	
409	Source Directed Relay	APPENDIX I	301.1.a:M	Yes__ No__	
410	Robust Communications Protocol	APPENDIX J	102.1.3.4:M	Yes__ No__	
411	Bose-Chaudhuri-Hocquenghem (15, 7) Coding Algorithm	APPENDIX K	102.1.3.4:M	Yes__ No__	
412	Transmission Channel Interfaces	APPENDIX L	M	Yes__ No__	

A.7.1 This paragraph was intentionally left blank for paragraph conformity.

A.7.2 Network Access Control Algorithm (NAC).

Item	Protocol Feature	Reference	Status	Support	Notes
403	Network Access Control Algorithm (NAC)	APPENDIX C	M	Yes__ No__	
403.1	Network Timing Model	C.3	M	Yes__ No__	
403.1.a	The network access control protocol shall be used to detect the presence of active transmissions on a multiple-station-access communications network and shall provide a means to preclude data transmissions from conflicting on the network	C.3	M	Yes__ No__	
403.1.b	All stations on a network shall use the same network access control protocol and timing parameter values in order to maintain network discipline	C.3	M	Yes__ No__	
403.1.1	Network Timing Model Definitions	C.3.1	M	Yes__ No__	
403.1.2	Network Timing Model Parameters	C.3.2	M	Yes__ No__	
403.1.2.1	Equipment Preamble Time (EPRE)	C.3.2.1	M	Yes__ No__	
403.1.2.2	Phasing Transmission Time (PHASING)	C.3.2.2	M	Yes__ No__	
403.1.2.2.a	PHASING is the time the DTE shall send an alternating sequence of one and zero bits after the completion of EPRE and prior to sending the first bit of DATA	C.3.2.2	M	Yes__ No__	
403.1.2.2.b	The DTE shall use the DCE bit rate to compute the number of PHASING bits to transmit	C.3.2.2	M	Yes__ No__	
403.1.2.3	Data Transmission Time (DATA)	C.3.2.3	M	Yes__ No__	
403.1.2.3.a	DATA shall begin immediately after the end of PHASING	C.3.2.3	M	Yes__ No__	
403.1.2.3.b	The transmitting DTE shall indicate end of transmission immediately after the last bit of data is sent to the DCE	C.3.2.3	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
403.1.2.4	Coupled Acknowledgment Transmission Time (S)	C.3.2.4	M	Yes__ No__	
403.1.2.4.a	For these frames, the length of the fields (including zero bit insertion) used in network timing equations when the Multi-Dwell protocol and convolutional coding are not used shall be:	C.3.2.4	M	Yes__ No__	
403.1.2.4.a.1	The 64-bit message synchronization field	C.3.2.4.a	M	Yes__ No__	
403.1.2.4.a.2	An optional embedded COMSEC MI field	C.3.2.4.b	M	Yes__ No__	
403.1.2.4.a.3	The 168-bit TWC and Transmission Header TDC block	C.3.2.4.c	M	Yes__ No__	
403.1.2.4.a.4	80 bits if neither the FEC nor TDC function is selected, 168 bits if only FEC is selected, and 384 bits if both FEC and TDC are selected	C.3.2.4.d	M	Yes__ No__	
403.1.2.5	Equipment Lag Time (ELAG)	C.3.2.5	M	Yes__ No__	
403.1.2.6	Turnaround Time (TURN)	C.3.2.6	M	Yes__ No__	
403.1.2.7	DTE ACK Preparation Time (DTEACK)	C.3.2.7	M	Yes__ No__	
403.1.2.8	DTE Processing Time (DTEPROC)	C.3.2.8	M	Yes__ No__	
403.1.2.9	DTE Turnaround Time (DTETURN)	C.3.2.9	M	Yes__ No__	
403.1.2.9.a	DTETURN shall be a variable parameter where the range shall be from 0.000 to 0.100 seconds in one (1) millisecond resolution steps.	C.3.2.9	M	Yes__ No__	
403.1.2.10	Tolerance Time (TOL)	C.3.2.10	M	Yes__ No__	
403.1.2.10.a	SALT shall be less than or equal to the receiving DCE and transmitting DCE pair with the smallest delay in the network	C.3.2.10	M	Yes__ No__	
403.1.2.10.b	If SALT is not known, then zero (0) shall be assumed	C.3.2.10	M	Yes__ No__	
403.2	Network Access Control	C.4	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
403.2.a	The stations shall implement the following four basic NAC subfunctions:	C.4	M	Yes__ No__	
403.2.a.1	Network busy sensing	C.4.a	M	Yes__ No__	
403.2.a.2	Response hold delay (RHD)	C.4.b	M	Yes__ No__	
403.2.a.3	Timeout period (TP)	C.4.c	M	Yes__ No__	
403.2.a.4	Network access delay (NAD)	C.4.d	M	Yes__ No__	
403.2.1	Network Busy Sensing Function	C.4.1	M	Yes__ No__	
403.2.1.a	Network busy sensing for a data signal shall be provided	C.4.1	M	Yes__ No__	
403.2.1.1	Data network busy sensing	C.4.1.1	M	Yes__ No__	
403.2.1.1.a	When receiving a data transmission, network busy shall be detected within a fixed time	C.4.1.1	M	Yes__ No__	
403.2.1.1.b	Parameter B shall be used to compute this fixed time	C.4.1.1	M	Yes__ No__	
403.2.1.1.c	For synchronous mode B shall be less than or equal to (32/n) seconds	C.4.1.1	M	Yes__ No__	
403.2.1.1.d	For asynchronous mode B shall be less than or equal to (64/n) seconds	C.4.1.1	M	Yes__ No__	
403.2.1.1.e	For packet mode B shall be less than or equal to 250 milliseconds	C.4.1.1	M	Yes__ No__	
403.2.1.1.f	Upon detection of data network busy, the data link network busy indicator shall be set	C.4.1.1	M	Yes__ No__	
403.2.1.1.g	Setting the data link network busy indicator shall inhibit all message transmissions, including coupled response messages	C.4.1.1	M	Yes__ No__	
403.2.1.1.h	The data link network busy indicator shall be reset upon indication from the physical layer that neither voice nor digital data is being detected by the station	C.4.1.1	M	Yes__ No__	
403.2.1.2	Voice Network Busy Sensing	C.4.1.2	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
403.2.1.2.a	If voice transmissions are not detected, this function shall report that the network is never busy due to a voice transmission	C.4.1.2	M	Yes__ No__	
403.2.1.2.b	Upon detection of voice network busy, the data link network busy indicator shall be set	C.4.1.2	M	Yes__ No__	
403.2.1.2.c	Setting the data link network busy indicator shall inhibit all message transmissions, including coupled response messages	C.4.1.2	M	Yes__ No__	
403.2.1.2.d	The data link network busy indicator shall be reset upon indication from the physical layer that neither voice nor digital data is being detected by the station	C.4.1.2	M	Yes__ No__	
403.2.1.3	Network Busy Detect Time	C.4.1.3	M	Yes__ No__	
403.2.1.3.a	The time allowed to detect data network busy shall be the same for all stations on the network	C.4.1.3	M	Yes__ No__	
403.2.1.3.b	The equation below shall be used as a default in cases where the parameter table has not been updated to reflect actual measurements for specific device	C.4.1.3	M	Yes__ No__	
403.2.1.3.c	Where a communications device provides a signal to detect network busy earlier than the calculated parameter B value, the DTE shall interface to that signal	C.4.1.3	M	Yes__ No__	
403.2.1.3.d	Where the communication media does not provide special capabilities or these capabilities cannot be used by all stations on the network, the station shall examine received data to detect data network busy	C.4.1.3	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
403.2.1.3.e	The time allowed to detect data network busy shall be given by the formula: Net_Busy_Detect_Time = EPRE + ELAG + B + TOL	C.4.1.3	M	Yes__ No__	
403.2.2	Response Hold Delay	C.4.2	M	Yes__ No__	
403.2.2.a	The individual RHD value to be used shall be determined by the position of the receiving station's individual or special address in the PDU destination portion of the address field	C.4.2	M	Yes__ No__	
403.2.2.b	The Reserved Address (0) in the destination portion of the address field shall be ignored	C.4.2	M	Yes__ No__	
403.2.2.c	When calculating an individual RHD value, the Reserved Address shall not be considered to occupy a position in the destination portion of the address field	C.4.2	M	Yes__ No__	
403.2.2.d	The RHD time shall start precisely at the end of ELAG	C.4.2	M	Yes__ No__	
403.2.2.e	All stations on a subnetwork shall use the same values in calculating RHD	C.4.2	M	Yes__ No__	
403.2.2.f	The RHD_0 period shall be calculated by the following formula: RHD_0 = EPRE + PHASING + S + ELAG + TURN + TOL	C.4.2	M	Yes__ No__	
403.2.2.g	The TP shall be calculated by all stations on the network/link as follows: TP = (j * RHD_0) + TOL + Maximum(DTEACK, TURN)	C.4.2	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
403.2.2.h	The transmitting station shall not include special address 3 in the total for j, and the value of all non-integer variables (that is, RHD_0, TOL, and TURN) in the TP equation are rounded to the nearest one thousandth	C.4.2	M	Yes__ No__	
403.2.2.i	The individual addressed station's response hold delay (RHD_i) shall be calculated by $RHD_i = (i - 1) * RHD_0$ + Maximum (DTEACK, TURN) + TOL	C.4.2	M	Yes__ No__	
403.2.3	Timeout Period	C.4.3	M	Yes__ No__	
403.2.3.a	TP is the time all stations shall wait before they can schedule the NAD	C.4.3	M	Yes__ No__	
403.2.3.b	The transmitting station shall wait to receive the anticipated Type 3 coupled acknowledgment response frame(s), from all applicable addressed stations	C.4.3	M	Yes__ No__	
403.2.3.c	The parameter values used to compute TP shall be the same for all stations on a subnet unless immediate retransmission has been selected	C.4.3	M	Yes__ No__	
403.2.3.d	When immediate retransmission has been requested, the sending station shall compute the timeout period using only individual addresses and special addresses 1 and 2	C.4.3	M	Yes__ No__	
403.2.3.e	All receiving stations shall compute the timeout period using the individual addresses and special addresses 1, 2 and 3	C.4.3	M	Yes__ No__	
403.2.3.f	The TP time shall start precisely at the end of ELAG	C.4.3	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
403.2.3.g	A retransmission of a Type 3 shall be executed whenever TP has been exceeded without expected acknowledgments having been received from all Type 3 individual and special destinations	C.4.3	M	Yes__ No__	
403.2.3.h	Prior to retransmission, the address field of the frame shall be modified to delete the destination station(s) that previously acknowledged the frame	C.4.3	M	Yes__ No__	
403.2.3.i	Operationally, TP shall be used as follows:	C.4.3	M	Yes__ No__	
403.2.3.i.1	Upon termination of a message transmission that requires an immediate response, the transmitting station shall set the TP timer	C.4.3.a	M	Yes__ No__	
403.2.3.i.2	If the transmitting station does not receive all the expected responses (TEST, URR, or URNR) within the TP, and if the number of transmissions is less than the Maximum Number of Transmissions data link parameter, the station shall retransmit the frame when it is the highest precedence frame to send	C.4.3.a	M	Yes__ No__	
403.2.3.i.3	For all stations, if a Type 1, Type 2 or Type 4 frame is received when a response-type frame is expected, the newly received frame shall be processed	C.4.3.a	M	Yes__ No__	
403.2.3.i.4	The RHD and TP timers shall not be suspended and the TP procedures in use for the Type 3 frame shall be continued	C.4.3.a	M	Yes__ No__	
403.2.3.i.5	Response procedures, if any, for the newly received frame shall commence after the conclusion of the ongoing TP procedures	C.4.3.a	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
403.2.3.i.6	If the unexpected frame is a Type 3 frame the current TP procedure is aborted and the newly received Type 3 TP procedure shall be started	C.4.3.a	M	Yes__ No__	
403.2.3.i.7	After a station transmits or receives data that does not require a Type 3 coupled acknowledgment, and is not itself a Type 3 coupled acknowledgment, all stations except those using RE-NAD shall compute TP as: TP = Maximum(DTEPROC, TURN) + TOL	C.4.3.b	M	Yes__ No__	
403.2.3.i.8	Upon receiving a Type 3 coupled acknowledgment, a station shall determine whether it thinks a timeout period is already in progress	C.4.3.c	M	Yes__ No__	
403.2.3.i.9	If no timeout period is in progress, or if the acknowledgment contains an unexpected destination or source address, the receiving station shall compute TP using the following equation and shall start a timeout period precisely at the time the last bit of data for the Type 3 coupled acknowledgment was received. TP = (15 * RHD_0) + TOL + TURN **NOTE:** RHD_0 is as defined in C.4.2	C.4.3.c	M	Yes__ No__	
403.2.4	Network Access Delay	C.4.4	M	Yes__ No__	
403.2.4.a	NAD is defined as the time a station with a message to send shall wait to send a frame after the TP timer has expired	C.4.4	M	Yes__ No__	
403.2.4.b	All transmissions, except the coupled acknowledgments, shall begin at the start of the next NAD slot	C.4.4	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
403.2.4.c	Two of the access schemes, DAP-NAD and R-NAD, shall be available to all network participants using Synchronous Mode	C.4.4	M	Yes__ No__	
403.2.4.d	In all of the NAD schemes, if the TP timer is active, the stations with frames to transmit shall wait for the TP timer to expire before the NAD is started	C.4.4	M	Yes__ No__	
403.2.4.e	If the TP timer is not active, the station shall calculate its NAD using the proper NAD scheme for the network	C.4.4	M	Yes__ No__	
403.2.4.f	Upon receipt of a frame a TP timer shall be started	C.4.4.a	M	Yes__ No__	
403.2.4.g	Regardless of what was received a NAD value shall be recomputed and initiated after the TP timer expires	C.4.4.a	M	Yes__ No__	
403.2.4.h	If a station does not have a frame to transmit, it shall compute a NAD time using routine priority for its calculations	C.4.4.b	M	Yes__ No__	
403.2.4.i	If the NAD time arrives before a frame becomes available to transmit or frame(s) are not yet encoded for transmission, the station shall compute and use a new NAD time	C.4.4.b	M	Yes__ No__	
403.2.4.j	The starting time for the new NAD and the F value used in computing the NAD shall be based on the NAD method in effect: R-NAD P-NAD H-NAD RE-NAD DAP-NAD DAV-NAD	C.4.4.b	403.2.4.1:M 403.2.4.2:M 403.2.4.3:M 403.2.4.4:X 403.2.4.5:M 403.2.4.6:M	Yes__ No__ Yes__ No__ Yes__ No__ No Yes__ No__ Yes__ No__	
403.2.4.j.1	For P-NAD the F value shall be (NS + 1)	C.4.4.b.1	403.2.4.2:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
403.2.4.j.2	For R-NAD the F value shall be [(3/4) * NS + 1]	C.4.4.b.2	403.2.4.1:M	Yes__ No__	
403.2.4.j.3	For H-NAD the F value shall be 1 if the station has an urgent or priority frame to transmit and (Routine_MAX + 1 – Routine_MIN) if a station has only a routine frame(s) or no frame(s) to transmit	C.4.4.b.3	403.2.4.3:M	Yes__ No__	
403.2.4.j.4	For DAP-NAD and DAV-NAD, the F value shall be (NS)	C.4.4.b.5	403.2.4.5:M	Yes__ No__	
403.2.4.k	All stations on the network shall continue to sense the link for data or voice network busy and shall withhold transmission until the appropriate NAD period has expired	C.4.4.c	M	Yes__ No__	
403.2.4.l	NAD shall be calculated using the formula: NAD = F * Net_Busy_Detect_Time + Max(0, F-1) * DTETURN	C.4.4.c	M	Yes__ No__	
403.2.4.1	Random Network Access Delay	C.4.4.1	M	Yes__ No__	
403.2.4.1.a	The R-NAD calculation method shall ensure that each station has an equal chance of accessing the network	C.4.4.1	M	Yes__ No__	
403.2.4.1.b	The integer value of F shall be obtained from pseudorandom number generator	C.4.4.1	M	Yes__ No__	
403.2.4.1.c	F shall be an integer value (truncated) in a range between 0 and (3/4)NS	C.4.4.1	M	Yes__ No__	
403.2.4.2	Prioritized Network Access Delay	C.4.4.2	O	Yes__ No__	
403.2.4.2.a	The P-NAD calculation method shall ensure that the network access precedence order assigned to stations is preserved	C.4.4.2	403.2.4.2:M	Yes__ No__	
403.2.4.2.b	Each station shall calculate three unique P-NAD values, one for each of the three frame precedence levels	C.4.4.2	403.2.4.2:M	Yes__ No__	

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403.2.4.2.c	The integer value of F shall be calculated as: F = SP + MP + IS	C.4.4.2	403.2.4.2:M	Yes__ No__	
403.2.4.3	Hybrid Network Access Delay	C.4.4.3	O	Yes__ No__	
403.2.4.3.a	The integer value of F shall be calculated as: F = MIN + RAND * (MAX – MIN)	C.4.4.3	403.2.4.3:M	Yes__ No__	
403.2.4.4	Radio Embedded Network Access Delay (RE-NAD)	C.4.4.4	O	Yes__ No__	
403.2.4.4.1	RE-NAD Media Access	C.4.4.4.1	403.2.4.4:M	Yes__ No__	
403.2.4.4.1.a	If a higher precedence individual frame becomes available for transmission, the concatenated frames shall be re-built to include the higher precedence frame	C.4.4.4.1	403.2.4.4:M	Yes__ No__	
403.2.4.4.1.1	Random Schedule Interval	C.4.4.4.1.1	403.2.4.4:M	Yes__ No__	
403.2.4.4.1.2	Voice Component	C.4.4.4.1.2	403.2.4.4:M	Yes__ No__	
403.2.4.4.1.2.a	The initial voice factor shall be the minimum voice factor value	C.4.4.4.1.2	403.2.4.4:M	Yes__ No__	
403.2.4.4.1.2.1	Fast Attack	C.4.4.4.1.2.1	403.2.4.4:M	Yes__ No__	
403.2.4.4.1.2.1.a	Voice detection shall increment the voice factor by the voice factor increment value (range=0.0 sec to 10.0 sec) as indicated below:	C.4.4.4.1.2.1	403.2.4.4:M	Yes__ No__	
403.2.4.4.1.2.1.a.1	If the voice factor is at the minimum voice factor value, the scheduler is incremented immediately to protect the next voice hit	C.4.4.4.1.2.1.a C.4.4.4.1.2	403.2.4.4.1.2.1.a:M	Yes__ No__	
403.2.4.4.1.2.1.a.2	Otherwise, the increment occurs at the next scheduler expiration	C.4.4.4.1.2.1.b	403.2.4.4.1.2.1.a:M	Yes__ No__	
403.2.4.4.1.2.2	Slow Decay	C.4.4.4.1.2.2	403.2.4.4:M	Yes__ No__	
403.2.4.4.1.2.2.a	The voice factor shall be decremented every time the NAD expires by the voice decrement value (range=0.0 sec to 10.0 sec)	C.4.4.4.1.2.2	403.2.4.4:M	Yes__ No__	

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403.2.4.4.1.3	Calculation of the Scheduler Random Parameter	C.4.4.4.1.3	403.2.4.4:M	Yes__ No__	
403.2.4.4.1.3.a	Continuous calculation of the NumActiveMembers value shall be performed based on the number of known active data transmitters on the net	C.4.4.4.1.3	403.2.4.4:M	Yes__ No__	
403.2.4.4.1.3.b	SchedulerInterval shall be recomputed after every transmission by the DTE	C.4.4.4.1.3	403.2.4.4:M	Yes__ No__	
403.2.4.4.1.4	Calculation of the Load Factor (Fload)	C.4.4.4.1.4	403.2.4.4:M	Yes__ No__	
403.2.4.4.1.5	100 msec Immediate Mode Scheduling	C.4.4.4.1.5	403.2.4.4:M	Yes__ No__	
403.2.4.4.1.5.1	Any traffic, voice or data, detected during the immediate mode operation shall abort the 100 msec Immediate Mode and set it to OFF	C.4.4.4.1.5.e	403.2.4.4:M	Yes__ No__	
403.2.4.4.1.6	Immediate Mode Scheduling	C.4.4.4.1.6	403.2.4.4:M	Yes__ No__	
403.2.4.4.2	RE-NAD Network Access	C.4.4.4.2	403.2.4.4:M	Yes__ No__	
403.2.4.4.2.a	When the precedence level of the transmission changes, the DTE shall set the precedence level of the new transmission	C.4.4.4.2	403.2.4.4:M	Yes__ No__	
403.2.4.4.3	Network Busy Sensing and Receive Status	C.4.4.4.3	403.2.4.4:M	Yes__ No__	
403.2.4.5	Deterministic Adaptable Priority-Network Access Delay (DAP-NAD)	C.4.4.5	102.1.3.2:M	Yes__ No__	
403.2.4.5.a	The station that transmits the message shall increment the First Station Number subfield contained in the last message it received and place the number in the First Station Number subfield of the Transmission Header	C.4.4.5	403.2.4.5:M	Yes__ No__	

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403.2.4.5.a.1.a	Those stations that do not have any urgent messages awaiting transmission shall wait for at least the NS+1 access opportunity before they can transmit	C.4.4.5	403.2.4.5:M	Yes__ No__	
403.2.4.5.a.1.b	Those stations that have only routine messages awaiting transmission shall wait for at least the 2NS+1 access opportunity before transmitting	C.4.4.5	403.2.4.5:M	Yes__ No__	
403.2.4.5.a.2.a	Those stations that have any messages awaiting transmission, regardless of priority, by the 2NS+1 access opportunity can transmit when their calculated access opportunity arrives	C.4.4.5	403.2.4.5:M	Yes__ No__	
403.2.4.5.a.2.b	The very first network access period following completion of the transmission while in Priority mode shall be reserved for any station with an Urgent message to notify all other stations to revert back to Urgent network mode	C.4.4.5.b	403.2.4.5:M	Yes__ No__	
403.2.4.5.a.2.c	After reverting to Urgent mode, the station with the station number matching the First Station Number in the Transmission Header of the transmission completed just before the reserved slot shall have the first network access opportunity	C.4.4.5.b	403.2.4.5:M	Yes__ No__	
403.2.4.5.a.2.d	The network shall then remain in the Urgent mode until all stations have had an opportunity to access the network	C.4.4.5.b	403.2.4.5:M	Yes__ No__	
403.2.4.5.a.3.a	The very first network access period following completion of the transmission shall be reserved for any station with an Urgent or Priority message to cause the network to go to Urgent mode	C.4.4.5.c	403.2.4.5:M	Yes__ No__	
403.2.4.5.1	NAD Information Field	C.4.4.5.1	403.2.4.5:M	Yes__ No__	

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403.2.4.5.1.a	Data Link Precedence subfield shall contain the value 0 if an urgent message is in the frame, 1 if a priority but no urgent message is in the frame and 2 if neither an urgent or priority message is in the frame	C.4.4.5.1	403.2.4.5:M	Yes__ No__	
403.2.4.5.1.b	The variable NP in the equations below shall be set equal to the content of the Data Link Precedence subfield for the next network access period	C.4.4.5.1	403.2.4.5:M	Yes__ No__	
403.2.4.5.2	NAD Equations	C.4.4.5.2	403.2.4.5:M	Yes__ No__	
403.2.4.5.2.a	If a station does not begin transmitting at one term (e.g. NAD_2), it shall wait until at least the next term (e.g. NAD_3) before it can begin transmitting	C.4.4.5.2	403.2.4.5:M	Yes__ No__	
403.2.4.5.2.b	It shall have a value of 0 if there are any urgent messages awaiting transmission, the value 1 if there are any priority messages and no urgent messages awaiting transmission, and the value 2 if there are no urgent or priority messages awaiting transmission	C.4.4.5.2	403.2.4.5:M	Yes__ No__	
403.2.4.5.2.c	NP shall have the value 0 if an urgent message was in the last transmission, 1 if a priority but no urgent message was in the last transmission, and 2 if neither an urgent or priority message was in the last transmission	C.4.4.5.2	403.2.4.5:M	Yes__ No__	
403.2.4.5.3	Initial Condition State	C.4.4.5.3	403.2.4.5:M	Yes__ No__	
403.2.4.5.3.a	These stations shall be considered to be in the initial condition state	C.4.4.5.3	403.2.4.5:M	Yes__ No__	

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403.2.4.5.3.b	Regardless of what causes a station to be in the initial condition state, transmissions shall be delayed by at least the time specified by equation 7 while in that state. Equation 7: INAD = TP + ((3 * NS) + 1) * Net_Busy_Detect_Time + (3 * NS) * DTETURN	C.4.4.5.3	403.2.4.5:M	Yes__ No__	
403.2.4.5.3.c	INAD (Initial condition state Network Access Delay) is the minimum time that a station shall delay transmission of a message after it has become capable of receiving and transmitting messages, but no more than 20 seconds	C.4.4.5.3	403.2.4.5:M	Yes__ No__	
403.2.4.5.3.d	The TP in the equation shall be a worst case TP, i.e., as if there had just been a Type 3 message on the network that required acknowledgment and was addressed to 16 stations on the net	C.4.4.5.3	403.2.4.5:M	Yes__ No__	
403.2.5	Data and voice-network access delay (DAV-NAD)	C.4.4.6	O	Yes__ No__	
403.2.5.a	The station that transmits the message shall increment the First Station Number subfield contained in the last message it received by a fixed constant called the FSN Increment Number (FSNIN) and place the result in the First Station Number subfield of the Transmission Header.	C.4.4.6	403.2.5:M	Yes__ No__	
403.2.6	Voice/Data Network Sharing	C.4.5	M	Yes__ No__	
403.2.6.a	When operating in a mixed voice and data network, voice and data network sharing shall operate in the following matter:	C.4.5	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
403.2.6.a.1	A receive operation shall be considered a voice reception unless a valid synchronization pattern is identified	C.4.5.a	M	Yes__ No__	
403.2.6.a.2	A receive operation that is less than 0.75 seconds in length shall be considered a noise burst instead of a voice reception	C.4.5.a 6.3.2.2.2	M	Yes__ No__	
403.2.6.a.3	The network shall be synchronized based on RHD and TP timers, which are driven only by data transmissions and receptions	C.4.5.b	M	Yes__ No__	
403.2.6.a.4	Voice receptions and noise bursts shall not be used for resynchronizing network timers	C.4.5.b	M	Yes__ No__	
403.2.6.a.5	A station shall not transmit during a noise burst or a voice reception	C.4.5.c	M	Yes__ No__	
403.2.6.a.6	After completion of a voice reception, a station shall wait at least TURN milliseconds before initiating transmission	C.4.5.c	M	Yes__ No__	
403.2.6.a.7	After completion of a voice reception, operation of the P-NAD network access scheme shall be reinitiated if P-NAD is being used	C.4.5.d	M	Yes__ No__	
403.2.6.a.8	After a voice reception is completed, the current, partially-completed NAD slot group and the next complete NAD slot group shall be used only by stations with urgent-precedence data transmissions	C.4.5.d	M	Yes__ No__	
403.2.6.a.9	The NAD slot group after these groups shall be used only by stations with urgent-precedence or priority-precedence data transmissions	C.4.5.d	M	Yes__ No__	
403.2.6.a.10	RHD and TP timers shall not be suspended or resumed as a result of voice receptions	C.4.5.e	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
403.2.6.a.11	Data link protocol timers shall be suspended and resumed as a result of voice receptions	C.4.5.f	M	Yes__ No__	
403.2.6.a.12	The Intranet layer timers shall not be suspended and resumed as a result of voice receptions	C.4.5.g	M	Yes__ No__	
403.2.6.a.13	Relative priorities of voice and data on the network shall be adjusted by selectively enabling or disabling physical and/or data link concatenation for a station	C.4.5.h	M	Yes__ No__	

A.7.3 <u>Communications Security Standards.</u>

Item	Protocol Feature	Reference	Status	Support	Notes
404	Communications Security Standards	APPENDIX D	O	Yes__ No__	
404.1	Interoperability	D.1.3	404:M	Yes__ No__	
404.1.a	The systems integrators and systems planners shall ensure that compatible media and signaling are chosen if interoperability is desired	D.1.3	404:M	Yes__ No__	
404.2	General Requirements	D.4	404:M	Yes__ No__	
404.2.a	The forward-compatible mode shall apply for all DTE subsystems with embedded COMSEC	D.4	404:M	Yes__ No__	
404.3	Detailed Requirements	D.5	404:M	Yes__ No__	
404.3.1	Traditional COMSEC Transmission Frame	D.5.1	404:O	Yes__ No__	
404.3.1.a	The traditional COMSEC transmission frame shall be composed of the following components:	D.5.1	404.3.1:M	Yes__ No__	
404.3.1.a.1	COMSEC Bit Synchronization	D.5.1.a	404.3.1.a:M	Yes__ No__	
404.3.1.a.2	COMSEC Frame Synchronization	D.5.1.b	404.3.1.a:M	Yes__ No__	
404.3.1.a.3	Message Indicator	D.5.1.c	404.3.1.a:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
404.3.1.a.4	Phasing	D.5.1.d	404.3.1.a:M	Yes__ No__	
404.3.1.a.5	Transmission Synchronization	D.5.1.e	404.3.1.a:M	Yes__ No__	
404.3.1.a.6	Data Field (incl. Transmission Header)	D.5.1.f	404.3.1.a:M	Yes__ No__	
404.3.1.a.7	COMSEC Postamble	D.5.1.g	404.3.1.a:M	Yes__ No__	
404.3.1.1	COMSEC Preamble Field	D.5.1.1	404.3.1:M	Yes__ No__	
404.3.1.1.a	The COMSEC preamble field shall consist of three components: a COMSEC bit synchronization subfield, a COMSEC frame synchronization subfield, and a Message Indicator (MI) subfield	D.5.1.1	404.3.1:M	Yes__ No__	
404.3.1.1.1	COMSEC Bit Synchronization Subfield	D.5.1.1.1	404.3.1:M	Yes__ No__	
404.3.1.1.1.a	This subfield shall be used to provide a signal for achieving bit synchronization and for indicating activity on a data link to the receiver	D.5.1.1.1	404.3.1:M	Yes__ No__	
404.3.1.1.1.b	The duration of the COMSEC bit synchronization subfield shall be selectable from 65 milliseconds to 1.5 seconds	D.5.1.1.1	404.3.1:M	Yes__ No__	
404.3.1.1.1.c	The COMSEC bit synchronization subfield shall consists of the data-rate clock signal for the duration of the subfield	D.5.1.1.1	404.3.1:M	Yes__ No__	
404.3.1.1.2	COMSEC Frame Synchronization Subfield	D.5.1.1.2	404.3.1:M	Yes__ No__	
404.3.1.1.2.a	This subfield shall be used to provide a framing signal indicating the start of the encoded MI to the receiving station	D.5.1.1.2	404.3.1:M	Yes__ No__	
404.3.1.1.2.b	This subfield shall be 465 bits long, consisting of 31 Phi-encoded bits	D.5.1.1.2	404.3.1:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
404.3.1.1.2.c	A logical 1 data bit shall be encoded as Phi(1) = 000100110101111 (MSB on the left), and logical 0 data bit shall be encoded as Phi(0) = 111011001010000 (MSB on the left)	D.5.1.1.2	404.3.1:M	Yes__ No__	
404.3.1.1.3	Message Indicator Subfield	D.5.1.1.3	404.3.1:M	Yes__ No__	
404.3.1.1.3.a	This subfield shall contain the COMSEC-provided MI, a stream of random bits that are redundantly encoded using Phi patterns	D.5.1.1.3	404.3.1:M	Yes__ No__	
404.3.1.2	Phasing	D.5.1.2, C.3.2.2	404.3.1:M	Yes__ No__	
404.3.1.2.a	This field shall be a string of alternating ones and zeros, beginning with a one, sent by the DTE	D.5.1.2	404.3.1:M	Yes__ No__	
404.3.1.3	Transmission Synchronization Field	D.5.1.3	404.3.1:M	Yes__ No__	
404.3.1.3.a	This field, consisting of the frame synchronization subfield, optional robust frame format subfield, and the TWC subfield, shall be as defined in 5.2.1.3	D.5.1.3	404.3.1:M	Yes__ No__	
404.3.1.4	Data Field	D.5.1.4	404.3.1:M	Yes__ No__	
404.3.1.4.a	This field, including Transmission Header, shall be as defined in 5.2.1.4	D.5.1.4, 5.2.1.4	404.3.1:M	Yes__ No__	
404.3.1.5	COMSEC Postamble Field	D.5.1.5	404.3.1:M	Yes__ No__	
404.3.1.5.a	This field shall be used to provide an end-of-transmission flag to the COMSEC at the receiving station	D.5.1.5	404.3.1:M	Yes__ No__	
404.3.1.6	COMSEC Algorithm	D.5.1.6	404.3.1:M	Yes__ No__	
404.3.1.6.a	The COMSEC algorithm shall be backward-compatible with VINSON equipment	D.5.1.6	404.3.1:M	Yes__ No__	
404.3.1.7	COMSEC Modes of Operation	D.5.1.7	404.3.1:M	Yes__ No__	
404.3.1.7.a	The COMSEC shall be operated in Mode A	D.5.1.7	404.3.1:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
404.3.1.7.b	The rekey functions shall be performed through the use of KY-57 rekeys for backward compatibility	D.5.1.7	404.3.1:M	Yes__ No__	
404.3.2	Embedded COMSEC Transmission Frame	D.5.2	404:O	Yes__ No__	
404.3.2.a	The embedded COMSEC transmission frame shall be composed of the following components:	D.5.2	404.3.2:M	Yes__ No__	
404.3.2.a.1	Phasing	D.5.2.a	404.3.2.a:M	Yes__ No__	
404.3.2.a.2	Frame Synchronization	D.5.2.b	404.3.2.a:M	Yes__ No__	
404.3.2.a.3	Optional Robust Frame Format	D.5.2.c	404.3.2.a:M	Yes__ No__	
404.3.2.a.4	Message Indicator	D.5.2.d	404.3.2.a:M	Yes__ No__	
404.3.2.a.5	Transmission Word Count	D.5.2.e	404.3.2.a:M	Yes__ No__	
404.3.2.a.6	Data Field	D.5.2.f	404.3.2.a:M	Yes__ No__	
404.3.2.a.7	COMSEC Postamble	D.5.2.g	404.3.2.a:M	Yes__ No__	
404.3.2.1	Phasing	D.5.2.1 C.3.2.2	404.3.2:M	Yes__ No__	
404.3.2.1.a	This field shall be a string of alternating ones and zeros, beginning with a one, sent by the DTE	D.5.2.1	404.3.2:M	Yes__ No__	
404.3.2.2	Frame Synchronization Subfield	D.5.2.2	404.3.2:M	Yes__ No__	
404.3.2.2.a	This subfield shall be either the Robust Frame Synchronization subfield or the Frame Synchronization subfield	D.5.2.2, 5.2.1.3.1.2 5.2.1.3.1.1	404.3.2:M	Yes__ No__	
404.3.2.3	Robust Frame Format Subfield	D.5.2.3	404.3.2:M	Yes__ No__	
404.3.2.3.a	When the Robust Frame Synchronization subfield is used, the Robust Frame Format subfield also shall be used	D.5.2.3 5.2.1.3.1.2	404.3.2:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
404.3.2.3.b	The Robust Frame Format subfield shall not be used when the Robust Frame Synchronization subfield is not used	D.5.2.3	404.3.2:M	Yes__ No__	
404.3.2.4	Message Indicator Field	D.5.2.4	404.3.2:M	Yes__ No__	
404.3.2.4.a	This field shall contain the MI, a stream of random data that shall be encoded using Golay	D.5.2.4 5.3.14.1 5.3.14.2	404.3.2:M	Yes__ No__	
404.3.2.4.b	The COMSEC shall provide the MI bits	D.5.2.4	404.3.2:M	Yes__ No__	
404.3.2.4.c	For backward compatibility, these MI bits shall be redundantly encoded using Phi patterns	D.5.2.4	404.3.2:M	Yes__ No__	
404.3.2.5	Transmission Word Count Subfield	D.5.2.5	404.3.2:M	Yes__ No__	
404.3.2.5.a	This subfield shall be as defined in 5.2.1.3.1.4	D.5.2.5 5.2.1.3.1.4	404.3.2:M	Yes__ No__	
404.3.2.6	Data Field	D.5.2.6	404.3.2:M	Yes__ No__	
404.3.2.6.a	This field, including Transmission Header, shall be as defined in 5.2.1.4	D.5.2.6 5.2.1.4	404.3.2:M	Yes__ No__	
404.3.2.7	COMSEC Postamble Field	D.5.2.7	404.3.2:M	Yes__ No__	
404.3.2.7.a	This field shall be used to provide an end-of-transmission flag to the COMSEC at the receiving station	D.5.2.7	404.3.2:M	Yes__ No__	
404.3.2.7.b	The flag shall be cryptographic function and may be used by the data terminal as an end-of-message flag as well	D.5.2.7	404.3.2:M	Yes__ No__	
404.3.2.8	COMSEC Algorithm	D.5.2.8	404.3.2:M	Yes__ No__	
404.3.2.9	COMSEC Modes of Operation	D.5.2.9	404.3.2:M	Yes__ No__	
404.3.2.9.a	COMSEC shall be operated in Mode A for all applications	D.5.2.9	404.3.2:M	Yes__ No__	
404.3.2.9.b	The rekey functions shall be performed through the use of KY-57 rekeys for backward-compatibility and shall be performed through over-the-air-rekeying (OTAR) techniques for forward compatibility	D.5.2.9	404.3.2:M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
404.3.2.9.c	Rekey signaling for OTAR shall be supplied by the host equipment	D.5.2.9	404.3.2:M	Yes__ No__	

A.7.4 CNR Management Processes using XNP.

Item	Protocol Feature	Reference	Status	Support	Notes
405	CNR Management Processes using XNP	APPENDIX E	O	Yes__ No__	
405.1	Network Configuration	E.3	405:M	Yes__ No__	
405.2	Exchange Network Parameters (XNP) Message	E.4	405:M	Yes__ No__	
405.2.1	XNP Message Structure	E.4.1	405.2:M	Yes__ No__	
405.2.1.a	Undefined bits shall be set to zero on transmission and ignored on receipt	E.4.1	405.2:M	Yes__ No__	
405.2.1.b	The processing of XNP messages containing undefined/invalid values shall be:	E.4.1	405.2:M	Yes__ No__	
405.2.1.b.1	Ignore any undefined bits in a bit map	E.4.1.a	405.2.1.b:M	Yes__ No__	
405.2.1.b.2	If the Version Number is invalid or unsupported, discard the XNP message	E.4.1.b	405.2.1.b:M	Yes__ No__	
405.2.1.b.3	If any field in the Forwarding Header is invalid, discard the XNP message	E.4.1.c	405.2.1.b:M	Yes__ No__	
405.2.1.b.4	If the Message Number field is invalid, discard the XNP message	E.4.1.d	405.2.1.b:M	Yes__ No__	
405.2.1.b.5	If the Length field is invalid in any Message Block (i.e., the value indicates that there are more octets than actually exist in the XNP message), discard the rest of the XNP message and continue processing the XNP message.	E.4.1.e	405.2.1.b:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
405.2.1.b.6	If the Block Number field is invalid in any XNP message, discard the block and continue processing the XNP message	E.4.1.f	405.2.1.b:M	Yes__ No__	
405.2.1.b.7	If the Length field is invalid in any Data Block (i.e., the value indicates that there are more octets than actually exist in the XNP message), discard the rest of the XNP message but act on the preceding blocks if possible	E.4.1.g	405.2.1.b:M	Yes__ No__	
405.2.1.b.8	If any other field is invalid in any Data Block, discard the data block and continue processing the XNP message	E.4.1.h	405.2.1.b:M	Yes__ No__	
405.2.1.b.9	If any other field is invalid in an XNP message, discard the XNP message	E.4.1.i	405.2.1.b:M	Yes__ No__	
405.2.1.1	Forwarding Header	E.4.1.1	405.2:M	Yes__ No__	
405.2.1.1.a	An "Unknown" Forwarder Link Address shall be represented by a value of 0 (zero)	E.4.1.1	405.2:M	Yes__ No__	
405.2.1.2	Message and Data Block Structure	E.4.1.2	405.2:M	Yes__ No__	
405.2.1.2.a	Any blocks or messages appearing after the Terminator Block shall be ignored	E.4.1.2	405.2:M	Yes__ No__	
405.2.2	XNP Message Formats	E.4.2	405.2:M	Yes__ No__	
405.2.2.1	Join Request	E.4.2.1	O	Yes__ No__	
405.2.2.1.a	If there is no URN a unique identifier shall be assigned to each potential user by a mechanism outside the scope of this appendix	E.4.2.1	405.2.2.1:M	Yes__ No__	
405.2.2.2	Join Accept	E.4.2.2	O	Yes__ No__	
405.2.2.3	Join Reject	E.4.2.3	O	Yes__ No__	
405.2.2.4	Hello Message	E.4.2.4	405.2:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
405.2.2.4.a	When a station receives a Hello message, it shall update its topology tables	E.4.2.4	405.2:M	Yes__ No__	
405.2.2.5	Goodbye Message	E.4.2.5	405.2:M	Yes__ No__	
405.2.2.5.a	When a station receives a Goodbye message, it shall update its topology tables	E.4.2.5	405.2:M	Yes__ No__	
405.2.2.6	Parameter Update Request Message	E.4.2.6	O	Yes__ No__	
405.2.2.7	Parameter Update Message	E.4.2.7	O	Yes__ No__	
405.2.2.7.a	The Parameter Update message shall be sent in response to the Parameter Update Request message	E.4.2.7	405.2.2.7:M	Yes__ No__	
405.2.2.8	Delay Time Message	E.4.2.8	O	Yes__ No__	
405.2.2.9	Status Notification Message	E.4.2.9	O	Yes__ No__	
405.2.2.9.a	A receiving station that is using a different set of parameter values (different parameter update identifier) shall notify the network controller and request the latest update	E.4.2.9	405.2.2.9:M	Yes__ No__	
405.2.2.9.b	Update shall be accomplished using the Parameter Update message	E.4.2.9	405.2.2.9:M	Yes__ No__	
405.2.2.9.c	The parameter update message shall utilize reliable link layer transmission services Type 3 ACK	E.4.2.9	405.2.2.9:M	Yes__ No__	
405.2.3	XNP Data Block Formats	E.4.3	405.2:M	Yes__ No__	
405.2.3.1	Block 1, Station Identification	E.4.3.1	405.2.2.7:M	Yes__ No__	
405.2.3.1.a	Block 1 consists of one field which is used to identify the station being reported. It is used with the Parameter Update message to identify the station to which the parameters apply, in Block 2, and/or Block 11 (that shall be preceded by Block 1).	E.4.3.1	405.2.2.7:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
405.2.3.2	Block 2, Basic Network Parameters	E.4.3.2	405.2.2.1:M 405.2.2.2:O 405.2.2.4:O 405.2.2.6:O 405.2.2.7:O	Yes__ No__ Yes__ No__ Yes__ No__ Yes__ No__ Yes__ No__	
405.2.3.3	Block 3, Configuration Parameters	E.4.3.3	403.2.1.3:M 403.2.2:M 403.2.3:M	Yes__ No__ Yes__ No__ Yes__ No__	
405.2.3.4	Block 4, Type 3 Parameters	E.4.3.4	203.3:M 405.2.2.2:M 405.2.2.6:O 405.2.2.7:O	Yes__ No__ Yes__ No__ Yes__ No__ Yes__ No__	
405.2.3.5	Block 5, Deterministic NAD Parameters	E.4.3.5	202.4.3:M 202.4.5:M	Yes__ No__ Yes__ No__	
405.2.3.6	Block 6, Probabilistic NAD Parameters	E.4.3.6	202.4.1:M 202.4.2:M	Yes__ No__ Yes__ No__	
405.2.3.7	Block 7, RE-NAD Parameters	E.4.3.7	202.4.4:M	Yes__ No__	
405.2.3.8	Block 8, Wait Time	E.4.3.8	O	Yes__ No__	
405.2.3.9	Block 9, Type 2 Parameters	E.4.3.9	203.2:M	Yes__ No__	
405.2.3.10	Block 10, Type 4 Parameters	E.4.3.10	203.4:M	Yes__ No__	
405.2.3.11	Block 11, NAD Ranking	E.4.3.11	202.4.3:M 202.4.5:M	Yes__ No__ Yes__ No__	
405.2.3.12	Block 12, Intranet Parameters	E.4.3.12	O	Yes__ No__	
405.2.3.12.a	The Intranet parameters shall be provided to joining stations to provide information for Intranet relaying within the local network	E.4.3.12	405.2.3.12:M	Yes__ No__	
405.2.3.12.b	This block shall be included with the Join Accept and Parameter Update messages	E.4.3.12	405.2.3.12:M	Yes__ No__	
405.2.3.13	Block 13, Error	E.4.3.13	O	Yes__ No__	
405.2.3.14	Block 14, Address Designation Parameters	E.4.3.14	O	Yes__ No__	
405.3	XNP Message Exchange	E.5	405.2:M	Yes__ No__	
405.3.a	XNP messages shall be exchanged using a UI command frame	E.5	405.2:M	Yes__ No__	
405.3.1	Data Link Addressing	E.5.1	405.2:M	Yes__ No__	

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405.3.1.a	If a station has not been assigned a data link address, it shall use this special data link address for network entry until an individual data link address has been assigned or selected	E.5.1	405.2:M	Yes__ No__	
405.3.1.b	The forwarder shall provide the full source directed relay path to the network controller at the Intranet layer	E.5.1	405.2:M	Yes__ No__	
405.3.1.c	The network controller shall use this same path in reverse to reach the joining station through the forwarder	E.5.1	405.2:M	Yes__ No__	
405.3.2	Poll/Final Bit	E.5.2	405.2:M	Yes__ No__	
405.3.3	Network Access	E.5.3	405.2:M	Yes__ No__	
405.3.3.a	MIL-STD-188-220 allows a network to choose among the network access delay methods defined in APPENDIX C. Each station that operates on the network shall use the same method.	E.5.3 APPENDIX C	405.2:M	Yes__ No__	
405.3.3.b	In the case that the network access method is unknown, a random method (R-NAD or RE-NAD) shall be used for the Join Request method	E.5.3	202.4.1:M 202.4.4:M	Yes__ No__ Yes__ No__	
405.3.3.c	When R-NAD is used, the default number of stations shall be 7 unless another number is known	E.5.3	202.4.1:M	Yes__ No__	
405.4	Network Joining Procedures	E.6	405.2:M	Yes__ No__	
405.4.1	Joining Concept	E.6.1	405.2:M	Yes__ No__	
405.4.1.a	When the joining station receives a Join Accept message response from the network controller, it shall broadcast a Hello message announcing entry to the network	E.6.1	405.2:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
405.4.1.b	Other members of the network shall update their topology tables upon receipt of the Hello message	E.6.1	405.2.2.4:M	Yes__ No__	
405.4.1.c	Other members of the network shall update their topology tables upon receipt of the Join Reject message	E.6.1	405.2.2.3:M	Yes__ No__	
405.4.1.d	When a station leaves a network, it shall send a Goodbye message	E.6.1	405.2:M	Yes__ No__	
405.4.1.e	Other members of the network shall update their topology tables upon receipt of the Goodbye message	E.6.1	405.2.2.5:M	Yes__ No__	
405.4.2	Procedures for Joining a Network	E.6.2	405.2:M	Yes__ No__	
405.4.2.a	The joining station shall send a Join Request message to the network controller	E.6.2	405.2:M	Yes__ No__	
405.4.2.b	The Join Request message shall be addressed to the network controller using the special data link address of 2 as the destination and the special data link address of 1 as the source in the UI frame	E.6.2	405.2:M	Yes__ No__	
405.4.2.c	If the joining station is unable to contact the network controller because of distance or topology, there will be no response to the Join Request message. In this event, the joining station shall retransmit the Join Request message after the Join Response Timer expires until the Maximum Number of Join Retries has been exceeded or until either a Join Reject or Join Accept message is received	E.6.2	405.2:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
405.4.2.d	If the maximum number of Join Retries is exceeded, the joining station shall then address a UI frame containing the Join Request message to the Global address	E.6.2	405.2:M	Yes__ No__	
405.4.2.e	The joining station shall continue sending the Join Request message to the Global address after the Join Response Timer expires until a response is received from an existing network member	E.6.2	405.2.2.1:M	Yes__ No__	
405.4.2.f	All network members that receive the globally addressed Join Request message, and intend to participate in the joining procedure, shall send a Delay Time message with an XNP Forwarding Header in response to the joining station	E.6.2	405.2.2.1:M	Yes__ No__	
405.4.2.g	The joining station shall select one of the responding stations as forwarder and resend the Join Request to the network controller using the forwarding parameters in the Forwarding Header received from the selected station	E.6.2	405.2:M	Yes__ No__	
405.4.2.h	The selected forwarder shall relay this Join Request to the network controller and forward the network controller's response (Join Accept or Join Reject message) back to the joining station	E.6.2	405.2:M	Yes__ No__	
405.4.2.i	The Join Accept message shall specify the data link address of the joining station	E.6.2	405.2:M	Yes__ No__	
405.4.2.j	The joining station shall expect the network controller response before expiration of the Delay Timer (the period of time specified in the selected forwarder's Delay Time message)	E.6.2	405.2:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
405.4.2.k	If the Delay Timer expires, the joining station shall try each responder in turn in an attempt to contact the network controller	E.6.2	405.2:M	Yes__ No__	
405.4.2.m	When the joining station receives a Join Accept message response from the network controller, it shall prepare a Hello message announcing entry to the network	E.6.2	405.2:M	Yes__ No__	
405.4.2.n	The Hello message shall use the joining station's assigned data link address (provided in the Join Accept message) as the source address and shall include both the forwarder's data link address and the Global multicast address as destinations in the UI frame	E.6.2	405.2.2.4:M	Yes__ No__	
405.4.2.o	The UI frame carrying this Hello message shall have the P-bit set	E.6.2	405.2.2.4:M	Yes__ No__	
405.4.2.p	The forwarder shall return a Type 3 acknowledgment to the joining station and then complete the broadcast of the Hello message to all network members	E.6.2	405.2.2.4:M	Yes__ No__	
405.4.2.q	The forwarder shall set the maximum hop count in the Intranet Header of the message to restrict the amount of relaying	E.6.2	405.2:M	Yes__ No__	
405.4.3	BLANK	NA	NA	---	
405.4.4	Joining Procedure Examples	E.6.4	405.2:M	Yes__ No__	
405.4.4.1	Fully Connected Network	E.6.4.1	405.2:M	Yes__ No__	
405.4.4.1.1	Sequence of Events	E.6.4.1.1	405.2:M	Yes__ No__	
405.4.4.1.2	Message Formats	E.6.4.1.2	405.2:M	Yes__ No__	
405.4.4.2	Disconnected Joiner	E.6.4.2	405.2:M	Yes__ No__	
405.4.4.2.1	Sequence of Events	E.6.4.2.1	405.2:M	Yes__ No__	
405.4.4.2.2	Message Formats	E.6.4.2.2	405.2:M	Yes__ No__	

A.7.5 Golay Coding Algorithm.

Item	Protocol Feature	Reference	Status	Support	Notes
406	Golay Coding Algorithm	APPENDIX F	102.1.3.1:M 102.1.3.2:M 102.1.3.3:X	Yes__ No__ Yes__ No__ No	
406.1	Forward Error Correction	F.3	406:M	Yes__ No__	
406.2	Golay Code	F.4	406:M	Yes__ No__	
406.2.1	Half-rate Golay Code	F.4.1	406.2:M	Yes__ No__	
406.2.2	Golay Code Implementation	F.4.2	406.2:M	Yes__ No__	
406.2.2.1	Hardware Implementation	F.4.2.1	406.2:O.<2>	Yes__ No__	
406.2.2.2	Hardware Decoding	F.4.2.2	406.2.2.1:M	Yes__ No__	
406.2.2.3	Software Implementation	F.4.2.3	406.2:O.<2>	Yes__ No__	
406.2.2.3.a	The transmitting DMTD shall generate the check bits using the following generator polynomial: $g(x)=x^{11} + x^{10} + x^6 + x^5 + x^4 + x^2 + 1$	F.4.2.3	406.2.2.3:M	Yes__ No__	
406.2.2.3.b	The 11 check bits shall be as derived from the generator matrix G, where the matrix contains the coefficients of the polynomials on the left	F.4.2.3	406.2.2.3:M	Yes__ No__	

A.7.6 Packet Construction and Bit Ordering.

Item	Protocol Feature	Reference	Status	Support	Notes
407	Packet Construction and Bit Ordering	APPENDIX G	M	Yes__ No__	
407.1	PDU Construction	G.3	M	Yes__ No__	
407.1.1	VMF Message Data Exchange	G.3.1	M	Yes__ No__	
407.1.1.1	Example of VMF Message Data Construction	G.3.1.1	NA	---	
407.1.2	Application Layer Data Exchange	G.3.2	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
407.1.2.1	Example of Application Layer PDU	G.3.2.1	NA	---	
407.1.3	Transport Layer Data Exchange	G.3.3	M	Yes__ No__	
407.1.3.1	An example of Segmentation / Reassembly (S/R) Data Segment construction	G.3.3.1	NA	---	
407.1.3.2	An Example of UDP Header Construction	G.3.3.2	X	---	
407.1.4	Network Layer Data Exchange	G.3.4	M	Yes__ No__	
407.1.4.1	Example of Internet Layer Header	G.3.4.1	102.1.3.1:M 102.1.3.2:M 102.1.3.3:X	Yes__ No__ Yes__ No__ No	
407.1.4.2	Example of Intranet Layer Header	G.3.4.2	102.1.3.1:M 102.1.3.2:M 102.1.3.3:X	Yes__ No__ Yes__ No__ No	
407.1.5	BLANK	G.3.5	NA	---	
407.1.6	Data Link Layer Data Exchange	G.3.6	M	Yes__ No__	
407.1.6.1	Example of Data Link Layer PDU	G.3.6.1	102.1.3.1:M 102.1.3.2:M 102.1.3.3:X	Yes__ No__ Yes__ No__ No	
407.1.6.1.1	Zero Bit Insert/v36 Scramble/FEC/TDC of the Data Link Frame	G.3.6.1.1	M	Yes__ No__	
407.1.6.1.2	Construction of the Transmission Header	G.3.6.1.2	M	Yes__ No__	
407.1.6.1.3	Zero Bit Insert/v36 Scramble/FEC of the Transmission Header	G.3.6.1.3	M	Yes__ No__	
407.1.6.1.4	Completed Data Link Layer PDU to be Passed to the Physical Layer	G.3.6.1.4	M	Yes__ No__	
407.1.7	Physical Layer Data Exchange	G.3.7	M	Yes__ No__	
407.1.7.1	Physical Layer Processing Example	G.3.7.1	102.1.3.1:M 102.1.3.2:M 102.1.3.3:X	Yes__ No__ Yes__ No__ No	
407.1.7.1.1	Transmit Word Count (TWC)	G.3.7.1.1	M	Yes__ No__	
407.1.7.1.2	FEC & TDC of Transmission Header	G.3.7.1.2	M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
407.1.7.1.3	The Physical Layer PDU	G.3.7.1.3	M	Yes__ No__	

A.7.7 Intranet Topology Update.

Item	Protocol Feature	Reference	Status	Support	Notes
408	Intranet Topology Update	APPENDIX H	301.2:M	Yes__ No__	
408.1	Problem Overview	H.3	301.2:M	Yes__ No__	
408.1.1	Routing Trees	H.3.1	301.2:M	Yes__ No__	
408.2	Topology Updates	H.4	301.2:M	Yes__ No__	
408.2.1	Exchanging Routing Trees	H.4.1	301.2:M	Yes__ No__	
408.2.2	Topology Tables	H.4.2	301.2:M	Yes__ No__	
408.2.3	Sparse Routing Trees	H.4.3	301.2:M	Yes__ No__	
408.2.4	Rules for Exchanging Topology Updates	H.4.4	301.2:M	Yes__ No__	
408.2.4.1	Topology Update Triggers	H.4.4.1	301.2:M	Yes__ No__	
408.2.4.2	Sending Topology Update Messages	H.4.4.2	301.2:M	Yes__ No__	
408.2.5	Non-relayers	H.4.5	301.2:M	Yes__ No__	
408.2.5.a	Non-relayer nodes remain in the sparse routing trees; however, they shall not have any subsequent branches	H.4.5	301.2:M	Yes__ No__	
408.2.5.b	Their entries in the routing table shall have the NR bit set to 1	H.4.5	301.2:M	Yes__ No__	
408.2.6	Quiet Nodes	H.4.6	301.2:M	Yes__ No__	
408.2.6.a	Nodes in the quiet state may appear in the sparse routing tables and in update packets with the QUIET bit set to 1; however, they shall not have any subsequent branches in the routing tree	H.4.6	301.2:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
408.2.6.b	Nodes wishing to announce that they are entering quiet mode shall add a separate entry into the sparse routing table and update packets with NODE ADDRESS and NODE PREDECESSOR set to their own address and the QUIET bit set to 1	H.4.6	301.2:M	Yes__ No__	
408.2.7	Topology Update Request Messages	H.4.7	301.2:M	Yes__ No__	

A.7.8 Source Directed Relay.

Item	Protocol Feature	Reference	Status	Support	Notes
409	Source Directed Relay	APPENDIX I	301.1.a:M	Yes__ No__	
409.1	Problem Overview	I.3	409:M	Yes__ No__	
409.2	Procedure	I.4	409:M	Yes__ No__	
409.2.1	Forward Routing	I.4.1	409:M	Yes__ No__	
409.2.1.a	The source shall calculate the path through the intranet network to reach each destination	I.4.1	409:M	Yes__ No__	
409.2.1.b	The specific source directed route for each destination shall be encoded into the intranet header	I.4.1	409:M	Yes__ No__	
409.2.2	End-to-end intranet Acknowledgments	I.4.2	409:M	Yes__ No__	
409.3	Examples	I.5	NA	---	
409.3.1	Example 1	I.5.1	NA	---	
409.3.2	Example 2	I.5.2	NA	---	
409.3.3	Example 3	I.5.3	NA	---	
409.3.4	Relay Processing	I.5.4	NA	---	
409.3.4.1	Relay Processing at Node C	I.5.4.1	NA	---	
409.3.4.2	Relay Processing at Node F	I.5.4.2	NA	---	

A.7.9 Robust Communications Protocol.

Item	Protocol Feature	Reference	Status	Support	Notes
410	Robust Communications Protocol	APPENDIX J	102.1.3.d:M	Yes__ No__	
410.1	Introduction	J.3	410:M	Yes__ No__	
410.1.1	Physical Protocol Components	J.3.1	410.1:M	Yes__ No__	
410.1.2	Optional Rate 1/3 Convolutional Coding	J.3.2	410.1:O	Yes__ No__	
410.1.2.a	The G2 output shall be inverted to provide some data scrambling capability	J.3.2	410.1.2:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
410.1.3	Optional Data Scrambling	J.3.3	410.1:O	Yes__ No__	
410.1.3.a	Physical layer data scrambling shall use the scrambler and descrambler described in FIGURE J-3	J.3.3	410.1.3:M	Yes__ No__	
410.1.3.b	Physical layer data scrambling shall use the pseudo-noise (PN) generator specified in CCITT V.33 Annex A	J.3.3	410.1.3:M	Yes__ No__	
410.1.3.c	The shift register D_s shall be initialized to zero before the first bit of data is scrambled on transmission	J.3.3	410.1.3:M	Yes__ No__	
410.1.3.d	On data reception, the descrambler shift register D_s shall be initialized to zero before the first received data bit is de-scrambled	J.3.3	410.1.3:M	Yes__ No__	
410.1.4	Optional Robust Multi-Dwell	J.3.4	410.1:O	Yes__ No__	
410.1.4.1	Multi-Dwell Packet Format	J.3.4.1	410.1.4:M	Yes__ No__	
410.1.4.1.a	When the HAVEQUICK II compatible radio is in active mode, multi-dwell packetizing shall be enabled	J.3.4.1	410.1.4.1:M	Yes__ No__	
410.1.4.2	Multi-Dwell SOP Field	J.3.4.2	410.1.4.1:M	Yes__ No__	
410.1.4.2.a	The length of the SOP pattern shall be determined by bits two, three and four of the robust frame format	J.3.4.2	410.1.4.2:M	Yes__ No__	
410.1.4.3	Multi-Dwell Segment Count Field	J.3.4.3	410.1.4.1:M	Yes__ No__	
410.1.4.3.a	The six required bits shall be encoded as 1, 3, or 5 BCH (15, 7) codewords depending on bits 2, 3, and 4 of the robust frame format	J.3.4.3	410.1.4.3:M	Yes__ No__	
410.1.4.3.b	The six-bit segment counter shall occupy the 6 LSBs of the seven-bit BCH data field	J.3.4.3	410.1.4.3:M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
410.1.4.3.c	The MSB of the data field shall be used as an end-of-frame flag which, when set, indicates that data transmission is complete	J.3.4.3	410.1.4.3:M	Yes__ No__	
410.1.4.3.d	A multi-dwell packet marked with an end-of-frame flag shall contain only the SOP pattern and the segment count field used to make the segment number of the first fill data segment transmitted in the previous packet	J.3.4.3	410.1.4.3:M	Yes__ No__	
410.1.4.3.e	If no fill data is included in the previous segment, the segment count field shall point to the last segment data plus one	J.3.4.3	410.1.4.3:M	Yes__ No__	
410.1.4.4	Multi-Dwell Data Segments	J.3.4.4	410.1.4:M	Yes__ No__	
410.1.4.4.a	Each multi-dwell packet shall contain 6, 11 or 13 consecutive 64-bit data segments	J.3.4.4	410.1.4.4:M	Yes__ No__	
410.1.4.4.b	Unless a channel interruption is detected during the transmission of the packet, each data segment shall contain the next 64 bits supplied by the data link layer for transmission	J.3.4.4	410.1.4.4:M	Yes__ No__	
410.1.4.4.c	The last multi-dwell packet shall contain pad bits and segments as necessary to complete the packet	J.3.4.4	410.1.4.4:M	Yes__ No__	
410.1.4.4.d	The transmitted pad data shall be an alternating one/zero sequence	J.3.4.4	410.1.4.4:M	Yes__ No__	
410.1.4.5	Multi-Dwell Hop Detection	J.3.4.5	410.1.4:M	Yes__ No__	
410.1.4.5.a	The physical layer shall have the means of detecting or predicting communications link outages	J.3.4.5	410.1.4.5:M	Yes__ No__	
410.1.4.6	Multi-Dwell Transmit Processing	J.3.4.6	410.1.4:M	Yes__ No__	
410.1.4.6.a	Data received from the data link layer for transmission shall be broken into 64 bit segments for transmission	J.3.4.6	410.1.4.6:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
410.1.4.6.b	The data shall be packetized as stated in J.3.4.1	J.3.4.6	410.1.4.6:M	Yes__ No__	
410.1.4.6.c	Packets shall be transmitted consecutively with the segment count field containing the count, modulo 64, of the first segment in the packet until a communications link outage is detected, at which time, the remainder of the data segments in the currently transmitted packet shall be filled with an alternating one/zero pattern	J.3.4.6	410.1.4.6:M	Yes__ No__	
410.1.4.6.d	The alternating one/zero pattern shall start soon enough to prevent a receiver from detecting a SOP header and segment count that would prematurely release segments that have been corrupted by a frequency hop	J.3.4.6	410.1.4.6:M	Yes__ No__	
410.1.4.6.e	If the configurable hop recovery time (HRT), is greater than the time remaining to complete the transmission of the current packet, the alternating one/zero sequence shall be extended to the end of the HRT period	J.3.4.6	410.1.4.6:M	Yes__ No__	
410.1.4.6.f	If a hop is detected during the multi-dwell SOP field, multi-dwell segment count field, or during the transmission of the first two segments, the entire multi-dwell packet shall be retransmitted	J.3.4.6	410.1.4.6:M	Yes__ No__	
410.1.4.6.g	The first multi-dwell packet transmitted in a frame shall not contain the multi-dwell SOP field or multi-dwell segment count field	J.3.4.6	410.1.4.6:M	Yes__ No__	
410.1.4.6.h	The SOP and the segment count field shall not be transmitted during a possible frequency hop	J.3.4.6	410.1.4.6:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
410.1.4.6.i	The implementation shall develop an algorithm to establish when possible frequency hops may occur and adjust the timing of the data transmission to avoid transmitting a header during any possible hop	J.3.4.6	410.1.4.6:M	Yes__ No__	
410.1.4.6.1	Hop Data Recovery Time Period	J.3.4.6.1	410.1.4.6:M	Yes__ No__	
410.1.4.6.1.a	A configurable variable called the HRT shall be used to determine if the fill data transmitted following a hop shall be extended to ensure that the following multi-dwell synchronization field can be received	J.3.4.6.1	410.1.4.6.1:M	Yes__ No__	
410.1.4.6.1.b	Because different hop detection/prediction methods flag the hop at different times relative to the beginning of the transmitting RF synthesizer frequency slew, the configured HRT shall be internally adjusted to insure that different DTEs in a network can all use the same configurable HRT	J.3.4.6.1	410.1.4.6.1:M	Yes__ No__	
410.1.4.6.2	Data Transmitted After a Hop	J.3.4.6.2	410.1.4.6:M	Yes__ No__	
410.1.4.6.2.a	The multi-dwell packet transmitted directly following a communications link outage shall retransmit data starting with the 64-bit segment preceding the segment that was being transmitted when the hop was detected plus sufficient segments to account for the transmitter pipeline delay if appropriate	J.3.4.6.2	410.1.4.6.2:M	Yes__ No__	
410.1.4.6.3	Termination of Transmission	J.3.4.6.3	410.1.4.6:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
410.1.4.6.3.a	After the final packet of the frame is transmitted, without a hop detected during a data segment containing actual data (not fill data), data transmission shall be terminated	J.3.4.6.3	410.1.4.6.3: M	Yes__ No__	
410.1.4.6.3.b	To prevent receive delays caused by the receiver not being able to determine that the last data segment has been received, a truncated multi-dwell packet shall be sent with the end-of-frame flag set	J.3.4.6.3	410.1.4.6.3: M	Yes__ No__	
410.1.4.6.3.c	The segment count associated with the end-of-frame flag shall mark the first fill data segment transmitted	J.3.4.6.3	410.1.4.6.3: M	Yes__ No__	
410.1.4.6.3.d	If no fill data is included in the previous segment, the segment count field shall point to the last segment data plus one	J.3.4.6.3	410.1.4.6.3: M	Yes__ No__	
410.1.4.6.3.e	The TP timer shall be recalculated based upon reception of the last bit of the segment counter of the truncated multi-dwell packet	J.3.4.6.3	410.1.4.6.3: M	Yes__ No__	
410.1.4.7	Multi-Dwell Receive Processing	J.3.4.7	410.1.4:M	Yes__ No__	
410.1.4.7.a	If the multi-dwell flag was set in the robust synchronization field, the receiver shall buffer the multi-dwell data packet	J.3.4.7	410.1.4.7:M	Yes__ No__	
410.1.4.7.b	The segment count for the first multi-dwell packet in a frame shall be assumed to be zero	J.3.4.7	410.1.4.7:M	Yes__ No__	
410.1.4.7.c	After the last packet bit is received, the receiver shall open the SOP correlation window	J.3.4.7	410.1.4.7:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
410.1.4.7.d	When the SOP pattern is recognized, the segment count shall be decoded using the combination of majority and BCH decoding specified in the robust synchronization field	J.3.4.7	410.1.4.7:M	Yes__ No__	
410.1.4.7.1	Receive End of Frame Detection	J.3.4.7.1	410.1.4.7:M	Yes__ No__	
410.1.4.7.1.a	The data remaining in the multi-dwell receive data buffer shall be provided to the higher-level protocol when an end-of-frame condition is detected	J.3.4.7.1	410.1.4.7.1:M	Yes__ No__	
410.1.4.7.1.b	The end-of-frame condition shall be determined by the multi-dwell end-of-frame flag	J.3.4.7.1	410.1.4.7.1:M	Yes__ No__	
410.1.4.7.1.c	If the end-of-frame flag is not detected before bit synchronization is lost then all buffered packets shall be released to the upper level protocol for receive processing	J.3.4.7.1	410.1.4.7.1:M	Yes__ No__	
410.1.4.7.2	Optional Soft Decision Information	J.3.4.7.2	410.1.4.7:O	Yes__ No__	
410.1.4.7.2.a	If fewer than three consecutive segment counts cannot be corrected the correct number of bits shall be supplied to the upper level protocol as to not cause a bit slip, and consequently, the loss of the remaining data in the frame	J.3.4.7.2	410.1.4.7.2:M	Yes__ No__	
410.1.4.8	Multi-Dwell Majority Logic Overhead Choice	J.3.4.8	410.1.4:M	Yes__ No__	
410.1.4.9	Multi-Dwell Overhead	J.3.4.9	410.1.4:M	Yes__ No__	
410.1.4.9.a	The multi-dwell protocol introduces an overhead that shall be considered in the network timing calculations	J.3.4.9	410.1.4.9:M	Yes__ No__	

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410.1.4.9.b	The six-segment multi-dwell packet shall be used for protocol acknowledgments and other single TDC block messages	J.3.4.9	410.1.4.9:M	Yes__ No__	
410.1.4.9.c	The calculated realized data rate shall be used for the bit rate of all data encapsulated by the multi-dwell protocol	J.3.4.9	410.1.4.9:M	Yes__ No__	
410.1.4.9.1	Terminals Lacking Hop Detection	J.3.4.9.1	410.1.4.9:M	Yes__ No__	
410.1.4.9.1.a	Since there is no hop timing information available, the DTE shall assume that the radio will hop at every possible time slot	J.3.4.9.1	410.1.4.9.1:M	Yes__ No__	
410.1.4.9.1.b	All DMTDs shall implement the capabilities to detect radio hops by monitoring the hop synch output signal from the HAVEQUICK II radio	J.3.4.9.1	410.1.4.9.1:M	Yes__ No__	
410.1.5	Robust Communications Protocol Network Timing	J.3.5	403:M	Yes__ No__	
410.1.5.1	Net Busy Sensing	J.3.5.1	410.1.5:M	Yes__ No__	
410.1.5.2	Response Hold Delay	J.3.5.2	410.1.5:M	Yes__ No__	
410.1.5.2.a	If it cannot be guaranteed that the entire acknowledgment can be transmitted on a single hop dwell all robust Type 3 coupled acknowledgments shall use the robust frame format 3 (MV 3:5, 6 segments)	J.3.5.2	410.1.5.2:M	Yes__ No__	
410.1.5.2.b	It should be noted that a multi-dwell format shall be used unless it is known that the current dwell is “long” because it cannot be assumed that network ELAG and HRT will allow a non multi-dwell acknowledgment on the shortest HAVEQUICK II dwell	J.3.5.2	410.1.5.2:M	Yes__ No__	

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410.1.5.2.c	All other characteristics of the response that will affect its length (e.g. FEC, TDC) are determined by the network configuration and shall be the same for all users	J.3.5.2	410.1.5.2:M	Yes__ No__	
410.1.5.2.d	In cases where the dwell length is not know, additional TRANSEC delays shall be accounted for by assuming the worst-case frequency hopping (Hop_All)	J.3.5.2	410.1.5.2:M	Yes__ No__	
410.1.5.2.1	Multi-Dwell Response	J.3.5.2.1	410.1.5.2:M	Yes__ No__	
410.1.5.2.1.a	All nodes in a network shall use the configured EPRE value to determine if there will be a "long" dwell in which to transmit acknowledgments to determine which acknowledgment method to use for that network	J.3.5.2.1	410.1.5.2.1:M	Yes__ No__	
410.1.5.2.2	Response Transmission Example	J.3.5.2.2	410.1.5.2:M	Yes__ No__	
410.1.5.2.2.a	Typically, the COMSEC bit synchronization time is not very accurate and may be long enough to push the MI field to the end of the guaranteed "long" dwell time. For this reason, the DTE shall wait to start data transmission on the first hop dwell following the long guaranteed dwell.	J.3.5.2.2	410.1.5.2.2:M	Yes__ No__	
410.1.5.2.3	Estimation of Multi-Dwell n_1	J.3.5.2.3	410.1.5.2:M	Yes__ No__	
410.1.5.2.4	Receive Processing Delays	J.3.5.2.4	410.1.5.2:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
410.1.5.2.4.a	In order to calculate the reference point for the RHD and TP timers, the receiving DTE shall know the time of arrival of the last bit of the transmission	J.3.5.2.4	410.1.5.2.4: M	Yes__ No__	
410.1.5.2.4.b	The received data rate of a multi-dwell transmission is not known. For this reason, when a multi-dwell transmission is received, the physical layer shall tag the time of arrival of the final multi-dwell bit.	J.3.5.2.4	410.1.5.2.4: M	Yes__ No__	
410.1.5.3	Timeout Period (TP)	J.3.5.3	410.1.5:M	Yes__ No__	
410.1.5.4	Network Access Delay (NAD)	J.3.5.4	410.1.5:M	Yes__ No__	
410.1.6	Application Guidance for the HAVEQUICK II Link	J.3.6	410.1:M	Yes__ No__	
410.1.6.1	Frequency Hop Synchronization	J.3.6.1	410.1.6:M	Yes__ No__	
410.1.6.1.a	To avoid the loss of critical data, such as the cryptographic synchronization and/or the protocol SOM patterns, the DTE transmission timing shall be synchronized to the frequency hops through use of hop detection and prediction	J.3.6.1	410.1.6.1:M	Yes__ No__	
410.1.7	Summary	J.3.7	410.1:M	Yes__ No__	
410.1.7.a	To maintain network timing using the Type 3 timing equations, the RHD shall be extended by inflating the S time for a fixed Type 3 acknowledgment transmit frame format for multi-dwell operation assuming the worst case hop rate (Hop_All)	J.3.7	410.1.7:M	Yes__ No__	
410.1.7.b	Since the message transmission time is variable, the time-out period (TP) sync point shall be figured from the final frame flag at the end of the transmission	J.3.7	410.1.7:M	Yes__ No__	
410.2	PDU Construction	J.4	410:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
410.2.a	The examples as shown in section J.4 shall be used to clarify robust PDU transmission order and processing order (i.e. scrambling, convolutional coding, and formation of packets)	J.4	410.2:M	Yes__ No__	
410.2.1	Robust PDU Header	J.4.1	410.2:M	Yes__ No__	
410.2.1.a	The robust PDU header shall be inserted first when implementing Robust Communications Protocol	J.4.1	410.2.1:M	Yes__ No__	
410.2.1.b	The robust frame format shall be formatted with multi-dwell majority vote 3 out of 5 BCH [15, 7] coding	J.4.1	410.2.1:M	Yes__ No__	
410.2.2	User Data	J.4.2	410.2:M	Yes__ No__	
410.2.2.a	PL scrambling and convolutional coding shall be applied to the user data if selected in the robust frame format	J.4.2	410.2.2:M	Yes__ No__	
410.2.2.b	The LSB of each octet passed from the data shall be transmitted first	J.4.2	410.2.2:M	Yes__ No__	
410.2.3	Multi-Dwell Flag Set	J.4.3	410.2:M	Yes__ No__	
410.2.3.a	The multi-dwell flag shall be set, in the robust frame format (RFF) if MDP is implemented	J.4.3	410.2.3:M	Yes__ No__	
410.2.3.b	Either PL scrambled or unscrambled, and/or convolutional coded user data shall be broken into 64-bit segments. Based on the Multi-dwell Transmission Format (MDTF) setting, these segments shall be packed into 6, 11, or 13 segment groups. Then, a packet shall be formed by appending the SOP and the segment counter to the end of the group	J.4.3	410.2.3:M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
410.2.3.c	BCH [15,7] shall be applied to the segment counter prior to appending. The number of BCH [15, 7] copies, 32-bit or 64-bit SOP pattern, and the number of segments per packet are determined by the MDTF setting	J.4.3	410.2.3:M	Yes__ No__	
410.2.4	Multi-Dwell Flag Not Set	J.4.4	410.2:M	Yes__ No__	
410.2.4.a	When the multi-dwell flag is zero the data shall not be put into packets	J.4.4	410.2.4:M	Yes__ No__	
410.2.4.b	Only the robust frame synchronization field and robust frame format shall be inserted and PL scrambling and/or convolutional coding can be applied to the user data	J.4.4	410.2.4:M	Yes__ No__	

A.7.10 Bose-Chaudhuri-Hocquenghem (15, 7) Coding Algorithm.

Item	Protocol Feature	Reference	Status	Support	Notes
411	Bose-Chaudhuri-Hocquenghem (15, 7) Coding Algorithm	APPENDIX K	102.1.3.1.2.b and 410 :M	Yes__ No__	
411.1	BCH (15, 7) Code	K.3	411:M	Yes__ No__	
411.1.1	Hardware Encoding	K.3.1	411.1:O.<2>	Yes__ No__	
411.1.2	Hardware/Software Decoding	K.3.2	411.1.1:M 411.1.3:M	Yes__ No__ Yes__ No__	
411.1.3	Software Encoding	K.3.3	411.1:O.<2>	Yes__ No__	

A.7.11 Transmission Channel Interfaces.

Item	Protocol Feature	Reference	Status	Support	Notes
412	Transmission channel interfaces	APPENDIX L	M	Yes__ No__	
412.1	Detailed Requirements	L.4	M	Yes__ No__	
412.1.1	Transmission Channel Interfaces	L.4.1	M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
412.1.1.1	NRZ Interface	L.4.1.1	M	Yes__ No__	
412.1.1.1.a	A NRZ signal waveform shall be used for the NRZ interface	L.4.1.1	M	Yes__ No__	
412.1.1.1.1	Waveform	L.4.1.1.1	M	Yes__ No__	
412.1.1.1.1.a	NRZ unbalanced waveform shall conform to 5.1.1.7 of MIL-STD-188-114A	L.4.1.1.1	M	Yes__ No__	
412.1.1.1.1.b	NRZ balanced waveform shall conform to 5.2.1.7 of MIL-STD-188-114A	L.4.1.1.1	M	Yes__ No__	
412.1.1.1.2	Transmission Rates	L.4.1.1.2	M	Yes__ No__	
412.1.1.1.2.a	Output transmission rates shall be the following bit rates: 75, 150, 300, 600, 1200, 2400, 4800, 9600, and 16000 bps	L.4.1.1.2	M	Yes__ No__	
412.1.1.1.3	Operating mode	L.4.1.1.3	M	Yes__ No__	
412.1.1.1.3.a	NRZ shall support half-duplex transmission	L.4.1.1.3	M	Yes__ No__	
412.1.1.2	FSK interface for voice frequency channels	L.4.1.2	O	Yes__ No__	
412.1.1.2.a	FSK data modem characteristics shall conform to 5.2.2 of MIL-STD-188-110	L.4.1.2	412.1.1.2:M	Yes__ No__	
412.1.1.2.1	Waveform	0	412.1.1.2:M	Yes__ No__	
412.1.1.2.1.a	FSK modulation waveform shall conform to 5.2.2.1 of MIL-STD-188-110	0	412.1.1.2:M	Yes__ No__	
412.1.1.2.1.b	Characteristic frequencies of FSK interface for voice frequency channels of 600 bps or less shall be 1300 Hz for mark frequency and 1700 Hz for space frequency	0	412.1.1.2:M	Yes__ No__	
412.1.1.2.1.c	Characteristic frequencies of FSK interface for voice frequency channels of 1200 bps shall be 1300 Hz for mark frequency and 2100 Hz for space frequency	0	412.1.1.2:M	Yes__ No__	

Item	Protocol Feature	Reference	Status	Support	Notes
412.1.1.2.2	Transmission Rates	L.4.1.2.1	412.1.1.2:M	Yes__ No__	
412.1.1.2.2.a	Output transmission rates of the FSK interface shall be the following bit rates: 75, 150, 300, 600, and 1200 bps	L.4.1.2.1	412.1.1.2:M	Yes__ No__	
412.1.1.2.3	Operating mode	L.4.1.2.2	412.1.1.2:M	Yes__ No__	
412.1.1.2.3.a	FSK interface shall support half-duplex transmission	L.4.1.2.2	412.1.1.2:M	Yes__ No__	
412.1.1.3	FSK interface for single-channel radio	L.4.1.3	O	Yes__ No__	
412.1.1.3.a	FSK interface data modem characteristics shall conform to 5.1 of MIL-STD-188-110	L.4.1.3	412.1.1.3:M	Yes__ No__	
412.1.1.3.1	Waveform	L.4.1.3.1	412.1.1.3:M	Yes__ No__	
412.1.1.3.1.a	FSK modulation waveform shall conform to 5.1.1 and 5.1.2 of MIL-STD-188-110	L.4.1.3.1	412.1.1.3:M	Yes__ No__	
412.1.1.3.1.b	Characteristic frequencies of FSK interface for single channel radio shall be 1575 Hz for mark frequency and 2425 Hz for space frequency	L.4.1.3.1	412.1.1.3:M	Yes__ No__	
412.1.1.3.2	Transmission rates	L.4.1.3.2	412.1.1.3:M	Yes__ No__	
412.1.1.3.2.a	Output transmission rates of the single-channel FSK interface shall be the following bit rates: 75, 150, 300, 600 and 1200 bps	L.4.1.3.2	412.1.1.3:M	Yes__ No__	
412.1.1.3.3	Operating mode	L.4.1.3.3	412.1.1.3:M	Yes__ No__	
412.1.1.3.3.a	Single-channel FSK interface shall support half-duplex transmission	L.4.1.3.3	412.1.1.3:M	Yes__ No__	
412.1.1.4	CDP Interface	L.4.1.4	O	Yes__ No__	
412.1.1.4.1	Waveform	L.4.1.4.1	412.1.1.4:M	Yes__ No__	
412.1.1.4.1.a	CDP modulation waveform shall conform to 5.4.1.4 of MIL-STD-188-200	L.4.1.4.1	412.1.1.4:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
412.1.1.4.1.b	Unbalanced signal waveform shall conform to 5.1.1.7 of MIL-STD-188-114A	L.4.1.4.1	412.1.1.4:M	Yes__ No__	
412.1.1.4.1.c	Balanced signal waveform shall conform to 5.2.1.7 of MIL-STD-188-114A	L.4.1.4.1	412.1.1.4:M	Yes__ No__	
412.1.1.4.2	Transmission Rates	L.4.1.4.2	412.1.1.4:M	Yes__ No__	
412.1.1.4.2.a	Output transmission rate of the CDP interface shall be 16 kbps and 32 kbps	L.4.1.4.2	412.1.1.4:M	Yes__ No__	
412.1.1.4.3	Operating mode	L.4.1.4.3	412.1.1.4:M	Yes__ No__	
412.1.1.4.3.a	CDP interface shall support half-duplex transmission	L.4.1.4.3	412.1.1.4:M	Yes__ No__	
412.1.1.5	DPSK interface for voice frequency channels	L.4.1.5	O	Yes__ No__	
412.1.1.5.a	DPSK modulation data modem (2400 bps) and the PSK modulation data modem (1200 bps) characteristics shall conform to the applicable requirements of MIL-STD-118-110	L.4.1.5	412.1.1.5:M	Yes__ No__	
412.1.1.5.1	Waveform	L.4.1.5.1	412.1.1.5:M	Yes__ No__	
412.1.1.5.1.a	DPSK modulation waveform shall conform to APPENDIX A of MIL-STD-118-110	L.4.1.5.1	412.1.1.5:M	Yes__ No__	
412.1.1.5.1.b	PSK modulation waveform shall conform to 5.3 of MIL-STD-118-110	L.4.1.5.1	412.1.1.5:M	Yes__ No__	
412.1.1.5.2	Transmission Rates	L.4.1.5.2	412.1.1.5:M	Yes__ No__	
412.1.1.5.2.a	Output transmission rate of the DPSK interface shall be 2400 bps	L.4.1.5.2	412.1.1.5:M	Yes__ No__	
412.1.1.5.2.b	Output transmission rate of the PSK interface shall be 1200 bps	L.4.1.5.2	412.1.1.5:M	Yes__ No__	
412.1.1.5.3	Operating mode	L.4.1.5.3	412.1.1.5:M	Yes__ No__	
412.1.1.5.3.a	DPSK interface shall support half-duplex transmission	L.4.1.5.3	412.1.1.5:M	Yes__ No__	

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Item	Protocol Feature	Reference	Status	Support	Notes
412.1.1.5.3.b	PSK interface shall support half-duplex transmission	L.4.1.5.3	412.1.1.5:M	Yes__ No__	
412.1.1.6	Packet Mode Interface	L.4.1.6	O	Yes__ No__	
412.1.1.6.a	The packet mode interface shall use a modified CCITT X.21 half-duplex synchronous interface, with a CCITT V.10 electrical circuit, for transferring data across the interface between DTE (i.e. the DMTD or C^4I system) and DCE	L.4.1.6	412.1.1.6:M	Yes__ No__	
412.1.1.6.1	Waveform	L.4.1.6.1	412.1.1.6:M	Yes__ No__	
412.1.1.6.1.a	The electrical characteristics of the packet mode interface shall be identical to CCITT V.10 for interfaces to voice band modems	L.4.1.6.1	412.1.1.6:M	Yes__ No__	
412.1.1.6.2	Transmission Rates	L.4.1.6.2	412.1.1.6:M	Yes__ No__	
412.1.1.6.2.a	The DTE device shall be required to accept signal timing from the DCE (radio) at 16 kbps	L.4.1.6.2	412.1.1.6:M	Yes__ No__	
412.1.1.6.2.b	The DTE shall be required to synchronize to the DCE signal timing and accept data at the supplied signaling timing rate	L.4.1.6.2	412.1.1.6:M	Yes__ No__	
412.1.1.6.3	Operating Mode	L.4.1.6.3	412.1.1.6:M	Yes__ No__	
412.1.1.6.3.a	The packet mode interface shall support half-duplex transmission	L.4.1.6.3	412.1.1.6:M	Yes__ No__	
412.1.1.7	ASK	L.4.1.7	O	Yes__ No__	
412.1.1.7.1	Waveform	L.4.1.7.1	412.1.1.7:M	Yes__ No__	
412.1.1.7.1.a	The ASK signal shall be a bipolar signal nominally centered around ground	L.4.1.7.1	412.1.1.7:M	Yes__ No__	
412.1.1.7.1.b	The ASK S/N ratio shall be in the range of 0-12 dB	L.4.1.7.1	412.1.1.7:M	Yes__ No__	

APPENDIX B

ANNEX A

Item	Protocol Feature	Reference	Status	Support	Notes
412.1.1.7.1.c	The ASK signal shall be demodulated using an optimal bit synchronizer with a BER performance of 1.5 dB from theoretical	L.4.1.7.1	412.1.1.7:M	Yes__ No__	
412.1.1.7.2	Transmission Rates	L.4.1.7.2	412.1.1.7:M	Yes__ No__	
412.1.1.7.2.a	The output transmission rates of the ASK interface shall be the following bit rates: 2400, 4800, 9600, and 16000 bps	L.4.1.7.2	412.1.1.7:M	Yes__ No__	
412.1.1.7.3	Operating Mode	L.4.1.7.3	412.1.1.7:M	Yes__ No__	
412.1.1.7.3.a	The ASK interfaces shall support half-duplex transmission	L.4.1.7.3	412.1.1.7:M	Yes__ No__	

APPENDIX C

NETWORK ACCESS CONTROL ALGORITHM

C.1 General.

C.1.1 Scope.

This appendix describes the network access control (NAC) algorithm to be used in the DMTD and interfacing C^4I systems.

C.1.2 Application.

This appendix is a mandatory part of MIL-STD-188-220. The information contained herein is intended for compliance.

C.2 Applicable documents.

A list of data link parameters and their values as well as parameter values for the Network Timing Model, described in APPENDIX C, are provided in a separate document entitled "MIL-STD-188-220 Parameter Table". This table is available via the CNR Implementation Working Group World Wide Web page: http://cnrwg.disa.mil.

C.3 Network timing model.

The network access control protocol shall be used to detect the presence of active transmissions on a multiple-station-access communications network and shall provide a means to preclude data transmissions from conflicting on the network. The network access control protocol is based on a generic network-timing model. All stations on a network shall use the same network access control protocol and timing parameter values in order to maintain network discipline.

C.3.1 Network timing model definitions.

A network station consists of a DCE and a DTE. The DTE is the data device that performs the MIL-STD-188-220 protocol. The DCE includes all equipment external to the DTE (e.g., a radio with or without external COMSEC) that is used to provide a communications channel for the DTE. The interface between the DTE and DCE can operate in synchronous, asynchronous, or packet mode. The interface is synchronous if the DCE provides all required clocks to the DTE. The packet mode interface is a synchronous interface that conforms to CCITT X.21. For synchronous mode, the bit rate (n) is the rate of the transmit clock supplied by the DCE. If the DCE does not provide clocks to the DTE, the interface is asynchronous. For asynchronous mode, the bit rate (n) is the rate at which the DTE transmits. The data link bit rate is defined as the effective bit rate at which the physical layer transmits the data bits. The data link bit rate is usually the same as the bit rate (n) at the physical layer, except for the PSK/DPSK modems (refer to MIL-STD-188-110). The robust protocol case is separately described in APPENDIX J.

C.3.2 Network timing model parameters.
The parameters of the network timing model are general enough to model interactions with a wide variety of DCEs. All parameters are specified at the DTE to DCE interface and are in units of seconds with a resolution of one millisecond. Parameters may have a value of zero if they are not applicable to the DCE being used. Network timing model parameters are shown in FIGURE C-1. Actual network timing model parameter values are provided in a separate document entitled "MIL-STD-188-220 Parameter Table". The use of identical values is crucial to interoperability, even more important than the values themselves. All stations participating in a network should utilize the values stated in the same version of this table.

C.3.2.1 Equipment preamble time (EPRE).
EPRE is the time from when the DTE initiates a transmission, often by asserting Push-to-Talk (PTT), until the transmitting DTE sends to its DCE the first bit of information that will be delivered to the receiving DTE. EPRE is a characteristic of the DCE. It accounts for DCE start up time, including time required for radio power up and transmission of COMSEC and other DCE preambles. EPRE can have a value between 0.000 and 30.000 seconds.

a. For Synchronous mode, EPRE is measured from PTT until the DCE provides a clock to the DTE for its first bit of information. For the purposes of the Network Timing Model, it is assumed that the DTE will begin sending information to the DCE with the first clock edge provided by the DCE. During this time, the DTE sends nothing.

b. For Asynchronous mode, EPRE is measured from PTT until the first signal transmitted by the sending DTE is also transmitted by the sending DCE to receiving DCEs. This accounts for time that the transmitting DCE is not listening to signals sent by the transmitting DTE. During this time, the transmitting DTE may send an alternating sequence of one and zero bits.

c. For Packet mode, EPRE is measured from the time the DTE indicates it is ready to transmit (by asserting the C-lead and transmitting flags on the T-lead as described in 6.3.2.1.2) until the DCE indicates it is ready to accept information from the DTE (by transmitting flags to the DTE on the R-lead as described in 6.3.2.1.2).

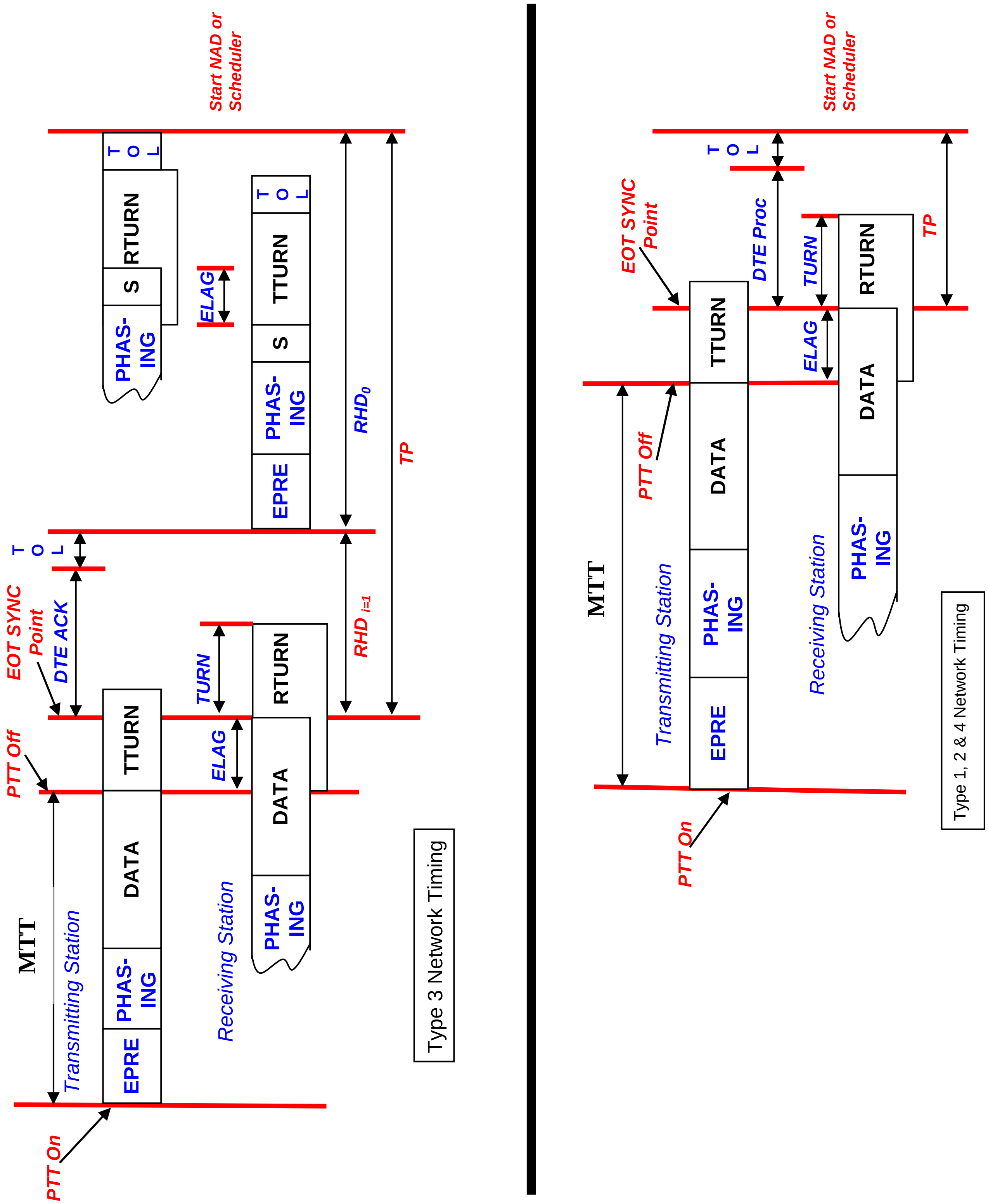


FIGURE C-1. Network timing model.

C.3.2.2 Phasing transmission time (PHASING).
PHASING is the time the DTE shall send an alternating sequence of one and zero bits after the completion of EPRE and prior to sending the first bit of data. PHASING can be needed due to characteristics of the DCE, DTE, or both. PHASING can have a value between 0.000 and 10.000 seconds. The DTE shall use the DCE bit rate to compute the number of phasing bits to transmit.

a. For Synchronous mode, PHASING can be needed if the DCE delivers extraneous clock edges to the DTE prior to the start of a valid, continuous transmit clock or if the DCE provides a transmit clock to the DTE before it is ready to reliably deliver bits from the DTE to receiving DCEs.

b. For Asynchronous mode, phasing is often needed by the receiving DTE to achieve bit synchronization.

c. For Packet mode, phasing is always zero.

CAUTION. The terms PHASING and “phasing” are not interchangeable. PHASING refers to the Phasing Transmission Time. Phasing is bit stream of alternating “1” and ”0”, as defined in paragraph 5.2.1.2.

C.3.2.3 Data transmission time (DATA).
DATA is the time during which the transmitting DTE sends transmit data to its DCE. Transmit data includes all fields shown in FIGURE 5. This includes embedded COMSEC information shown in FIGURE 5b. It also includes transmission of concatenated frames (including bit synchronization between physically concatenated frames) as shown in FIGURE 3. DATA shall begin immediately after the end of PHASING. The transmitting DTE shall indicate end of transmission immediately after the last bit of data is sent to the DCE. CAUTION. The terms DATA and “data” are not interchangeable. DATA refers to the Data Transmission Time. Data is the information bit stream.

C.3.2.4 Coupled acknowledgment transmission time (S).
S is a special case of DATA, where the Data Field shown in FIGURE 5 contains only one Type 3 URR, URNR or TEST response frame with the F-bit set to 1 and no information field. For these frames, the length of the fields in FIGURE 5 (including zero bit insertion) used in network timing equations when the Multi-Dwell protocol and convolutional coding are not used shall be:

a. The 64-bit message synchronization field.

b. An optional embedded COMSEC MI field.

c. The 168-bit Transmission Word Count and Transmission Header TDC block.

d. 80 bits if neither the FEC nor TDC function is selected, 168 bits if only FEC is selected, and 384 bits if both FEC and TDC are selected.

The sum of these components is transmitted at the data link bit rate.

C.3.2.5 Equipment lag time (ELAG).
ELAG is equal to or greater than the worst-case time from when the last bit of data is sent by the transmitting DTE until the time when the same last bit of data is delivered to the receiving DTE by the receiving DCE. ELAG is a characteristic of the DCEs and the propagation delay. It accounts for frequency hopping throughput delays, satellite transmission delays, Packet Mode radio-embedded FEC delays and other related delays. The end of ELAG is the synchronization point for the Timeout Period (TP) and Response Hold Delay (RHD) Timers.

ELAG >= MAX(DCE_Tx_Delay) + MAX propagation delay + MAX(DCE_Rx_Delay)

DCE_Tx_Delay is the time when a bit is sent to the Transmitting DCE until that bit is transmitted. DCE_Rx_Delay is the time from when a bit arrives at the receiving DCE until that bit is delivered to the DTE.

C.3.2.6 Turnaround time (TURN).
TURN is the time from the end of ELAG until the end of TTURN or RTURN, whichever is later. TURN is computed using the equation:

TURN = Maximum((TTURN - ELAG), (RTURN - ELAG))

where:

a. TTURN is the time from when the transmitting DTE indicates end of transmission at the end of DATA until the transmitting DCE is ready to begin a new transmit or receive operation. TTURN is a characteristic of the DCE. It includes time when the transmitting DCE sends COMSEC or other postambles after transmitting all data.

b. RTURN is the time from when the transmitting DTE indicates end of transmission at the end of DATA until the receiving DCE is ready to begin a new transmit or receive operation. RTURN is a characteristic of the DCE.

c. ELAG may be either larger or smaller than TTURN, but is always less than or equal to RTURN, as shown in FIGURE C-2.

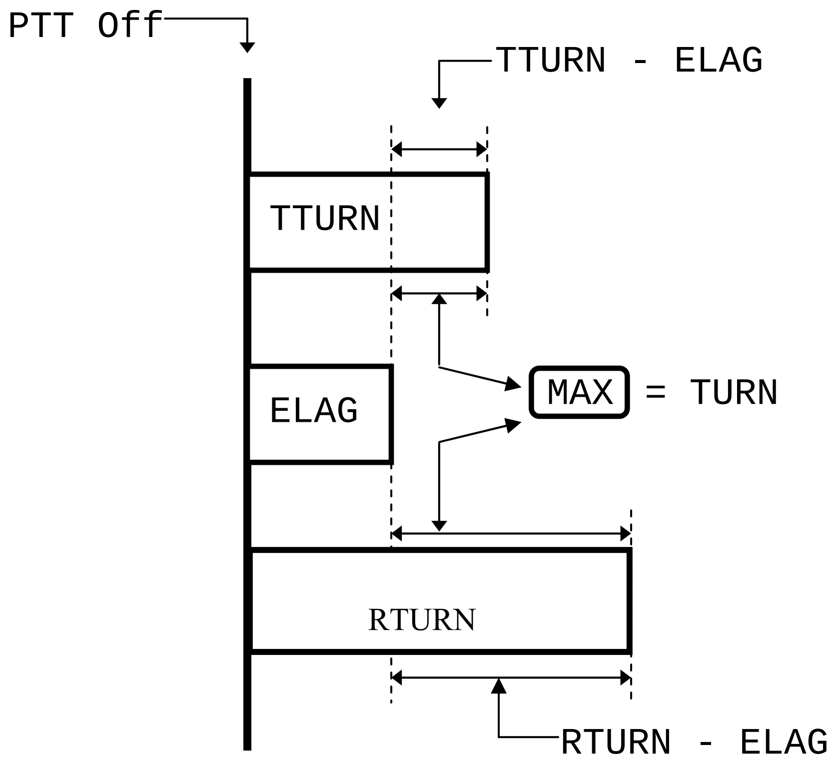


FIGURE C-2. Turnaround time (TURN) calculation.

C.3.2.7 DTE ACK preparation time (DTEACK).
DTEACK is the time from the end of ELAG until the slowest DTE on the network can process any possible Type 3 frame requiring a coupled acknowledgment, prepare the coupled Type 3 acknowledgment frame, and begin sending its coupled acknowledgment frame to its DCE (including time for transmit relays for PTT to close). DTEACK is a characteristic of the DTE. Unless a larger value is known, use the value TURN for the particular radio and operating environment as the default value for DTEACK.

C.3.2.8 DTE processing time (DTEPROC).
DTEPROC is the time from the end of ELAG until the slowest DTE on the network can prepare a worst case size frame for transmission and to start transmitting (including time for transmit relays for PTT to close) after receiving data not requiring a coupled, Type 3 acknowledgment. DTEPROC is a characteristic of the DTE. Unless a larger value is known, use the value TURN for the particular radio and operating environment as the default value for DTEPROC.

C.3.2.9 DTE turnaround time (DTETURN).
DTETURN is the time required for the DTE or modem to stop listening for received data or squelch detect and to activate the radio's PTT. DTETURN shall be a variable parameter where the range shall be from 0.000 to 0.100 seconds in one (1) millisecond resolution steps. Varying the DTETURN parameter could allow different modems on the same radio net to match their network access delay slots.

C.3.2.10 Tolerance time (TOL).
TOL is a time value used to compensate for variances in the actual realized lag times from a transmitting DTE to a receiving DTE. If the Smallest Actual Lag Time (SALT) is known, the tolerance time required for the network can be optimized. SALT shall be less than or equal to the receiving DCE and transmitting DCE pair with the smallest delay in the network. If SALT is not known, then zero (0) shall be assumed. TOL is calculated by the following equation:

$$TOL >= ELAG – SALT$$

TOL may be greater to allow for other variances (e.g. different radios of the same make and model).

C.3.2.11 Maximum Transmit Time (MTT).
MTT represents the maximum amount of time allowed on a net for a single transmission. It is used to limit concatenation and has no effect on an individual message. It represents the duration of time from PTT on until PTT off as shown in FIGURE C-1.

C.4 Network access control.
The stations shall implement the following four basic NAC subfunctions:

a. Network busy sensing.

b. Response hold delay (RHD).

c. Timeout period (TP).

d. Network access delay (NAD).

C.4.1 Network busy sensing function.
The network busy function is used to establish the presence of a data or voice signal at the receiving station due to activity on the net. Network busy sensing for a data signal shall be provided. Network busy sensing for a voice signal may be provided. Network busy may be provided by data network busy sensing or may utilize other more efficient network sensing capabilities, such as, a DCE notification.

C.4.1.1 Data network busy sensing.
When receiving a data transmission, network busy shall be detected within a fixed time. Parameter B shall be used to compute this fixed time. For synchronous mode B shall be less

than or equal to (32/n) seconds. For asynchronous mode B shall be less than or equal to (64/n) seconds. For packet mode B shall be less than or equal to 0.250 seconds. Upon detection of data network busy, the data link network busy indicator shall be set. Setting the data link network busy indicator shall inhibit all message transmissions, including coupled response messages. The data link network busy indicator shall be reset upon indication from the physical layer that neither voice nor digital data is being detected by the station.

C.4.1.2 Voice network busy sensing.
Network busy due to a voice transmission may be detected. If voice transmissions are not detected, this function shall report that the network is never busy due to a voice transmission. Upon detection of voice network busy, the data link network busy indicator shall be set. Setting the data link network busy indicator shall inhibit all message transmissions, including coupled response messages. The data link network busy indicator shall be reset upon indication from the physical layer that neither voice nor digital data is being detected by the station.

C.4.1.3 Network busy detect time.
The time allowed to detect data network busy shall be the same for all stations on the network. This Net_Busy_Detect_Time is a key factor in achieving both throughput and speed of service. The Net_Busy_Detect_Time values, as specified in the parameter table, should be used per indicated Radio/System. All stations participating in a network should utilize the values stated in the "MIL-STD-188-220 Parameter Table", which is available on the CNRWG website specified at 2.3.4. The equation below shall be used as a default in cases where the parameter table has not been updated to reflect actual measurements for specific device. Where a communications device provides a signal to detect network busy earlier than the calculated parameter B value, the DTE shall interface to that signal. The parameter table lists the device specific signals that should be supported in order to use the timing values specified. Where a communication media provides capabilities to detect data network busy more quickly, the use of these capabilities has been reflected in the parameter table Net_Busy_Detect_Time values. In these cases, Net_Busy_Detect_Time can be set to reflect the capabilities of the media. Where the communication media does not provide special capabilities or these capabilities cannot be used by all stations on the network, the station shall examine received data to detect data network busy. In these cases, the time allowed to detect data network busy shall be given by the formula:

Net_Busy_Detect_Time = EPRE + ELAG + B + TOL

NOTE: Parameters EPRE and ELAG are initialized locally or learned using the XNP messages described in APPENDIX E. Net_Busy_Detect_Time can also be learned using the XNP messages described in APPENDIX E or from the parameter table.

C.4.2 Response hold delay.
An RHD_0 period and an individual RHD value are calculated to determine the time that an addressed receiving station delays before sending a Type 3 response PDU upon receiving a Type 3 command PDU (UI and TEST). The RHD controls network access and the NAD algorithm is

suspended during this period. An RHD_0 period is the worst-case amount of time that a single response takes. The individual RHD is the time at which a particular station waits before accessing the network. If the scheduler is running, immediate scheduling should be used for Type 3 Acknowledgment. The individual RHD value to be used shall be determined by the position of the receiving station's individual or special address in the PDU destination portion of the address field. The Reserved Address (0) in the destination portion of the address field shall be ignored. That is, when calculating an individual RHD value, the Reserved Address shall not be considered to occupy a position in the destination portion of the address field. The calculated values for RHD_i, TP, and NAD are computed to the nearest millisecond. The RHD time shall start precisely at the end of ELAG. All stations on a subnetwork shall use the same values in calculating RHD. These values can be initialized locally or learned, using the XNP messages described in APPENDIX E.

a. The RHD_0 period shall be calculated by the following formula:

$$RHD_0 = EPRE + PHASING + S + ELAG + TURN + TOL$$

b. The TP shall be calculated by all stations on the network/link as follows:

$$TP = (j * RHD_0) + TOL + Maximum(DTEACK, TURN)$$

where j = The total number of destination link addresses - to include special and individual but not group or global addresses - for this transmitted frame. The transmitting station shall not include special address 3 in the total for j, and the value of all non-integer variables (that is, RHD_0, TOL, and TURN) in the TP equation are rounded to the nearest one thousandth.

c. The individual addressed station's response hold delay (RHD_i) shall be calculated by

$$RHD_i = (i - 1) * RHD_0 + Maximum(DTEACK, TURN) + TOL$$

The variable i (where $1 \leq i \leq 16$) is the individual station's position in the destination portion of the address field.

C.4.3 Timeout period.

TP is the time all stations shall wait before they can schedule the NAD. During this window of time, the transmitting station shall wait to receive the anticipated Type 3 coupled acknowledgment response frame(s), from all applicable addressed stations. The parameter values used to compute TP shall be the same for all stations on a subnet unless immediate retransmission has been selected. When immediate retransmission has been requested, the sending station shall compute the timeout period using only individual addresses and special addresses 1 and 2. All receiving stations shall compute the timeout period using the individual addresses and special addresses 1, 2 and 3. The calculated value of TP is computed to the nearest millisecond. The TP time shall start precisely at the end of ELAG. A retransmission of a

Type 3 frame shall be executed whenever TP has been exceeded without expected acknowledgments having been received from all Type 3 individual and special destinations. Prior to retransmission, the address field of the frame shall be modified to delete the destination station(s) that previously acknowledged the frame. Operationally, TP shall be used as follows:

a. Upon termination of a message transmission that requires an immediate response, the transmitting station shall set the TP timer. If the transmitting station does not receive all the expected responses (TEST, URR, or URNR) within the TP, and if the number of transmissions is less than the Maximum Number of Transmissions data link parameter, the station shall retransmit the frame when it is the highest precedence frame to send. For all stations, if a Type 1, Type 2 or Type 4 frame is received when a response-type frame is expected, the newly received frame shall be processed. The RHD and TP timers shall not be suspended and the TP procedures in use for the Type 3 frame shall be continued. Response procedures, if any, for the newly received frame shall commence after the conclusion of the ongoing TP procedures. If the unexpected frame is a Type 3 frame the current TP procedure is aborted and the newly received Type 3 TP procedure shall be started.

b. After a station transmits or receives data that does not require a Type 3 coupled acknowledgment, and is not itself a Type 3 coupled acknowledgment, all stations except those using RE-NAD shall compute TP as:

$$TP = \text{Maximum}(DTEPROC, TURN) + TOL$$

c. Upon receiving a Type 3 coupled acknowledgment, a station shall determine whether a timeout period is already in progress. If no timeout period is in progress, or if the acknowledgment contains an unexpected destination or source address, the receiving station shall compute TP using the following equation and shall start a timeout period precisely at the time the last bit of data for the Type 3 coupled acknowledgment was received.

$$TP = (15 * RHD_0) + TOL + TURN$$

NOTE: RHD_0 is as defined in C.4.2.

C.4.4 <u>Network access delay.</u>
NAD is defined as the time a station with a message to send shall wait to send a frame after the TP timer has expired. NAD discipline is based on an infinite sequence of “slots” that begin when the TP timer has expired. Slots are defined to be long enough so that all stations on the network will detect a station transmitting at the beginning of a slot prior to the beginning of the next slot. The duration of the NAD shall take the Net_Busy_Detect_Time into account as specified by the equation at the end of this paragraph. All transmissions, except the coupled acknowledgments, shall begin at the start of the next NAD slot.

There are six schemes for calculating NAD. The six schemes are defined below. Two of the access schemes, DAP-NAD and R-NAD, shall be available to all network participants using

Synchronous Mode. Five schemes (R-NAD, P-NAD, H-NAD, DAV-NAD and DAP-NAD) compute a value F for each station on the net. The F value is the number of NAD slots that each station will wait before transmitting, if it has any information to send.

The Random Network Access Delay (R-NAD) scheme provides all stations with an equal chance to access the network. The Prioritized Network Access Delay (P-NAD) scheme ensures the highest precedence station with the highest priority message will access the network first. In the case of RE-NAD, network access delay is computed by the radio. With RE-NAD the DTE (DMTD or C^4I system) does not compute network access delay but does schedule channel access opportunities at which an access attempt can be initiated by the DTE. DAP-NAD and DAV-NAD, like P-NAD, ensure the highest priority message will access the network first. They do not ensure first access by highest precedence station however. The Hybrid Network Access Delay (H-NAD) scheme combines random access with the preferential access by frame priority. The random and hybrid schemes might result in a collision (the same NAD value for two stations). The P-NAD, DAV-NAD and DAP-NAD schemes always produce a unique NAD value for each station. In all of the NAD schemes, if the TP timer is active, the stations with frames to transmit shall wait for the TP timer to expire before the NAD is started. If the TP timer is not active, the station shall calculate its NAD using the proper NAD scheme for the network. Each NAD scheme produces a set of allowed access periods. The network may be accessed only at the beginning of one of those periods. If a station using P-NAD, DAP-NAD, DAV-NAD or H-NAD is waiting for its NAD time and a higher priority frame becomes available for transmission, the station may shorten its NAD time to a time it would have computed if it had computed its original NAD time using the new, higher frame priority. Below are the frame reception and transmission procedures:

a. Upon receipt of a frame a TP delay timer shall be started. The transmission of additional frames shall be suspended until expiration of the TP delay timer. (All pending frames shall await expiration of the TP delay timer). After the frame check sequence has been verified, the address and control fields are analyzed. If the received frame is either a UI or TEST frame and the poll bit is set to 1, the TP timer allows for receipt of the requested coupled acknowledgments. For receptions other than the UI or TEST with poll bit set, the TP timer provides sufficient delay to allow all systems to compete equally for access. Regardless of what was received, a NAD value shall be recomputed and initiated after the TP timer expires. The calculated value of the NAD is rounded to the nearest millisecond.

b. If a station does not have a frame to transmit, it shall compute a NAD time using routine priority for its calculations. If the NAD time arrives before a frame becomes available to transmit or frame(s) are not yet encoded for transmission, the station shall compute and use a new NAD time. The starting time for the new NAD and the F value used in computing the new NAD shall be based on the NAD method as indicated in the following paragraphs.

1) For P-NAD the new NAD time shall begin immediately following the NAD that just expired. The F value shall be (NS + 1). This creates another group of

NAD slots for all stations on the network. Adding this value at all stations preserves the algorithmic collision prevention property of P-NAD.

2) For R-NAD the new NAD time shall begin immediately following the NAD that just expired. The F value shall be [(3/4) * NS + 1]. Adding the same constant value at all stations preserves the random property of R-NAD.

3) For H-NAD the new NAD time shall begin immediately following the NAD that just expired. The F value shall be 1 if the station has an urgent or priority frame to transmit and (Routine_MAX + 1 - Routine_MIN) if a station has only a routine frame(s) or no frame(s) to transmit. The value 1 preserves the intent of H-NAD that is to grant preferential network access to stations with urgent or priority frames to send. The value (Routine_MAX + 1 - Routine_MIN) preserves the random property of H-NAD for stations with only routine frames to send.

4) For RE-NAD, F is not used.

5) For both DAP-NAD and DAV-NAD, a series of NAD are calculated as per equation 1 in paragraph C.4.4.5.2. The start time for each NAD in the series is calculated relative to the end of the last transmission that was received. The F value for DAP-NAD and DAV-NAD shall be as specified in the reference equation, i.e. NS. The referenced equation creates an infinite series of unique and accurate NAD times for each station on the network such that the algorithmic collision prevention properties of DAP-NAD and DAV-NAD are maintained even when messages become available for transmission at the same time at different stations after a long idle period.

c. All stations on the network shall continue to sense the link for data or voice network busy and shall withhold transmission until the appropriate NAD period has expired. NAD shall be calculated using the formula:

NAD = F * Net_Busy_Detect_Time + MAX(0, F-1) * DTETURN

where Net_Busy_Detect_Time is as defined in C.4.1.3 and DTETURN is as defined in C.3.2.9.

C.4.4.1 Random network access delay.
The R-NAD calculation method shall ensure that each station has an equal chance of accessing the network. The random nature also may provide a resolution if an access conflict occurs. Each attempt to access the network potentially can use a NAD value different from the station's previous value. The integer value of F shall be obtained from a pseudorandom number

generator. The range of the pseudorandom number depends on the number of stations (NS) in the network. F shall be an integer value (truncated) in a range between 0 and (3/4)NS. NS can be learned through the XNP join exchange, or fixed by a system parameter established at initialization.

C.4.4.2 Prioritized network access delay.
The P-NAD calculation method shall ensure that the network access precedence order assigned to stations is preserved. Each station shall calculate three unique P-NAD values, one for each of the three frame precedence levels. The integer value of F shall be calculated as:

$$F = SP + MP + IS$$

where:

SP = the station priority:
SP = (station rank -1) for the initial transmission; and
SP = 0 for subsequent transmissions.

MP = the message precedence:
MP = 0 for all urgent messages;
MP = (NS + 1) for all priority messages;
MP = 2 * (NS + 1) for all routine messages,
where NS is the number of stations on the network.

IS = the initial/subsequent factor:
IS = 0 for the initial transmission, and
IS = NS for subsequent transmissions.

Only one station on the network uses the subsequent factor. That is the station that transmitted last on the net. However, transmissions of coupled Type 3 acknowledgments do not count as transmissions for the purpose of determining which station transmitted last.

C.4.4.3 Hybrid network access delay.
The H-NAD calculation method ensures that network access delay times are shorter for higher priority frames, while maintaining equal access chances for all stations. Each priority level has a distinct range of pseudorandom F values determined by the NS in the subnetwork, the network percentage of the particular priority level frames, and the traffic load. The integer value of F shall be calculated as

$$F = MIN + RAND * (MAX - MIN)$$

where:

RAND = pseudorandom number in the range 0.0 to 1.0

MAX and MIN are integer values defining the ranges:

Urgent_MIN = 0, for urgent frames

Urgent_MAX = USIZE + 1, for urgent frames

Priority_MIN = Urgent_MAX + 1, for priority frames

Priority_MAX = Priority_MIN + PSIZE + 1, for priority frames

Routine_MIN = Priority_MAX + 1, for routine frames

Routine_MAX = Routine_MIN + RSIZE + 1, for routine frames

USIZE = the additional number of random numbers generated for urgent frames

PSIZE = the additional number of random numbers generated for priority frames

RSIZE = the additional number of random numbers generated for routine frames

where the minimum MIN/MAX range size is 2.

The additional range sizes (xSIZE) are integers based on the percent of frames expected at a specific priority level (%priority_level) and the NS adjusted (ADJ_NS) by the expected traffic load (TL). NS, %priority_level, and traffic load, may be input using the XNP messages or by initialization input. xSIZE is rounded to the nearest non-negative integer.

USIZE = %U * ADJ_NS, %U = percentage of urgent frames (default 25%)

PSIZE = %P * ADJ_NS, %P = percentage of priority frames (default 25%)

RSIZE = %R * ADJ_NS, %R = percentage of routine frames or 100% - (%U + %P)
(default 50%)

where the adjusted NS increases if the expected traffic load is heavy and decreases if the traffic load is light. The minimum random number range at each of the three priority levels is 2, so 6 stations are subtracted from the adjusted NS.

ADJ_NS = INTEGER (NS * TL) -6 or = 1 (whichever is greater)

where:

TL = 1.2 Heavy Traffic Load
= 1.0 Normal Traffic Load
= 0.8 Light Traffic Load

C.4.4.4 Radio embedded network access delay (RE-NAD).

C.4.4.4.1 RE-NAD media access.
The RE-NAD DTE data link layer uses a channel access protocol between the DTE (DMTD or C^4I system) and DCE which is influenced by radio net voice activity. When the continuous scheduler (Tc) interval timer expires and the previous series of concatenated frames was successfully transmitted, a new series of frames is sent to the physical layer. If there is a pending series of concatenated frames, its transmission is requested again. It should be noted that the physical layer holds the series of concatenated frames when channel access has been denied. If channel access was denied a new Tc interval is calculated and channel access for transmission of the pending series of concatenated frames is requested when the new Tc interval timer expires. If a higher precedence individual frame becomes available for transmission, the concatenated frames shall be re-built to include the higher precedence frame.

For the Type 3 acknowledgment, the RE-NAD portions in both DTE and DCE are suspended and channel access is controlled by the RHD and TP processes. The RE-NAD algorithm is resumed following expiration of the TP timer.

C.4.4.4.1.1 Random schedule interval.
In order to achieve high performance radio network communication, efficient channel access and multi-level precedence, a fast attack slow decay RE-NAD algorithm is implemented in the DTE. This algorithm uses the “continuous scheduler” concept to provide a random distribution of timing for channel access via the Tc interval timer. The Tc interval timer is the sum of a voice component and a data component. The voice component is a fast attack slow decay function permitting voice to immediately slow down the scheduler (fast attack) while gradually speeding the scheduler back up to normal as long as there isn’t any voice on the radio net (slow decay). It is described more fully in C.4.4.4.1.2. The DATA component is a randomization around net size and the Fload algorithm. It is discussed in C.4.4.4.1.3 and C.4.4.4.1.4.

The value of Tc interval is recalculated after every local transmission attempt from the expression:

Tc interval = voice factor + uniform_random(SchedulerInterval)

where uniform_random (SchedulerInterval) is a uniform random number function using the range 0 - SchedulerInterval. Uniform_random returns an integer value.

C.4.4.4.1.2 Voice component.
The voice factor in C.4.4.4.1.1 is a value bound by its minimum and maximum limits. The maximum voice factor (range=0.3 to 10.0 sec) is the upper bound on the value of the voice factor. The minimum voice factor (range=0.3 to 10.0 sec) is the lower bound on the value of the voice factor. The initial voice factor shall be the minimum voice factor value. Detection of voice on the radio net increments the voice factor value while the absence of voice decrements the voice factor value.

C.4.4.4.1.2.1 Fast attack.
Voice detection shall increment the voice factor by the voice factor increment value (range=0.0 sec to 10.0 sec) as indicated below:

a. If the voice factor is at the minimum voice factor value (see C.4.4.4.1.2), the scheduler is incremented immediately to protect the next voice hit.

b. Otherwise, the increment occurs at the next scheduler expiration

The voice factor value is upper bounded by the maximum voice factor (see C.4.4.4.1.2).

C.4.4.4.1.2.2 Slow decay.
The voice factor shall be decremented every time the NAD expires by the voice decrement value (range=0.0 sec to 10.0 sec). The voice factor value is lower bounded by the minimum voice factor.

C.4.4.4.1.3 Calculation of the scheduler random parameter.
The parameter SchedulerInterval depends on queue lengths and the number of net members transmitting data as follows:

SchedulerInterval = [NADScaleTime * (NumActiveMembers / 16)] * Fload
minimum=(settable range=0.1 to 3.0 sec)
maximum=(settable range=1.0 to 50 sec)

where:

NADScaleTime = adjustment factor (range=0.1 – 5.0 sec).

NumActiveMembers = number of net members actively transmitting data on the net. All net members are within two intranet hops of the node determining this value. Continuous calculation of this value shall be performed based on the number of known active data transmitters on the net. A station’s own status is included in this count.

Neighbor agent timer = this timer (range = 1 – 600 sec) is used to age out net member active status. When this timer expires and a data transmission has not been received from a net member, that net member is marked inactive. This timer should be greater than the topology update timer to assure net members are not aged out between topology updates in fragmented nets.

SchedulerInterval shall be recomputed after every transmission by the DTE.

C.4.4.4.1.4 Calculation of the load factor (Fload).
The Fload is computed in a fully distributed manner by every node in the net. In the transmission header, the six least significant bits of the second octet (as indicated in the Queue Precedence and Queue Length subfields of FIGURE 10, see 5.3.1) are dedicated to transmitting the number of messages at the highest priority level remaining in the information frame queue; the remaining two bits are spare. The two least significant bits (LSB) indicate the level of the highest priority message. The four most significant bits (MSB) indicate the number of frame concatenations required to transmit all of the messages at the above priority level. The four MSB are quantified as shown in TABLE C-I.

TABLE C-I. Calculation of the load factor.

Number of Concatenated Frames Required	Bit Pattern 7 6 5 4
0.0	0 0 0 0
0.0 (exclusive) - 0.5 (inclusive)	0 0 0 1
0.5 (exclusive) - 1.0 (inclusive)	0 0 1 0
1.0 (exclusive) - 2.0 (inclusive)	0 0 1 1
2.0 (exclusive) - 3.0 (inclusive)	0 1 0 0
3.0 (exclusive) - 4.0 (inclusive)	0 1 0 1
4.0 (exclusive) - 5.0 (inclusive)	0 1 1 0
> 5.0	0 1 1 1

The Load Factor takes on values such that 1.0 < Fload < 18.0. The minimum value of 1.0 places an upper limit on the speed of the scheduler per the Fload description. The value of 18.0 provides a useful range for adaptation of the scheduler due to differing traffic loads, and is divisible by 2 and 3, resulting in integer ranges for the three different precedence values. Higher values of the Load Factor indicate that the node has shorter queues of equal or lesser priority. In cases of high load factor, it is desirable to increase the scheduling interval to give neighboring nodes with higher priority or longer queues of equal priority more opportunities to transmit. The

Load Factor is calculated after every expiration of the scheduler, prior to calculation of the next expiration.

ALGORITHM: Calculation of the Load Factor, Fload.

1. Determine the number of unique neighboring node priority levels broadcast by all the nodes including this one. This data is taken from the last transmission received from each neighboring node.

2. Divide the interval 0.0 to 18.0 into equal segments, one per unique announced priority level. The first segment (0.0 to 9.0 for two levels) is allocated to the highest priority traffic. Define the Segment Offset as the lower bound of the chosen segment. For two precedence levels, the Segment Offset is 0.0 for the highest precedence and 9.0 for the Lowest Precedence. Define the Segment width equal to 18.0/Number of precedence levels. For all three precedence levels, each precedence level has a segment width of 6.0.

3. Each segment is subdivided into n unique levels where n is the number of unique quantified concatenated frame lengths reported by the neighboring nodes and the node doing the computation. In the case of only one length, all nodes use the midpoint of the segment. In the case of multiple lengths, these lengths are ordered from longest to shortest (1 -> n). In the following computation of Load Factor (see TABLE C-II), a node would use a value of m determined by its position in that ordering. All nodes with the longest quantified length use the value 1, while those with the shortest use the value n for variable m in the following equation:

Fload = Segment offset + (Segment width*m)/(n+1)

where

Segment Offset is the Lower bound of the segment chosen by precedence level from step 2.

Segment Width is the maximum Load Factor (18) divided by the number of unique precedence levels

n is the number of unique quantified queue lengths.

m is this nodes positioning within the ordering of quantified queue lengths.

TABLE C-II. Calculation of the load factor -- example 1.

Node Number	Highest Precedence	Quantified Queue Length 7 6 5 4	Load Factor
1	Routine	0 0 0 1	12.0
2	Routine	0 0 0 1	12.0
3	Routine	0 0 1 1	6.0
4	Routine	0 0 1 1	6.0

All nodes compute the load factor in the following manner.

1. There is only 1 unique priority level (Routine).

2. The Segment is determined to encompass the whole range 0->18.

3. The Segment Offset is the lower bound (0).

4. The Segment Width is the entire range (18).

5. Two unique Quantified Queue Lengths are noted. The value of n is set to 2.

6. The unique Quantified Queue Lengths are ordered from longest to shortest (3,1).

7a. Nodes 1 and 2 note that their positioning in this sequence is 2 and set m to 2.

7b. Nodes 3 and 4 note that their positioning in this sequence is first and set m to 1.

8a. Nodes 1 and 2 compute their load factor from the equation.

Fload = Segment Offset + (Segment Width*m)/(n+1)

= 0 + (18 * 2) / (2+1) = 12

8b. Likewise, Nodes 3 and 4 do the Load Factor computation.

Fload = 0 + (18 * 1) / (2+1) = 6

TABLE C-III. Calculation of the load factor -- example 2.

Node Number	Highest Precedence	Quantified Queue Length 7 6 5 4	Load Factor
1	Routine	0 0 0 1	13.5
2	Routine	0 0 0 1	13.5
3	Urgent	0 0 1 0	6.0
4	Urgent	0 0 1 1	3.0

All nodes compute the load factor in the following manner.

1. There are two unique precedence levels (Urgent and Routine).

2. The load Factor Range is divided into two segments 0-9, 9-18. The segment 0-9 is reserved for Urgent, while the segment 9-18 is reserved for Routine.

3. The Segment Offset is the lower bound of the segment. The Segment Offset is 0 for Urgent and 9 for Routine.

4. The Segment Width for both precedence levels is the entire range (0->18) divided by the number of precedence levels. Segment Width = 18/2 = 9.

Nodes 1, 2 perform the following computations:

5. There is only one Quantified Queue Length. Thus, n is equal to 1 and since there is only 1 length both nodes use the first position in the sequence and set m to 1.

6. Fload = Segment Offset + (Segment Width*m)/(N+1)
   = 9 + (9 * 1) / (1+1) = 13.5

Nodes 3,4 perform the following computations.

7. The unique Quantified Queue Lengths are ordered from longest to shortest (3,2). There are two unique lengths which sets the value of n to 2.

8. Node 3 has a length of 2, which occupies position 2 in the ordering of step 7. Because it occupies position 2, the value of m is set to 2.

   Fload = Segment Offset + (Segment Width*m)/(n+1)
   = 0 + (9 * 2) / (2+1) = 6

   Node 4 has length of 3, which occupies position 1 in the ordering of step 7. Node 4 sets its value of m to 1.

   Fload = Segment Offset + (Segment Width*m)/(N+1)
   = 0 + (9 * 1) / (2+1) = 3

C.4.4.4.1.5 <u>100 msec Immediate mode scheduling.</u>
In lightly loaded nets quicker access to the radio net medium is provided through the "100 msec immediate mode" scheduling all types except Type 3 ACK PDUs as follows:

a. If the scheduler expires and the following conditions are met: (1) there are no concatenated frames awaiting transmission, (2) the RE-NAD voice factor is at its minimum value, and (3) all other members of the net reported transmission queue lengths of zero; set Immediate Mode to READY. Compute and start the next random interval of the continuous scheduler (Tc).

b. When an information PDU arrives for transmission and Immediate Mode is READY, cancel the previously scheduled Tc and assign a scheduling interval as follows:

   Tc = 100 msec

c. When this is done, Immediate Mode is set to ON. The 100 msec allows an opportunity for messages which have been segmented/fragmented/received to be piggy-backed into the same series of concatenated frames. This increases efficiency without imposing delay.

d. When the scheduler expires due either to the Tc scheduled as a result of the immediate mode operation or due to normal continuous operation, and I-frame(s), S-frame(s), U-frame(s) or a frame concatenation are pending, perform concatenated frame processing as normally is done. Compute and start the next random interval of the continuous scheduler (Tc) in the normal manner.

e. Any traffic, voice or data, detected during the immediate mode operation shall abort the 100 msec Immediate Mode and set it to OFF. The scheduler is then computed in the normal manner.

C.4.4.4.1.6 Immediate mode scheduling.
If the PDU is Type 1or Type 3, the Tc is set to 0.0 seconds which permits net access to be controlled without a randomized scheduler influence.

C.4.4.4.2 RE-NAD network access.
When the precedence level of the transmission changes, the DTE shall set the precedence level of the new transmission. This precedence level will correspond to the frame with the highest precedence value within the series of concatenated frames.

C.4.4.4.3 Network busy sensing and receive status.
The presence of multiple stations on a single random access communications network requires voice/data Network Busy Sensing and the use of network access control to reduce the possibility of data collisions on the net. The combined Data and Voice Nets require cooperation between the DTE (DMTD or C^4I system) and the DCE.

The DCE indicates the presence of receive data and voice by signaling the following conditions:

a. Data being received.

b. Voice operation.

c. Idle/Transmission completed.

d. Data being transmitted.

The transmission of data by the DTE is allowed only in the Idle/Transmission completed state.

C.4.4.5 Deterministic adaptable priority-network access delay (DAP-NAD).
DAP-NAD is a method of generating Network Access Delays to control network accesses which provides every station with an opportunity to use a radio/wireline net. It is deterministic in that every station has a unique opportunity to access the network and given the device, network, and protocol parameter settings, the maximum delay for network access can be calculated.

The mechanism for providing network access is to give the first “access opportunity” (the time at which a station may transmit a message if one is available) to a different station at each “network access period” (the time between message transmissions when all stations are determining when to transmit) and to give later access opportunities to all other stations in sequence. Each station is assigned a unique Station Number that is in the range of 1 to the Number of Stations (NS in the equations that follow). It is recommended that the Frequency of Access Ranking (FOAR) algorithm described in Section 6 (paragraph 6.3.3.1) be utilized to determine Station Number whenever DAP-NAD is to be used. This algorithm increases fairness whenever DAP-NAD is the mechanism used to access the network. During the first network access period, station number 1 is given the first access opportunity, station number 2 is given the second access opportunity, station number 3 the third access opportunity, etc. After the last station has been given an access opportunity, station number 1 is again given an access opportunity, followed by station number 2, etc. This continues until a station transmits a message. The station that transmits the message shall increment by one (1) the First Station Number (FSN) subfield contained in the last message it received and places the resulting number in the FSN subfield of the Transmission Header. The very next access period (the first DAP-NAD time slot following the message transmission) is referred to as the "bump slot" and is reserved, such that any node can interrupt the network in case they have an urgent message to transmit. All nodes having messages to transmit with an urgent precedence would transmit either a short Urgent control frame (Transmission Header) or the actual urgent message in the reserved slot using only Type 1, Type 2 or Type 4 (Type 3 shall not be utilized in the bump slot). Upon receipt of this Urgent frame or detection of a network busy condition during the reserved slot, all receiving nodes would assume that the network precedence had gone to Urgent and act accordingly. In this manner, transmissions in the bump slot would serve to interrupt the operation of a network operating at Priority or Routine causing it to elevate to Urgent mode. The next station authorized to access the network is the First Station Number specified in the Transmission Header of the transmission that occurred before reverting to Urgent mode. Each station calculates different NAD times for each network access period. Note that a station with an Urgent message ready for transmission shall not utilize the bump slot if the FSN indicates that this station is the very next one authorized to access the network. The station that utilized the bump slot shall retransmit its Urgent message in its authorized access opportunity. This is necessary for the rare instance of a collision in the bump slot. Type 3 is authorized in this retransmission. There are three Network Precedence (NP) modes: urgent, priority and routine. Regardless of the NP mode in use, every station shall be provided at least one opportunity to access the network before NP is reduced to next lower level. If no station accesses the network, at any specific NP, each station will obtain exactly one access opportunity. If a station does access the network during any specific NP, the network shall remain at that NP for another NS access opportunities. This is demonstrated by two examples in FIGURE C-3.

* This example assumes that NP = U, FSN =1, Station 4 has just completed an urgent transmission and no stations require access to network. The first access slot following the transmission by Station 4 is a bump slot.

Access	B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Station #	A	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
FSN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
NP	U	U	U	U	U	P	P	P	P	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R

* This example assumes that NP = U, FSN =1, Station 4 has just completed an urgent transmission and Station 3 has a priority message to transmit. Once again, the first access slot following the transmission by Station 4 is a bump slot. In addition, there is a bump slot immediately following the Priority transmission by Station 3.

Access	B	1	2	3	4	5	6	7	B	8	9	10	12	13	14	15	16	17	18	19	20	21
Station #	A	1	2	3	4	1	2	Tx by 3	A	2	3	4	1	2	3	41	1	2	3	4	1	2
FSN	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
NP	U	U	U	U	U	P	P	P	P	P	P	P	P	R	R	R	R	R	R	R	R	R

FIGURE C-3. Example of FSN and NP operation.

The first NS number of access opportunities of a network access period are reserved for stations that have an urgent message awaiting transmission. Those stations that do not have any urgent messages awaiting transmission shall wait for at least the NS+1 access opportunity before they can transmit. The next NS number of access opportunities of the network access period are reserved for stations that have a priority (or an urgent if one has become available since the previous access opportunity) message awaiting transmission. Those stations that have only routine messages awaiting transmission shall wait for at least the 2NS+1 access opportunity before transmitting. Those stations that have any messages awaiting transmission, regardless of priority, by the 2NS+1 access opportunity can transmit when their calculated access opportunity arrives. The calculations of the NAD times are discussed in the following paragraphs.

a. Network in Urgent Mode. The first NS number of access opportunities of a network access period are reserved for stations that have an urgent message awaiting transmission. If no Urgent messages are transmitted during this time frame, the NP drops to Priority Mode. If an Urgent message is transmitted, the network will remain in Urgent Mode for another NS access opportunities. The very first network access period following completion of the transmission while in Urgent mode shall be reserved for any other station with an Urgent message to send. Those stations that do not have any urgent messages awaiting transmission shall wait for at least another NS access opportunities before they can transmit.

b. Network in Priority Mode. The first NS access opportunities are reserved for stations that have an urgent or priority message awaiting transmission. If no Urgent or Priority messages are transmitted during this time frame, the NP drops to Routine Mode. If an Urgent message is transmitted, the NP will elevate to Urgent. If a Priority message is transmitted, the NP shall remain at Priority for another NS access opportunities. Those stations that only have routine messages awaiting transmission shall wait for at least another NS access opportunities before they can transmit. The very first network access period following completion of the transmission while in Priority mode shall be reserved for any station with an Urgent message to send When the interrupting station obtains access and transmits the Urgent message, the NP shall remain at NP = Urgent for at least another NS access opportunities.

c. Network in Routine Mode. In Routine Mode, any station that has a message, regardless of priority, can transmit when their calculated access opportunity arrives. If no messages are transmitted, or if a Routine Message is transmitted, the NP remains at Routine. If a Priority Message is transmitted, the NP elevates to Priority. If an Urgent Message is transmitted, the NP elevates to Urgent. The very first network access period following completion of a Routine transmission shall be reserved for any station with an Urgent message to send. Routine mode remains in effect until a message with an NP greater than Routine is transmitted.

FIGURE C-4 shows an example of the DAP-NAD key. And FIGURE C-5 shows an example of using the key.

NP = **N**etwork **P**recedence, highest MAC precedence of any frame in the last transmission (NP = URGENT this example)
NS = **N**umber of **S**tations (NS = 4 this example) the net is configured to support
NAD = **N**et **A**ccess **D**elay, time after TP that a station must listen for a busy net before starting to transmit
Net **B**usy **D**etect, time from when a station begins transmitting until it can be detected by other stations
A = **A**ny Station Number, used to indicate that any station may transmit during the bump slot to quickly transmit an urgent message and set NP to urgent

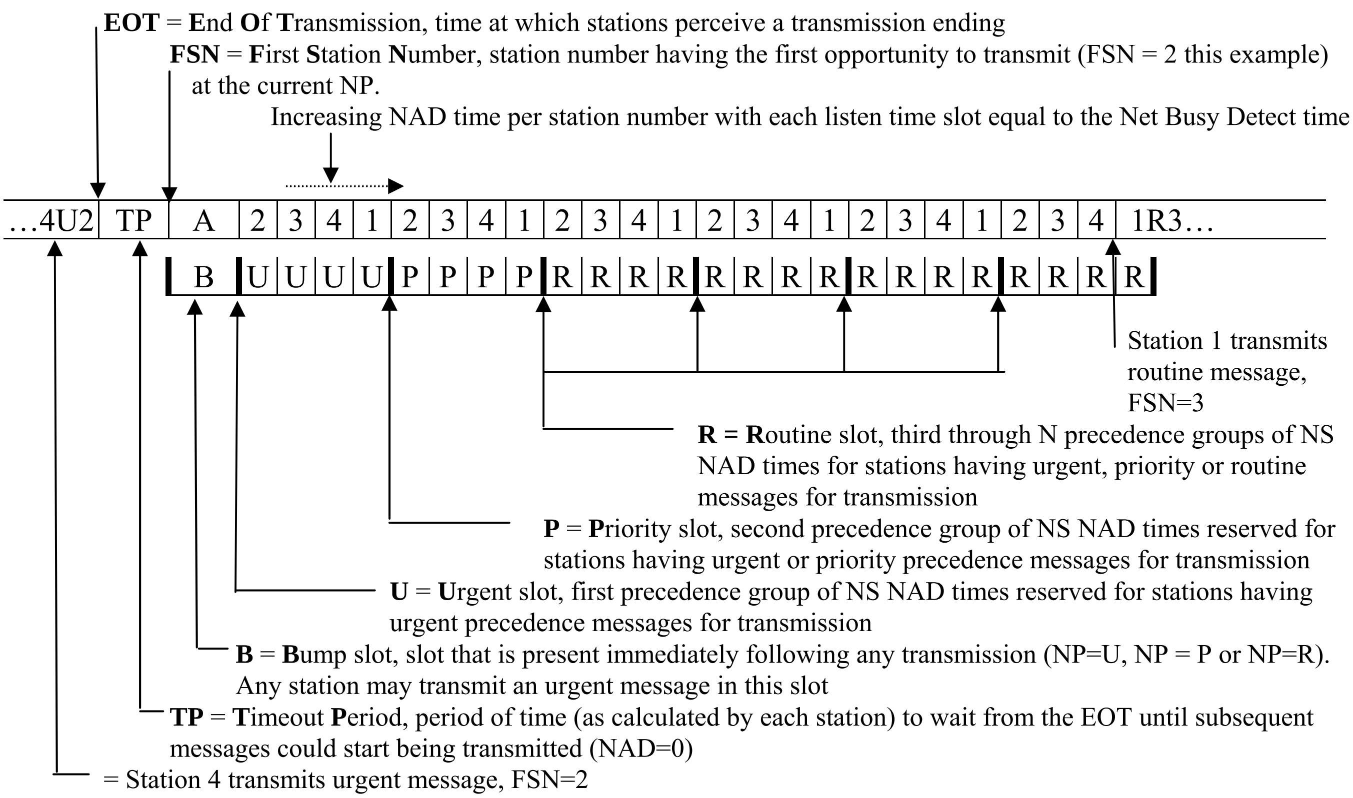
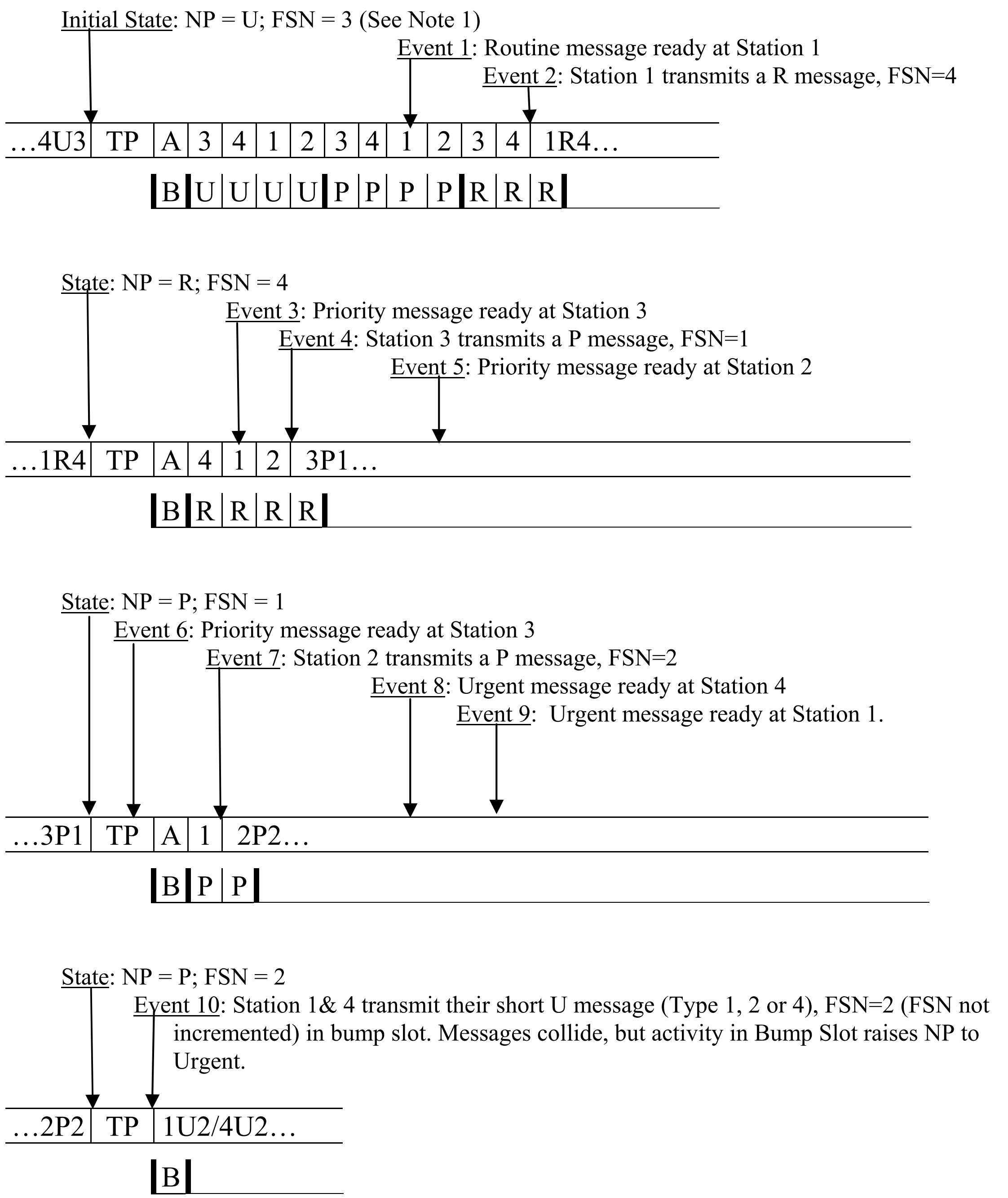


FIGURE C-4. DAP-NAD example key.



Note 1: Example assumes initially that station 4 has just finished transmitting a frame with an FSN=3 and NP=U, that no messages are pending transmission from any station at the end of this transmission, and that the net is configured for 4 stations

FIGURE C-5. DAP-NAD example.

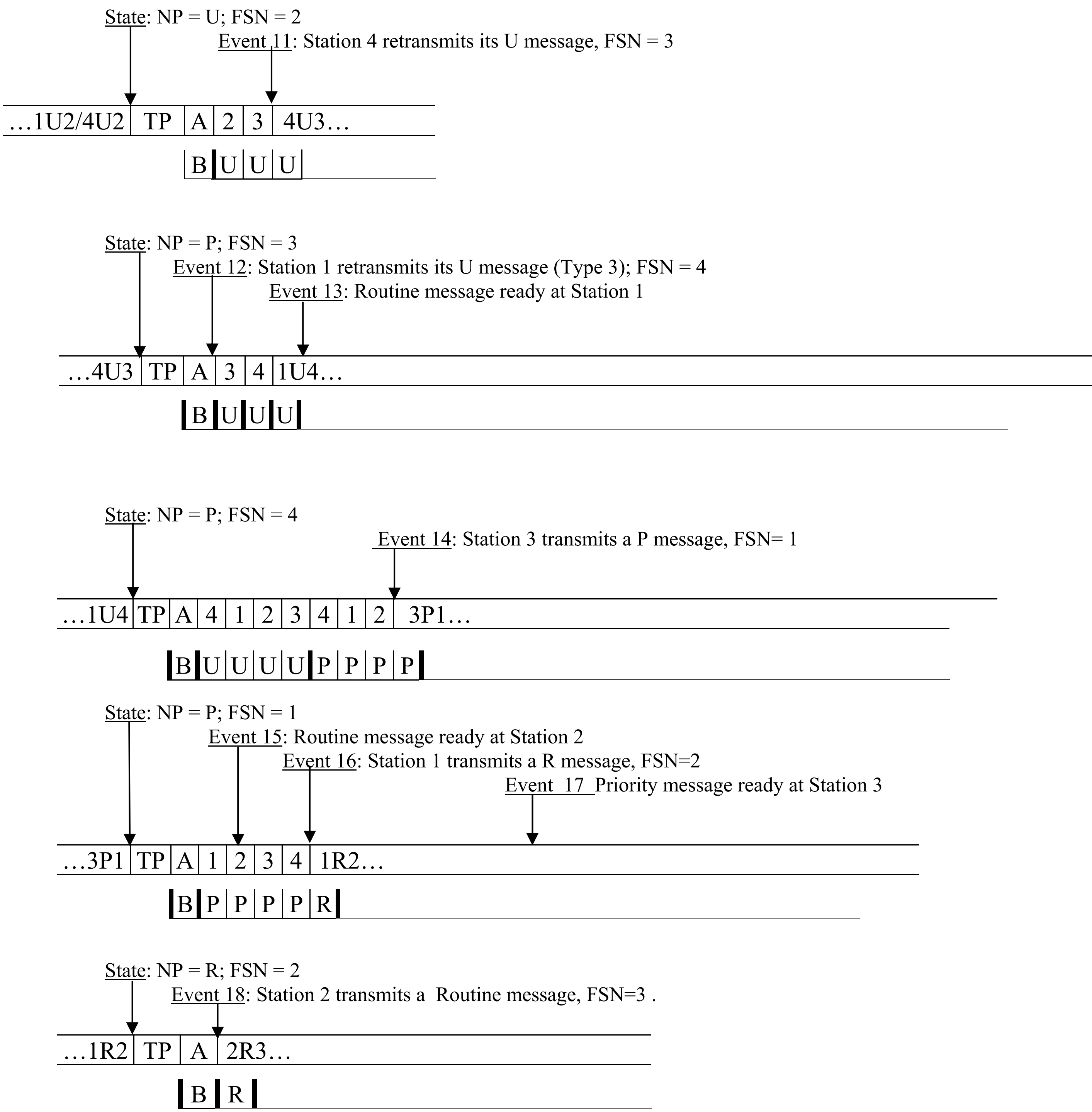
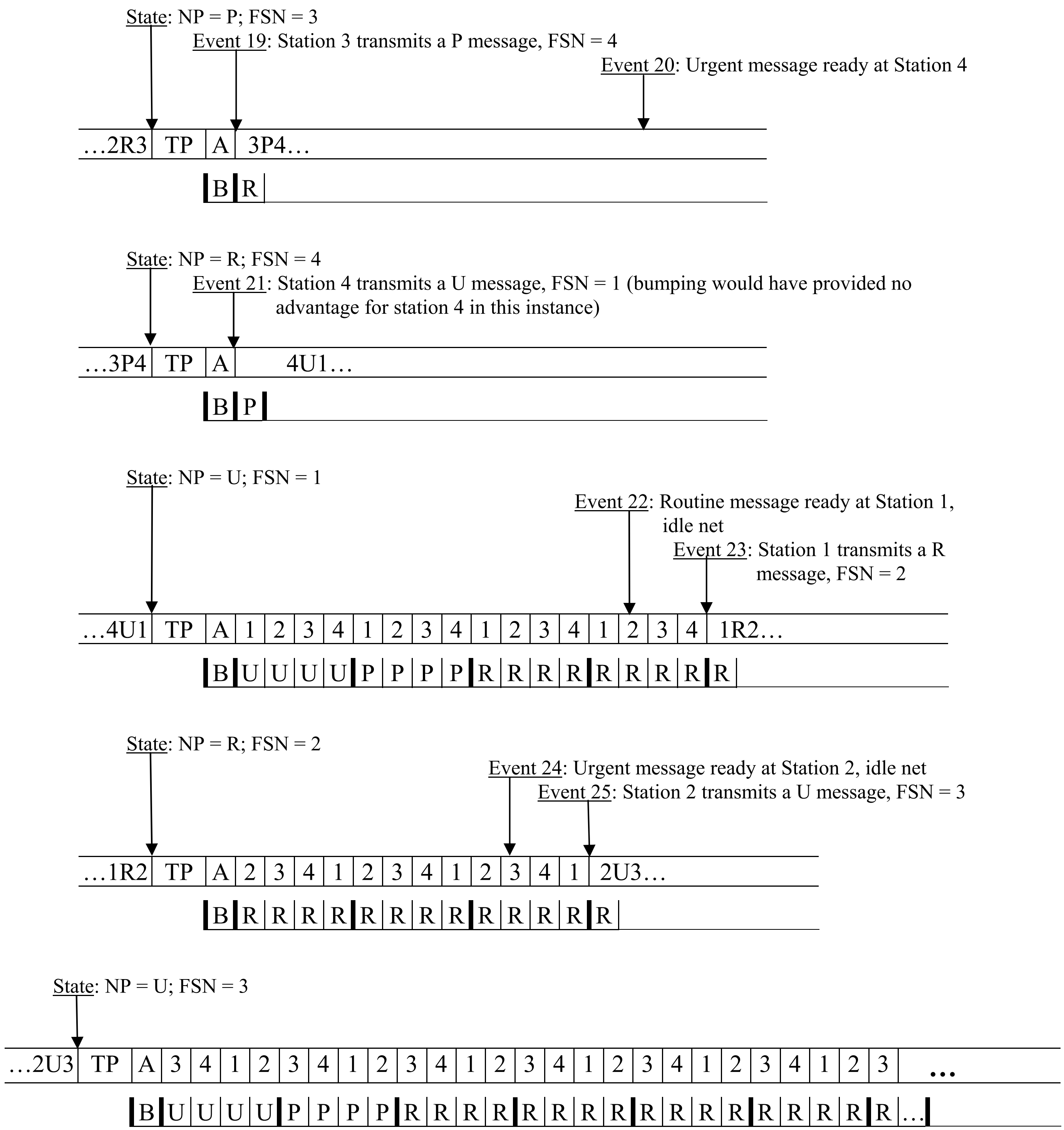


FIGURE C-5. DAP-NAD example - Continued.



(Net goes idle for indefinite time period and NADs continue to be calculated by each station during the idle period in order to avoid collisions when a message of any precedence is ready for transmission at more than one station at the same time in the future.)

FIGURE C-5. DAP-NAD example - Continued.

C.4.4.5.1 NAD information field.

To allow for rapid recovery (resynchronization) to the NAD mechanism when messages are not received correctly due to noise, etc., and to provide stations information about the priority of a message, an Information Field has been added to the Transmission Header. This field defines the next access opportunity. This field is present in all physical frames. This field contains the First Station Number subfield which contains the number of the station that is to have the first network access opportunity at the next network access period (the one immediately following this transmission). The number of the station that has the first network access opportunity is the variable FSN in the equations below. This Information Field also contains the Data Link Precedence subfield which indicates the highest priority of any message that is contained in the physical frame. It shall contain the value 0 if an urgent message is in the frame, 1 if a priority but no urgent message is in the frame and 2 if neither an urgent or priority message is in the frame. The Type 3 acknowledgment sent in response to a transmission will use the same Data Link Precedence and First Station Number as used in the original message to which the acknowledgment applies. The variable NP in the equations below shall be set equal to the content of this subfield for the next network access period. If the transmission contained multiple frames, the variable NP is set equal to the highest value in any of the frames. If network busy is detected in the reserved network access period, the network reverts to the Urgent mode regardless of the setting in the Data Link Precedence subfield.

C.4.4.5.2 NAD equations.

A sequence of NADs for each network access period is generated. A station may transmit a message(s) when the time following the Timeout Period equals any one of the terms (NAD values) in the sequence. Equation 1 is used by each station to calculate its NADs.

Equation 1: $$NAD_n = F_n * Net\_Busy\_Detect\_Time + Max(0, F_n\text{-}1) * DTETURN \quad \text{for } n=1 \text{ to } \infty$$

NAD_n is the nth term in the sequence of NADs that are associated with a station during a network access period. Each term (NAD_1, NAD_2, NAD_3, etc.) is a point in time (a delay following the Timeout Period) at which a station may begin transmitting. If a station does not begin transmitting at one term (e.g. NAD_2), it shall wait until at least the next term (e.g. NAD_3) before it can begin transmitting. The values of the terms calculated by a station will be different than the values of the terms that are calculated by all of the other stations (no two stations will have terms with the same values). Also, the values of the terms calculated by a station for one network access period will be different than the values of the terms calculated by that station for the next network access period. F_n is nth term in a sequence of factors that, when used in conjunction with DTETURN and Net_Busy_Detect_Time, yields the nth NAD term. F_n is an integer calculated per equation 2.

Equation 2: $F_n = F_1 + (n-1)NS$ for $n=1$ to ∞

F_n is the nth term in a sequence of factors. F_1 is the first term in the sequence and is the base from which all the other terms are calculated. It is calculated per equation 3. NS is the number of stations on the network and is the common difference between the terms of the sequence. The variable n is an integer and has a range of 1 to infinity.

Equation 3: $F_1 = F_{min} + I + P * NS$

F_1 is the first term in the sequence of factors. The first term that a station can have is the minimum factor (F_{min}) plus the interrupt factor (I) plus an offset determined by priority of messages awaiting transmission. F_{min} is calculated using equation 4. P is the factor that accounts for message priority. It is calculated using equation 5. Interrupt factor I is computed using equation 6.

Equation 4: $F_{min} = SN - FSN$ if $SN \geq FSN$, else $F_{min} = NS + SN - FSN$

F_{min} is the minimum possible factor that a station could have if message priority and network precedence mode were ignored. SN is the number of the station. It is an integer, has a range of 1 to NS, and is assigned at communications initialization. FSN is the number of the station that has the first network access opportunity for the present network access period. It is set equal to the value received in the NAD information field of the Transmission Header of the last transmission on the net.

Equation 5: $P = MP - NP$ if $MP \geq NP$, else $P = 0$

P is the factor that accounts for priority of messages awaiting transmission. It is used to generate the offset to add to F_{min} to generate F_1. MP is a variable indicating the highest priority of any messages awaiting transmission. It shall have a value of 0 if there are any urgent messages awaiting transmission, the value 1 if there are any priority messages and no urgent messages awaiting transmission, and the value 2 if there are no urgent or priority messages awaiting transmission. NP is a variable indicating the highest priority of any messages contained in the last transmission on the network. It shall have the value 0 if an urgent message was in the last transmission, 1 if a priority but no urgent message was in the last transmission, and 2 if neither an urgent or priority message was in the last transmission.

Equation 6: $I = 1$

I is a factor that provides a slot for stations to interrupt the network whenever a station has an urgent message for transmission.

C.4.4.5.3 Initial condition state.
The above operations and equations only apply to stations after they are on-line and have received a message. A station that has just come on line and has not yet received a message is not in synchronism with other stations (this station has not yet started any timers and if it had, they would not have been started at the same time as other stations = timers). These stations shall be considered to be in the initial condition state. Regardless of what causes a station to be in the initial condition state, transmissions shall be delayed by at least the time specified by equation 7 while in that state.

Equation 7: INAD = TP + ((3 * NS) + 1) * Net_Busy_Detect_Time + (3 * NS) * DTETURN

INAD (Initial condition state Network Access Delay) is the minimum time that a station shall delay transmission of a message after it has become capable of receiving and transmitting messages, but no more than 20 seconds. The TP in the equation shall be a worst case TP, i.e., as if there had just been a Type 3 message on the network that was addressed to 16 stations on the net. The FSN in this instance shall be set to the station's own FSN.

C.4.4.6 Data and voice-network access delay (DAV-NAD).
DAV-NAD is almost identical to DAP-NAD defined in C.4.4.5. Implementers of DAV-NAD should refer to paragraph C.4.4.5 for a description of the Network in the three precedence modes, C.4.4.5.1 for a description of the NAD information field, C.4.4.5.2 for NAD equations and C.4.4.5.3 for Initial condition state.

The only difference is the way the FSN is incremented. For DAV-NAD, the station that transmits the message shall increment the First Station Number subfield contained in the last message it received by a fixed constant called the FSN Increment Number (FSNIN) and place the result in the First Station Number subfield of the Transmission Header. This fixed constant is provided in TABLE C-IV.

DAV-NAD uses the parameters specified for DAP-NAD in the MIL-STD-188-220 Parameter Table, which is available on the CNRWG website specified at 2.3.4.

TABLE C-IV. FSN Increment Numbers for DAV-NAD

Number of Stations (NS)	FSNIN
2	1
3	2
4	3
5	2
6	5
7-8	3
9	4
10	3
11	4
12-14	5
15-20	7
21	8
22-23	9
24-32	11
33-38	13
39-51	17
52-56	19
57-64	23

FIGURE C-6 shows an example of the DAV-NAD (FSNIN from TABLE C-IV) key and FIGURE C-7 shows an example of using the key.

NP = **N**etwork **P**recedence, highest MAC precedence of any frame in the last transmission (NP = URGENT this example)
NS = **N**umber of **S**tations (NS = 4 this example) the net is configured to support
FSNIN = First **S**tation **N**umber Increment Number (FSNIN = 3 this example)
NAD = **N**et **A**ccess **D**elay, time after TP that a station must listen for a busy net before starting to transmit
Net **B**usy **D**etect, time from when a station begins transmitting until it can be detected by other stations
A = **A**ny Station Number, used to indicate that any station may transmit during the bump slot to quickly transmit an urgent message and set NP to urgent

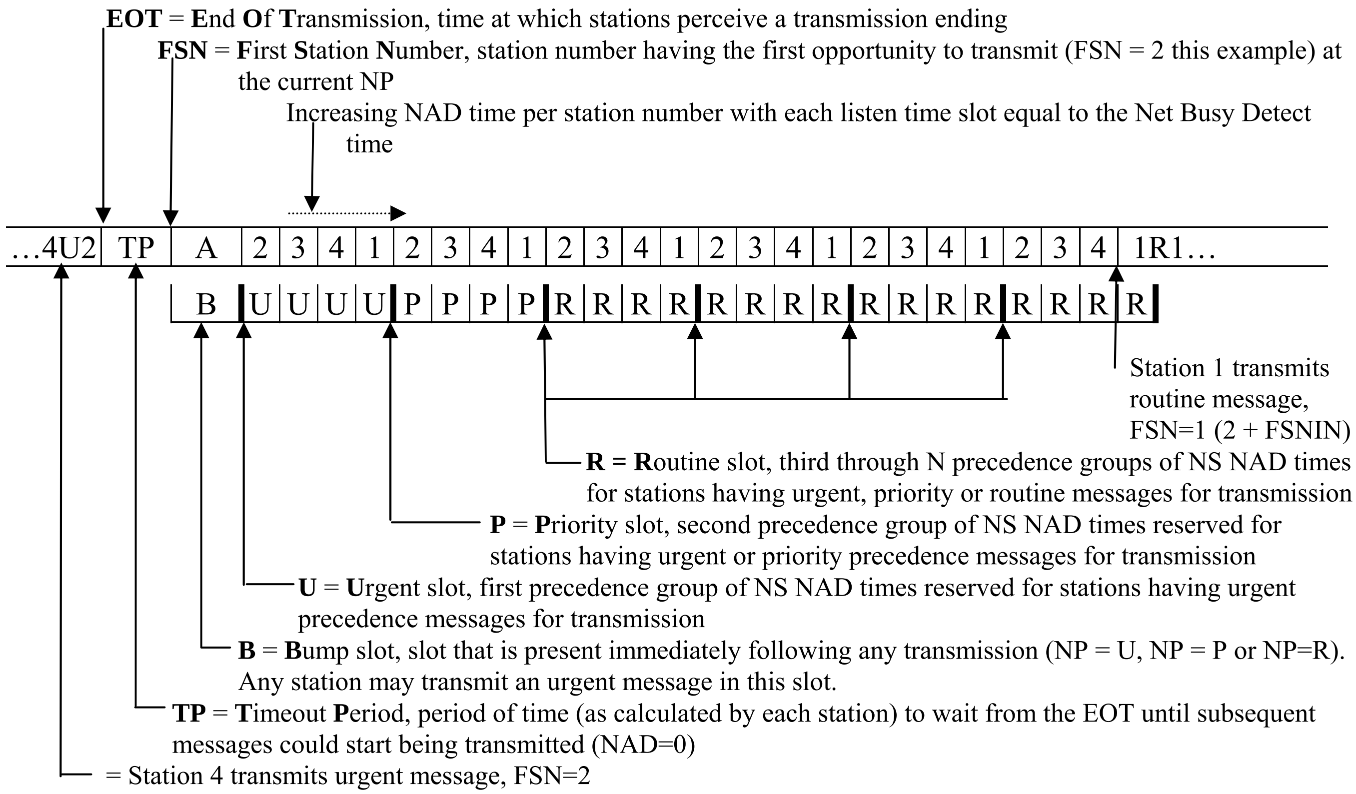
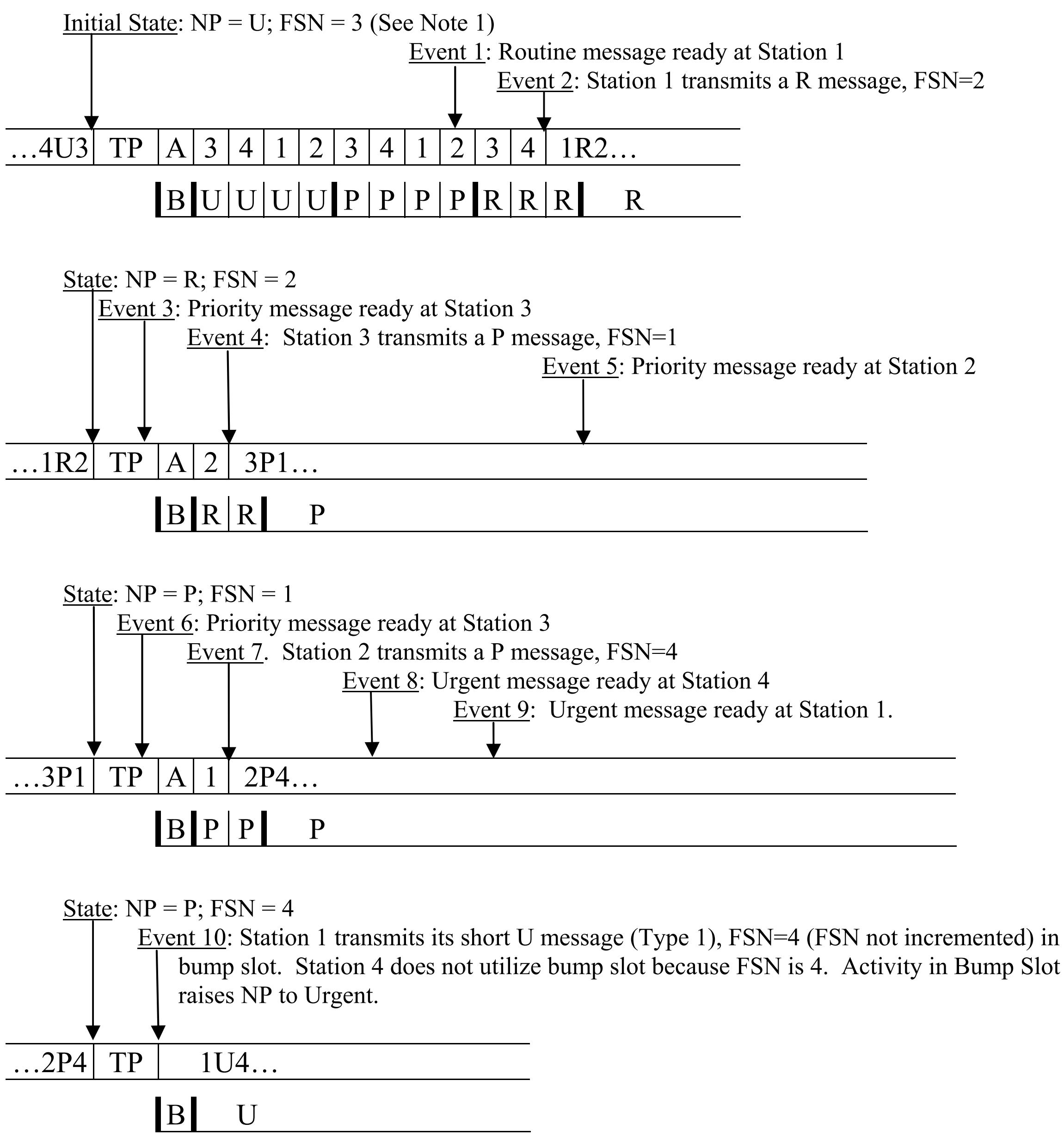


FIGURE C-6. DAV-NAD example key



*Note 1: Example assumes initially that station 4 has just finished transmitting a frame with an FSN=3 and NP=U, that no messages are pending transmission from any station at the end of this transmission, and that the net is configured for 4 stations

FIGURE C-7. DAV-NAD example

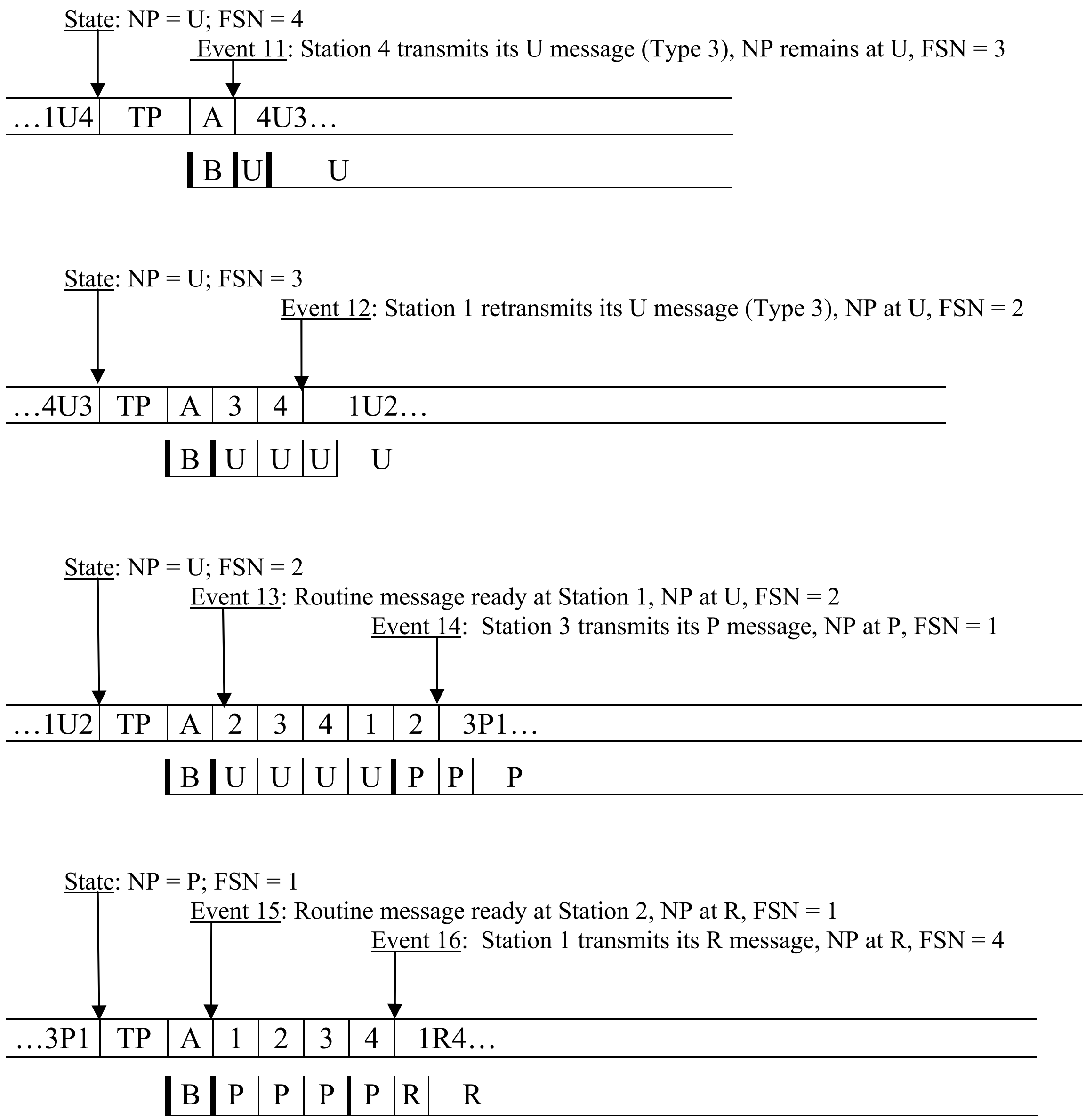


FIGURE C-7. DAV-NAD example-Continued

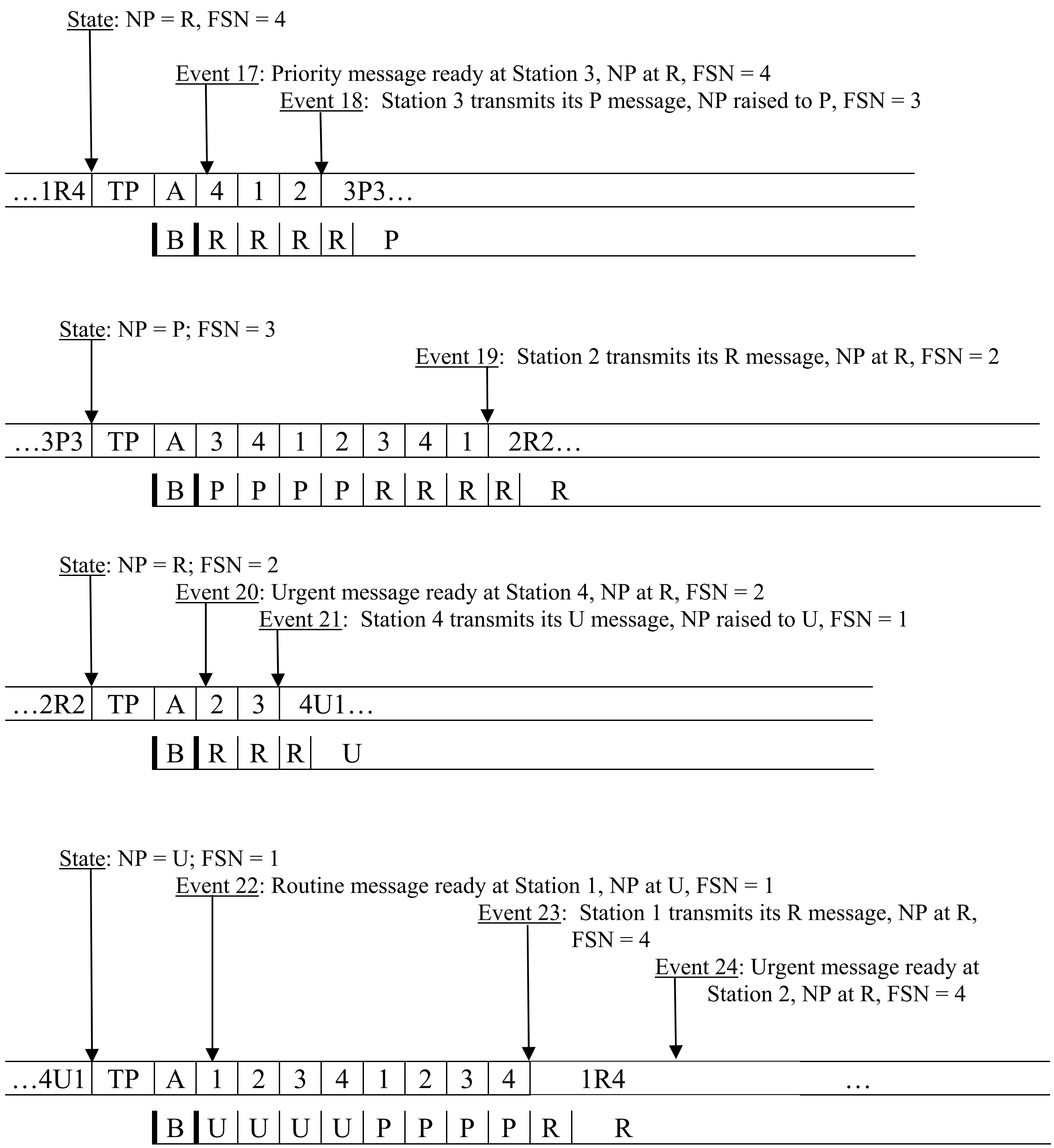
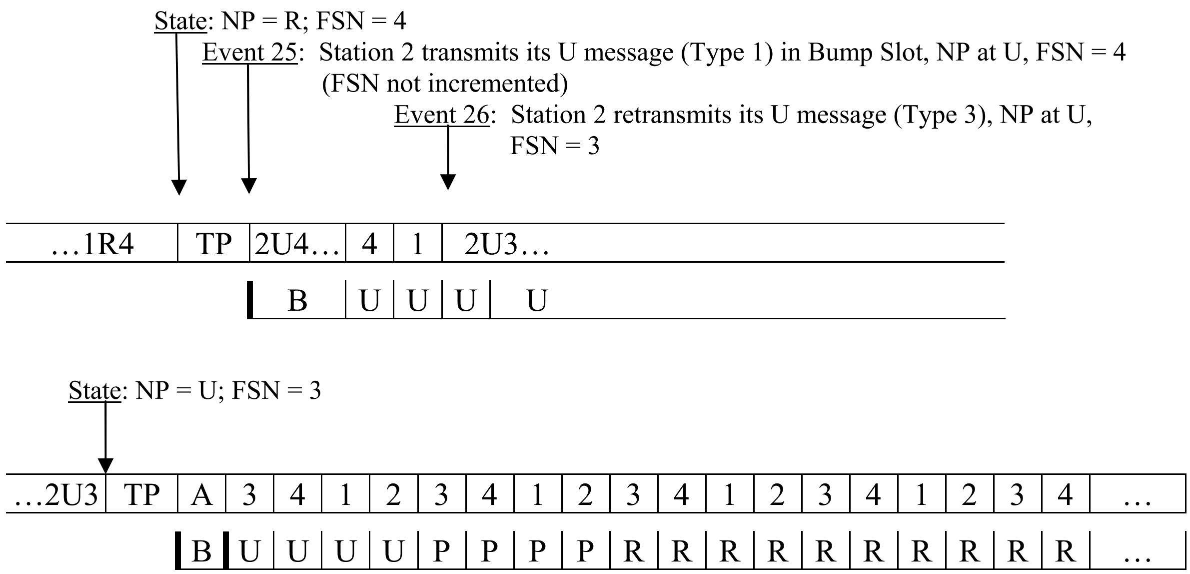


FIGURE C-7. DAV-NAD example-Continued



(Net goes idle for indefinite time period and NADs continue to be calculated by each station during the idle period in order to avoid collisions when a message of any precedence is ready for transmission at more than one station at the same time in the future.)

FIGURE C-7. DAV-NAD example-Continued

C.4.5 Voice/data network sharing.

A station may support this protocol on a network where both voice and data transmissions are allowed to occur. When operating in a mixed voice and data network, voice and data network sharing shall operate in the following manner:

a. A receive operation shall be considered a voice reception unless a valid synchronization pattern is identified. A receive operation that is less than 0.75 seconds in length shall be considered a noise burst instead of a voice reception. See Section 6, Notes, (6.3.2.2.2) for additional information.

b. The network shall be synchronized based on RHD and TP timers, which are driven only by data transmissions and receptions. Voice receptions and noise bursts shall not be used for resynchronizing network timers.

c. A station shall not transmit during a noise burst or a voice reception. After completion of a voice reception, a station shall wait at least TURN seconds before initiating transmission. When voice/noise reception begins and ends during a Type 3 acknowledgment sequence, an acknowledging station will begin transmission only at the beginning of its individual RHD and will not begin transmission after the start of its RHD period.

d. After completion of a voice reception, operation of the P-NAD network access scheme shall be reinitiated if P-NAD is being used. P-NAD consists of a sequence of NAD slot groups. Within each NAD slot group there is one NAD slot assigned to each station and one slot assigned to the station that transmitted last. After a voice reception is completed, the current, partially-completed NAD slot group and the next complete NAD slot group shall be used only by stations with urgent-precedence data transmissions. The NAD slot group after these groups shall be used only by stations with urgent-precedence or priority-precedence data transmissions. Subsequent NAD slot groups may be used by any station. This preserves the intent of P-NAD, which is to deterministically avoid collisions and to ensure that high-precedence traffic is always transmitted first.

e. RHD and TP timers shall not be suspended or resumed as a result of voice receptions.

f. Data link protocol timers shall be suspended and resumed as a result of voice receptions.

g. The Intranet layer timers shall not be suspended and resumed as a result of voice receptions.

h. Relative priorities of voice and data on the network shall be adjusted by selectively enabling or disabling physical and/or data link concatenation for a station. Concatenation may be disabled to give priority to voice and may be enabled to give priority to data.

APPENDIX D

COMMUNICATIONS SECURITY STANDARDS

D.1 General.

D.1.1 Scope.

This appendix describes the COMSEC interoperability parameters for DMTD and interfacing C^4I systems.

D.1.2 Application.

This appendix is a mandatory part of MIL-STD-188-220 for systems using COMSEC. The information contained herein is intended for compliance.

D.1.3 Interoperability.

This appendix cannot guarantee the user end-to-end interoperability. The selection of COMSEC and signaling is a function of communications media. Traditional COMSEC equipment is specific to communications media and may not be compatible due to signaling differences. The systems integrators and systems planners shall ensure that compatible media and signaling are chosen if interoperability is desired. This COMSEC specification will provide for interoperability of the underlying encryption algorithm.

D.2 Applicable Documents.

a. 0N431125 WINDSTER Cryptographic Standards (U)

b. DS-68 INDICTOR Cryptographic Standards (U)

Information regarding 0N431125 WINDSTER and DS-68 Cryptgraphic Standards can be obtained from Director, National Security Agency NSA/CSS Enterprise Standards Program (NESP), 9800 Savage Road, STE (DE), Fort George G. Meade, MD 20755-6997 Telephone: (301) 688-6194.

D.3 Definitions.

Refer to APPENDIX A.

D.4 General requirements.

The backward-compatible mode applies when link encryption is provided by external COMSEC devices. These external COMSEC devices may be standalone equipment (such as the VINSON and KG-84) or communications equipment with built-in COMSEC. The forward-compatible mode shall apply for all DTE subsystems with embedded COMSEC. The backward-compatible mode may also be emulated using embedded COMSEC devices.

D.5 Detailed requirements.

D.5.1 Traditional COMSEC transmission frame.
The traditional COMSEC transmission frame shall be composed of the following components, as shown in FIGURE D-1. FIGURE D-1 provides additional detail to FIGURE 4.

a. COMSEC Bit Synchronization

b. COMSEC Frame Synchronization

c. Message Indicator

d. Phasing

e. Transmission Synchronization (see 5.2.1.3).

f. Data Field (including Transmission Header)

g. COMSEC Postamble

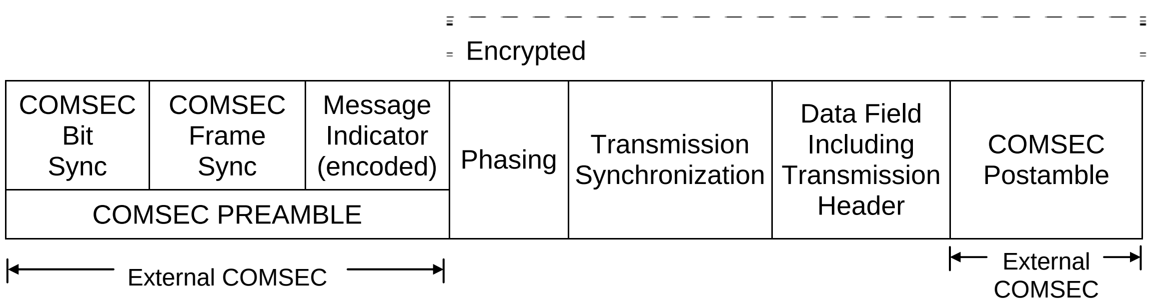


FIGURE D-1. Traditional COMSEC transmission frame structure.

D.5.1.1 COMSEC preamble field.
The COMSEC preamble field shall consist of three components: a COMSEC bit synchronization subfield, a COMSEC frame synchronization subfield, and a Message Indicator (MI) subfield. This field is used to achieve cryptographic synchronization over the link.

D.5.1.1.1 COMSEC bit synchronization subfield.
This subfield shall be used to provide a signal for achieving bit synchronization and for indicating activity on a data link to the receiver. The duration of the COMSEC bit synchronization subfield shall be selectable from 0.065 to 1.5 seconds. The COMSEC bit synchronization subfield shall consist of the data-rate clock signal for the duration of the subfield.

D.5.1.1.2 COMSEC frame synchronization subfield.
This subfield shall be used to provide a framing signal indicating the start of the encoded MI to the receiving station. This subfield shall be 465 bits long, consisting of 31 Phi-encoded bits, as shown in FIGURE D-2a. The Phi patterns are a method of redundantly encoding data bits. A logical 1 data bit shall be encoded as shown in FIGURE D-2b, and logical 0 data bit shall be encoded as shown in FIGURE D-2c. A simple majority voting process may be performed at the receiver to decode the Phi-encoded frame pattern to its original format.

MSB	LSB
0111111111111111111111111111111	

FIGURE D-2a. Phi encoding.

MSB	LSB
000100110101111	

FIGURE D-2b. Phi encoding for logical 1 data bit.

MSB	LSB
111011001010000	

FIGURE D-2c. Phi encoding for logical 0 data bit.

FIGURE D-2. COMSEC frame synchronization pattern for Phi encoding.

D.5.1.1.3 Message Indicator subfield.
This subfield shall contain the COMSEC-provided MI, a stream of random bits that are redundantly encoded using Phi patterns. Cryptographic synchronization is achieved when the receiver acquires the correct MI.

D.5.1.2 Phasing.
This field shall be a string of alternating ones and zeros, beginning with a one, sent by the DTE. The length of this field is between 0.000 and 10.000 seconds. Phasing is further described in C.3.2.2.

D.5.1.3 Transmission synchronization field.
This field, consisting of the frame synchronization subfield, optional robust frame format subfield, and the TWC subfield, shall be as defined in 5.2.1.3.

D.5.1.4 Data field.
This field, including Transmission Header as defined in 5.3.1, shall be as defined in 5.2.1.4.

D.5.1.5 COMSEC postamble field.
This field shall be used to provide an end-of-transmission flag to the COMSEC at the receiving station. This will be automatically performed by the COMSEC key generator (KG). Refer to 0N431125, WINDSTER Cryptographic Standards, or DS-68, INDICTOR Cryptographic Standards, as appropriate.

D.5.1.6 COMSEC algorithm.
The COMSEC algorithm shall be backward-compatible with VINSON equipment. Refer to 0N431125, WINDSTER Cryptographic Standards.

D.5.1.7 COMSEC modes of operation.
The COMSEC shall be operated in Mode A. The rekey functions shall be performed through the use of KY-57 rekeys for backward compatibility. Refer to 0N431125, WINDSTER Cryptographic Standards.

D.5.2 Embedded COMSEC transmission frame.
The embedded COMSEC transmission frame shall be composed of the following components, as shown in FIGURE D-3:

a. Phasing

b. Frame synchronization
   - Standard Frame Synchronization
   - Robust Frame Synchronization

c. Robust Frame Format (RCP only)

d. Message Indicator

e. Transmission word count

f. Data Field

g. COMSEC Postamble

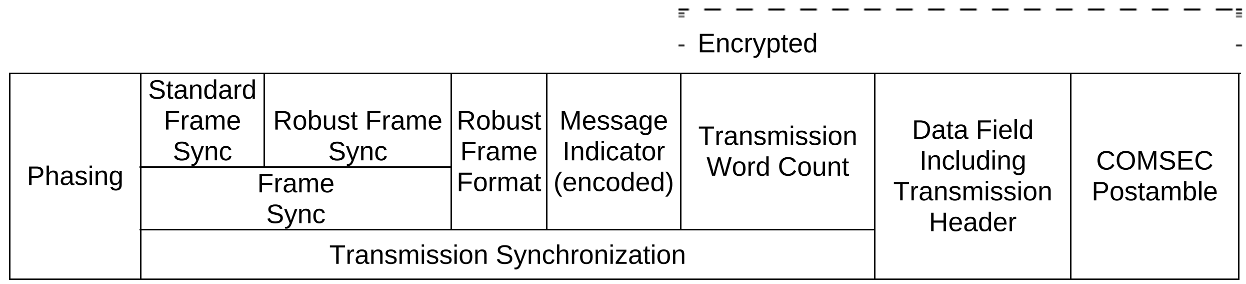


FIGURE D-3. Embedded COMSEC transmission frame structure.

D.5.2.1 Phasing.
This field shall be a string of alternating ones and zeros, beginning with a one, sent by the DTE. The length of this field is between 0 and 10 seconds. Phasing is further described in C.3.2.2.

D.5.2.2 Frame synchronization subfield.
This subfield shall be either the Robust Frame Synchronization subfield defined in 5.2.1.3.1.2 or the Frame Synchronization subfield defined in 5.2.1.3.1.1. In either case frame synchronization is to be provided for both the message frame and the COMSEC.

D.5.2.3 Robust frame format subfield.
When the Robust Frame Synchronization subfield is used, the Robust Frame Format subfield defined in 5.2.1.3.1.2 also shall be used. The Robust Frame Format subfield shall not be used when the Robust Frame Synchronization subfield is not used.

D.5.2.4 Message indicator field.
This field shall contain the MI, a stream of random data that shall be encoded using Golay, as defined in 5.3.14.1 and 5.3.14.2. Cryptographic synchronization is achieved when the receiver acquires the correct MI. The COMSEC shall provide the MI bits. For backward compatibility, these MI bits shall be redundantly encoded using Phi patterns, as described in D.5.1.1.2.

D.5.2.5 Transmission word count subfield.
This subfield shall be as defined in 5.2.1.3.1.4.

D.5.2.6 Data field.
This field, including Transmission Header as defined in 5.3.1, shall be as defined in 5.2.1.4.

D.5.2.7 COMSEC postamble field.
This field shall be used to provide an end-of-transmission flag to the COMSEC at the receiving station. The flag shall be a cryptographic function and may be used by the data terminal as an end-of-message flag as well.

D.5.2.8 COMSEC algorithm.
Refer to 0N431125, WINDSTER Cryptographic Standards.

D.5.2.9 COMSEC modes of operation.
COMSEC shall be operated in Mode A for all applications. The rekey functions shall be performed through the use of KY-57 rekeys for backward-compatibility and shall be performed through over-the-air-rekeying (OTAR) techniques for forward compatibility. Rekey signaling for OTAR shall be supplied by the host equipment. Refer to 0N431125, WINDSTER Cryptographic Standards.

D.5.3 Classified supplement.
A classified supplement to APPENDIX D can be obtained separately from the CNR WG Chairman.

APPENDIX E

CNR MANAGEMENT PROCESSES USING XNP

E.1 General.

E.1.1 Scope.

This appendix describes the XNP management processes associated with the data link and network layer. Since the tactical network using CNR may not be fully connected and since it is critical that all stations are provided compatible operating parameters, an Exchange Network Parameters (XNP) message has been defined. XNP messages that are transmitted within Type 1 UI frames, can be relayed, allow disconnected stations to participate fully in the network, and can be used to change network parameters dynamically.

E.1.2 Application.

This appendix is not a mandatory part of MIL-STD-188-220. The information contained herein is intended for guidance only. If you decide to use XNP, the information contained herein is intended for compliance.

E.1.3 Clarification of examples

Throughout this standard, many examples are provided as guidance only. In the event that an example is inconsistent with the text and DSPICS of the standard, the text description/DSPICS takes precedence over the example. Should a user detect any inconsistent examples, they should notify the CNRWG so that the example can be updated for a future release of the standard. It should also be noted that while all examples should be accurate in relation to the feature they are explaining, some of the examples provided may not reflect changes made to unrelated sections of the standard (e.g. examples to illustrate the use of XNP reflect the current version of XNP, but may not reflect the current version of the Intranet Header).

E.2 Applicable documents.

None

E.3 Network configuration.

The CNR management process defined herein covers the centralized network management operations. In a centralized managed network, a single network controller manages and controls all aspects of the network.

It is desirable that all stations be capable of performing the functions of network controller. The designation of network control station will be done by a network authority and only one station is designated the network controller at any one time. A configuration parameter or an operator command either at initialization or during normal operation times, may inform the station of its network control responsibility. Access parameters, for a joining station, may only be obtained from the one station designated as the network controller.

E.4 Exchange network parameters (XNP) message.
XNP messages have been designed to provide CNR management capabilities. However, they are not required if the stations on the network have been configured with data link addresses and operating parameters.

E.4.1 XNP message structure.
XNP messages are composed of a one-octet Version Number field (set to 0), an optional Forwarding Header followed by the actual XNP message and one or more data blocks as shown in FIGURE E-1.

Most Significant Octet<————————————————>Least Significant Octet

Version Number	Forwarding Header (Optional)	XNP Message (Identification plus basic information fields)	One or More XNP Data Blocks

FIGURE E-1. XNP message format.

Detailed formatting of the Forwarding Header, each XNP Message and each Data Block is described in the following paragraphs and tables. The Forwarding Header, each XNP Message and each Data Block consists of data fields. The data fields may be one or more octets in length and may be value coded or bit mapped. When the data field size exceeds one octet, octets are transmitted from the most significant octet (low number) to the least significant octet (high number). Bit mapping uses each bit individually in an on/off representation such that multiple values may be represented by each octet. Bit 0 always represents the least significant bit (2^0). FIGURE E-2 depicts an example 4-octet data field.

	Most Significant Octet<——————————>Least Significant Octet							
Octet	**1**		**2**		**3**		**4**	
Bit	7	0	7	0	7	0	7	0
Bit	31	24	23	16	15	8	7	0
	Most Significant Bit<————————————————>Least Significant Bit							

FIGURE E-2. Example 4-octet XNP data field.

Undefined bits shall be set to zero on transmission and ignored on receipt. Undefined values are invalid. The processing of XNP messages containing undefined/invalid values shall be:

a. Ignore any undefined bits in a bit map.

b. If the Version Number is invalid or unsupported, discard the XNP message.

c. If any field in the Forwarding Header is invalid, discard the XNP message.

d. If the Message Number field is invalid, discard the XNP message.

e. If the Length field is invalid in any Message Block (i.e., the value indicates that there are more octets than actually exist in the XNP message), discard the rest of the XNP message and continue processing the XNP message.

f. If the Block Number field is invalid in any XNP message, discard the block and continue processing the XNP message.

g. If the Length field is invalid in any Data Block (i.e., the value indicates that there are more octets than actually exist in the XNP message), discard the rest of the XNP message but act on the preceding blocks if possible.

h. If any other field is invalid in any Data Block, discard the data block and continue processing the XNP message.

i. If any other field is invalid in an XNP message, discard the XNP message.

E.4.1.1 Forwarding header.
A station joining a network might not have knowledge of the network topology and might be unable to contact all stations in the network being joined (e.g. stations might be behind obstacles or out of range). The Forwarding Header provides a means for a joining station to make use of an adjacent station which has access to the entire network via Intranet Relay.

Relay assistance is required for the joining process in a centralized network when the joiner is unable to directly communicate with the network controller, and when distribution of the Hello message is required. The joining station fills in this header to request relay assistance by an established station. The selected established station distributes these messages using appropriate Intranet Relaying techniques. Any and all responses go back to the selected established station who then forwards to the joiner. When an established member of a network receives an XNP message that contains a Forwarding Header with a Forwarder Link Address that matches its own data link address, the XNP message is retransmitted (via Intranet Relay) to the Destination Link Address in the Forwarding Header.

The Forwarding Header is shown in FIGURE E-3. It consists of the Source Link Address which identifies the originator, the Forwarder Link Address which designates the data link address of the station requested by the joiner to forward the XNP messages, and the Destination Link Address which identifies the final destination. An “Unknown” Forwarder Link Address shall be represented by a value of 0 (zero).

OCTET	FIELD IDENTIFICATION	VALUE
1	Message/Block Number: Identifies this as Forwarding Header.	0
2	Source Link Address: Identifies the originator of the XNP message.	1, 2, 4-95
3	Forwarder Link Address: Station selected to forward XNP messages from/to joining station.	0 (Unknown), 4-95
4	Destination Link Address: Identifies the intended recipient of the XNP.	1, 2, 4-95, 127

FIGURE E-3. Forwarding header.

E.4.1.2 Message and data block structure.
XNP messages and data blocks each have the structure shown in FIGURE E-4. Each message and data block starts with a one-octet identifier (message or block number) and a one-octet length field. These are followed by n data fields. Some data fields consist of multiple octets.

XNP messages are listed in TABLE E-I. Each of these messages may be combined with one or more of the XNP Data Blocks listed in TABLE E-II, depending upon the level of detailed information required.

A Terminator Block (TABLE E-III) designates the end of the XNP message and all associated data blocks. The Terminator Block is required at the end of all XNP messages. Any blocks or messages appearing after the Terminator Block shall be ignored.

Octet Number	Field Identification
1	identifier octet (message or block number)
2	message or block length
3	data field 1
•	•
•	•
•	•
n+2	data field n

FIGURE E-4. Message and Block structure.

TABLE E-I. XNP messages.

MESSAGE NUMBER	TITLE	DESCRIPTION
20	Join Request	Requests operating parameters assignment, validation, or both.
21	Join Accept	Accepts the Join Request. Provides update of parameters.
22	Join Reject	Rejects the Join Request with errors indicated.
23	Hello	Announces that a station is entering the network.
24	Goodbye	Announces that station is leaving the network.
25	Parameter Update Request	Requests update of network access and other operational parameters.
26	Parameter Update	Provides update of parameters.
27	Delay Time	Announces a known delay. Provides timer information.
28	Status Notification	Announces the identification number of the latest update message and identifies the NCS.

TABLE E-II. XNP data blocks.

BLOCK NUMBER	TITLE	DESCRIPTION
1	Station Identification	Provides a network wide unique identifier for a joiner.
2	Basic Network Parameters	Provides a list of network parameters.
3	Configuration Parameters	Provides a list of the Configuration parameters associated with reported station.
4	Type 3 Parameters	Provides Type 3 parameters to allow computation of RHD_i and TP.
5	Deterministic NAD Parameters	Provides listing of DAP-NAD and P-NAD parameters to allow computation of access slots.
6	Probabilistic NAD Parameters	Provides listing of R-NAD and H-NAD parameters to allow computation of access slots.
7	RE-NAD Parameters	Provides listing of RE-NAD parameters.
8	Wait Time	Notifies recipient of the amount of time to wait before making required updates.
9	Type 2 Parameters	Provides a list of Type 2 capabilities.

TABLE E-II. XNP data blocks - Continued.

BLOCK NUMBER	TITLE	DESCRIPTION
10	Type 4 Parameters	Provides a list of Type 4 capabilities.
11	NAD Ranking	System ranking for use in deterministic NAD computations.
12	Intranet Parameters	List of parameters for maintaining intranet layer implementation.
13	Error	List of unacceptable parameters.
14	Address Designation Parameters	Listing of a station's Unique Identifier, Link Address and IP address.
15-254	Undefined	
255	Terminator Block	Notification of end of block transmissions.

TABLE E-III. Terminator block.

OCTET	FIELD IDENTIFICATION	VALUE
1	End of message designator: Identifies the end of the XNP message and associated data blocks.	255

E.4.2 XNP message formats.
Seven messages are used in the procedure for a station to join a network or to request or verify the network operating parameters. These are the Join Request, Join Accept, Join Reject, Parameter Update Request, Parameter Update, Delay Time and Status Notification messages. The Hello message allows an initiating station to announce that it is entering the network. The Goodbye message is issued to report that a station is leaving the network. These messages may be combined with one or more data blocks to provide detailed network operating parameters. These messages are described in the following paragraphs and are depicted in TABLE E-IV through TABLE E-XII.

E.4.2.1 Join Request.
The Join Request message (TABLE E-IV) is sent by a station attempting to join a network. The joiner is expected to provide a unique identifier and indicate all implemented capabilities in order to lessen the probability of rejection by the network controller. The unique identifier is used to resolve ambiguities during the joining procedure. The unique identifier is the 24-bit Unit Reference Number (URN) with zeros in the eight most significant bits. If there is no URN a unique identifier shall be assigned to each potential user by a mechanism outside the scope of this appendix.

TABLE E-IV. Join request message.

OCTET	FIELD IDENTIFICATION	VALUE
1	Message Number: Identifies specific message content.	20
2	Message Length: Indicates the length of the Join Request Message block in octets	6
3-6	Station Identifier: Identifies the station trying to join the network	Unique identifier for the station

The joining station should include data block 2 and, if hardware parameters are known, data block 3. The joining station fills in the applicable data blocks with the parameters supported by the joiner.

Some fields within the Join Request data blocks allow the joiner to set all bits, indicating that all capabilities of that field are supported by the joining station, and the network controller is expected to provide the desired network operating parameters.

The Join Request message with no data blocks will suffice provided joiner has every capability listed in data block 2, has not been pre-assigned a data link address, is capable of all optional data link layer service types, and does not know hardware parameters.

E.4.2.2 Join Accept.
The Join Accept message (TABLE E-V) is sent by a network controller in response to the Join Request message, provided entry to the network has been approved. Actual network operating parameters will be provided in the appropriate data blocks combined with the Join Accept message. The appropriate data blocks appended to the Join Accept message depend upon the network configuration and the capabilities of the joining station. It will typically include data blocks 2, 4, 9 (if joiner indicated a Type 2 capability and there exists a network default), 10 (if joiner indicated a Type 4 capability) and either block 5, 6, or 7 (depending upon network access method in use).

The Join Accept message may include data block 8 to specify a period that the joining station should wait after sending a Hello message before it can assume its selected data link address has been accepted.

TABLE E-V. Join accept message.

OCTET	FIELD IDENTIFICATION	VALUE
1	Message Number: Identifies specific message content.	21
2	Message Length: Indicates the length of the Join Accept Message block in octets.	8
3	Parameter Update Identifier: A number to uniquely identify the latest parameter values distributed for use in the network.	1 - 255 in increments of 1
4-7	Station Identifier: Identifies the station trying to join the network.	Unique identifier for the station
8	Link Address: Data link address assigned to joining station.	4 - 95 = data link address

E.4.2.3 Join Reject.
The Join Reject message (TABLE E-VI) is sent by a network controller when entry to the network has not been approved. The Join Reject should be interpreted as being applied to the station identified in the Station Identifier field. Join Reject messages originated by any station other than a network controller (e.g. improper network controller designation) should be discarded and ignored.

The Join Reject message is sent in response to the Join Request message when the reason for rejection is that the parameters provided are not presently acceptable in this network. An error indication is provided with the Join Reject to clearly identify the unacceptable parameter(s). This error indication may be data block 13, which lists the unacceptable parameters and/or one or more other data blocks correcting the unacceptable parameter(s). Unless the joining station can correct the error(s), entry via XNP is not possible.

The Join Reject message is also sent in response to a Hello message to indicate that the joiner has selected a data link address that is in use. Rejection of a joining station's use of a data link address can be accomplished with only the basic Join Reject information fields, no data blocks (except the Termination Block) are required. Unless the joining station can correct the error(s), entry via XNP is not possible.

When a station receives a Join Reject message, the station identified in the Station Identifier field shall be removed from its topology tables unless it is a static node (link quality is 7).

TABLE E-VI. Join reject message.

OCTET	FIELD IDENTIFICATION	VALUE
1	Message Number: Identifies specific message content.	22
2	Message Length: Indicates the length of the Join Reject Message block in octets.	9
3	Parameter Update Identifier: A number to uniquely identify the latest parameter values distributed for use in the network.	1 - 255 in increments of 1
4-7	Station Identifier: Identifies the station trying to join the network.	Unique identifier for the station

E.4.2.4 Hello message.
The Hello message (TABLE E-VII) is sent by a station after the network operating parameters are known and the station is ready to enter the network. The message contains the data link address of the station entering the network. Address tables within receiving stations are updated, if necessary, with the new address information. When a station receives a Hello message, it shall update its topology tables.

TABLE E-VII. Hello message.

OCTET	FIELD IDENTIFICATION	VALUE
1	Message Number: Identifies specific message content.	23
2	Message Length: Indicates the length of the Hello Message block in octets.	7
3-6	Station Identifier: Identifies the station trying to join the network.	Unique identifier for the station.
7	Link Address: The actual data link address of this station.	Data link address of this station.

E.4.2.5 Goodbye message.
The Goodbye message (TABLE E-VIII) is sent by a station to notify the network controller and other network stations that it is leaving the network. The data link address used by the receiving station is made available for re-use by another station. Address tables within the receiving stations are updated, if necessary.

Before a station sends a Goodbye message, it should disconnect all Type 2 connections and broadcast a URNR to indicate it will no longer receive frames. When a station receives a Goodbye message, it shall update its topology tables.

TABLE E-VIII. Goodbye message.

OCTET	FIELD IDENTIFICATION	VALUE
1	Message Number: Identifies specific message content.	24
2	Message Length: Indicates the length of the Goodbye Message block in octets.	7
3-6	Station Identifier: Identifies the station leaving the network.	Unique identifier for this station.
7	Released Link Address: The data link address of the station leaving the network.	Data link address of this station.

E.4.2.6 Parameter Update Request message.
A station that is out of operation for some period of time or experiences a system failure may be unaware of changes to the network operating procedures/parameters or may have lost all record of the operating parameters. Once the outage or failure is corrected, the station may send this Parameter Update Request message (TABLE E-IX) to obtain new/changed parameters. The station may use this message to obtain an update of any or all parameters by attaching data blocks identifying the parameters that need to be updated.

TABLE E-IX. Parameter update request message.

OCTET	FIELD IDENTIFICATION	VALUE
1	Message Number: Identifies specific message content.	25
2	Message Length: Indicates the length of the Parameter Update Request Message block in octets.	7
3-6	Station Identifier: Identifies this station.	Unique identifier for the station
7	Update Requested: Update of parameters for requesting station or for all stations on the network. Actual parameters requested shall be stated in attached data blocks.	Bits set to one designate the following: 0 = Requesting Station 1 = All Stations 2 - 7 = Undefined

E.4.2.7 Parameter Update message.
The Parameter Update message (TABLE E-X) shall be sent in response to the Parameter Update Request message. It may be sent by the network controller before sending a Join Accept message in response to a Join Request message. The Parameter Update message may include

data block 8 to specify the time period, after receipt of the message that the network parameters become effective.

TABLE E-X. Parameter update message.

OCTET	FIELD IDENTIFICATION	VALUE
1	Message Number: Identifies specific message content.	26
2	Message Length: Indicates the length of the Parameter Update Message block in octets.	8
3	Parameter Update Identifier: A number to uniquely identify the latest parameter values distributed for use in the network.	1 - 255 in increments of 1
4-7	Station Identifier: Identifies a station.	Unique identifier for the station
8	Link Address: Data link address assigned to identified station.	4 - 95 = data link address

E.4.2.8 Delay Time message.
The Delay Time message (TABLE E-XI) is sent by a Forwarder in response to a broadcast Join Request message. It provides an indication to the joiner of how long a delay should be expected before the Forwarder will return a Join Accept or Reject message from the network controller after a Forwarded Join Request message is received from the joining station.

TABLE E-XI. Delay time message.

OCTET	FIELD IDENTIFICATION	VALUE
1	Message Number: Identifies specific message content.	27
2	Message Length: Indicates the length of the Delay Time Message block in octets.	7
3-6	Station Identifier: Identifies the station trying to join the network.	Unique identifier for the station
7	Time: The amount of time the joiner should expect to wait for a Join Accept message after sending a Join Request through this Forwarder.	1 to 255 seconds in 1 second increments

E.4.2.9 Status Notification message.
The Status Notification message (TABLE E-XII) is sent by the network controller on a one time basis (as required) or periodically. It provides all stations with the identification of the latest update of parameter values and identifies the network controller and backup. A receiving station that is using a different set of parameter values (different parameter update identifier) shall notify the network controller and request the latest update. Update shall be accomplished using the

Parameter Update message. The parameter update message shall utilize reliable link layer transmission services Type 3 ACK.

TABLE E-XII. Status notification message.

OCTET	FIELD IDENTIFICATION	VALUE
1	Message Number: Identifies specific message content.	28
2	Message Length: Indicates the length of the Status Notification Message block in octets.	16
3	Parameter Update Identifier: A number to uniquely identify the latest parameter values distributed for use in the network.	1 - 255 in increments of 1
4-7	NCS ID: Identification of the station performing NCS duties.	Unique identifier for the station
8-11	Backup NCS ID: Identification of the station designated as the backup NCS.	Unique identifier for the backup station
12-15	Secondary Backup NCS ID: Identification of the station designated as the secondary backup.	Unique identifier for the secondary backup station
16	Timing: Indicates how often this message is being sent. Value represents the frequency of transmission in 15 minute increments.	0 = one time 1 - 255 = number of 15 minute increments between transmissions

E.4.3 XNP data block formats.
One or more additional XNP Data Blocks may appear before the Terminator Block in each XNP message to either provide specific network operating parameters or to request specific parameters. The additional XNP Data Blocks are described in the following paragraphs and are depicted in TABLE E-XIII through TABLE E-XXVI.

E.4.3.1 Block 1, Station identification.
Block 1 (TABLE E-XIII) consists of one field which is used to identify the station being reported. It is used with the Parameter Update message to identify the station to which the parameters apply, in Block 2, and/or Block 11 (that shall be preceded by Block 1).

TABLE E-XIII. Station ID.

OCTET	FIELD IDENTIFICATION	VALUE
1	Block Number: Identifies specific data block.	1
2	Length: Indicates the length of the Station ID block in octets.	6
3-6	Unique Identifier: Identifies the station trying to join the network or being updated.	Unique identifier for the station

E.4.3.2 Block 2, Basic network parameters.
This block (TABLE E-XIV) is used to define basic network capabilities of a joining station, a requesting station or any other station identified by Block 1. It is mandatory in the Join Request message to identify capabilities of the joining station, unless the joining station has all possible capabilities listed. It is optional with the Join Accept message, Hello message, Parameter Update Request message and Parameter Update message.

TABLE E-XIV. Basic network parameters.

OCTET	FIELD IDENTIFICATION	VALUE
1	Block Number: Identifies specific data block.	2
2	Length: Indicates the length of the Basic Network Parameters block in octets.	16
3	Individual/Network Capability: Indicates whether the parameter values provided in this block are those of an individual station or the specific values being used in the network.	0 = Individual station 1 = Network values
4	Link Address: Identifies the data link address of the station.	4 - 95 = data link address
5	Station Class: The types of data link services available (See 5.3.3.5).	0 = Class A 1 = Class B 2 = Class C 3 = Class D
6	NAD Methods: Identifies either the NAD methods available by a station or the specific NAD method being used in a network. Multiple bits may be set when defining the NAD methods available by a station.	Bit map: 0 = R-NAD 1 = H-NAD 2 = P-NAD 3 = DAP-NAD 4 = RE-NAD
7-10	Group Address: Bit map that identifies the group address(es) that are in use in the network or that the station is a member of.	Bit map: LSB = 96 MSB-2 = 125

TABLE E-XIV. Basic network parameters-Continued

OCTET	FIELD IDENTIFICATION	VALUE
11	Concatenation Capability: Indicates the types of concatenation supported by the network or the reporting station.	Bit map: 0 = No concatenation allowed 1 = Physical layer 2 = Data link layer
12	FEC/TDC/Scrambling Mode: Bit map which identifies the FEC, TDC and Scrambling capabilities.	Bit Map: 0 = Half-rate Golay FEC 1 = TDC 2 = PL Data Scrambling 3 = V.36 Scrambling
13-14	Max. UI, DIA and I Info. Octets: Indicates the largest information field size that can be handled by the reporting station or that is allowed on the network.	708 – 3345 octets 65535 = requested
15-16	Maximum Transmit Time (MTT): The maximum time allowed on a net for a single transmission in tenths of a second. Used only to limit physical and link concatenation.	0.1-254.0 seconds

E.4.3.3 Block 3, Configuration parameters.
Configuration parameters defined by Block 3 (TABLE E-XV) are required to enable computation of TP, RHD, Net_Busy_Detect_Time, and the NAD described in APPENDIX C. Although not mandatory with any message, it could lead to erroneous network control computations resulting in collisions if the information is not provided in a Join Request message.

TABLE E-XV. Configuration parameters

OCTET	FIELD IDENTIFICATION	VALUE
1	Block Number: Identifies specific data block	3
2	Length: Indicates the length of the Parameters block in octets	30
3-4	Equipment Preamble Time (EPRE): Network Access Control parameter defined in APPENDIX C.	0.000 – 30.000 sec in 1 msec increments
5-6	Phasing Time: Network Access Control parameter defined in APPENDIX C.	0.000 – 10.000 sec in 1 msec increments
7-8	Equipment Lag Time (ELAG): Network Access Control parameter defined in APPENDIX C.	0.000 – 65.534 sec in 1 msec increments
9-10	Turnaround Time (TURN): Network Access Control parameter defined in APPENDIX C.	0.000 – 65.534 sec in 1 msec increments

TABLE E-XV. Configuration parameters-Continued

11-12	Tolerance Time (TOL): Network Access Control parameter defined in APPENDIX C.	0.000 – 2.500 sec in 1 msec increments
13-14	DTE Processing Time (DTEPROC): Network Access Control parameter defined in APPENDIX C.	0.000 – 65.534 sec in 1 msec increments
15	DTE Acknowledgment Time (DTEACK): Network Access Control parameter defined in APPENDIX C.	0.000 – 0.254 sec in 1 msec increments
16	DTE turnaround time (DTETURN): Network Access Control parameter defined in APPENDIX C.	0.000 – 0.100 sec in 1 msec increments
17-18	Net Busy Sensing Time, B: The parameter “B” (data sensing busy detect) used to calculate Net Busy Detect Time (NBDT) defined in APPENDIX C.	0.000 – 65.534 sec in 1 msec increments
19-20	Net Busy Detect Time (Squelch Detect): The time to detect network busy using the squelch detection function of SINCGARS.	0.000 – 65.534 sec in 1 msec increments
21-22	Net Busy Detect Time (Non-Squelch Detect): The time to detect data network busy using received data rather than squelch detect.	0.000 – 65.534 sec in 1 msec increments
23	Mode Of Operation: Identifies the Physical Layer protocol capabilities of a specific station or those being used in the network. Multiple bits may be set.	Bit Map: 0 = System Capabilities 1 = Network Operations 2 = Synchronous Mode (SDM) 3 = Synchronous Mode (EDM) 4 = Asynchronous Mode 5 = Packet Mode 6 = Robust Comm. Protocol
24-25	TEST Time To Live (TTTL). The maximum time to wait, in seconds, to transmit the TEST response frame. A value of 0 indicates that the message shall never timeout.	0.000 – 65.535 seconds in 1 msec increments.
26-27	Join Request Time To Live (JRTTL). The maximum time to wait, in seconds, for transmission of the XNP_Join_Request_Frame. A value of 0 indicates no timeout.	0.000 – 65.535 seconds in 1 msec increments.
28-29	Join Response Timer (JRT). Number of seconds to wait for a Join Accept/Reject from NETCON after the XNP_Join_Request is successfully transmitted.	1.000 – 65.535 seconds in 1 msec increments.

TABLE E-XV. Configuration parameters-Continued

30	Net Busy Timeout (NBT). Maximum seconds to wait during continuous net busy condition before generating transmit failures. A value of 0 indicates no timeout.	1 – 255 seconds in 1 second increments.

E.4.3.4 Block 4, Type 3 parameters.
These parameters (TABLE E-XVI) are required for data link Type 3 operations and are mandatory with the Join Accept message to provide the joining station with sufficient information to use Type 3 in the network. This block is optional with the Parameter Update Request message and the Parameter Update message.

TABLE E-XVI. Type 3 parameters.

OCTET	FIELD IDENTIFICATION	VALUE
1	Block Number: Identifies specific data block.	4
2	Length: Indicates the length of the Type 3 Parameters block in octets	5
3	Type 3 Retransmissions: The maximum number of times to retransmit an unacknowledged frame.	0 to 5
4-5	Busy State Timer: The time interval following receipt of the URNR command PDU during which the station shall wait for the other station to clear the busy condition.	60 - 600 seconds in 1 second increments

E.4.3.5 Block 5, Deterministic NAD parameters.
This block (TABLE E-XVII) defines parameters needed to allow operation in a network configured for deterministic network access (DAP-NAD, DAV-NAD, or P-NAD) operations. It is mandatory with the Join Accept message if the network being joined is operating with P-NAD, DAP-NAD, or DAV-NAD. It may also be used with the Parameter Update Request message and the Parameter Update message. This block is required in the Parameter Update message if it is being used to announce the network's access procedures are changing to either P-NAD, DAP-NAD, or DAV-NAD.

TABLE E-XVII. Deterministic NAD parameters.

OCTET	FIELD IDENTIFICATION	VALUE
1	Block Number: Identifies specific data block	5
2	Length: Indicates the length of the Deterministic NAD Parameters block in octets	7
3	Number Of Stations: Indicates the number of stations participating on the network. Used in NAD calculations.	2 - 95
4	Number Of NAD Priorities: Number of priorities to be considered in P-NAD, DAP-NAD, and DAV-NAD method.	1 - 8
5	Number Of NAD Slots: Indicates the number of NAD slots available for P-NAD, DAP-NAD, and DAV-NAD operations.	1 - 127
6-7	NAD Slot Duration: Duration of the NAD time slot, in seconds, for NAD operations.	0.000 – 300.000 sec in 1 msec increments

E.4.3.6 Block 6, Probabilistic NAD parameters.
Block 6 (TABLE E-XVIII) provides network access delay operating parameters for probabilistic networks (R-NAD or H-NAD). It is mandatory with the Join Accept message to provide the joining station with required operating parameters if the network is configured for either R-NAD or H-NAD. It is optional with the Parameter Update Request message and the Parameter Update message. This block is required in the Parameter Update message if it is being used to announce the network's access procedures are changing to either R-NAD or H-NAD.

TABLE E-XVIII. Probabilistic NAD parameters.

OCTET	FIELD IDENTIFICATION	VALUE
1	Block Number: Identifies specific data block	6
2	Length: Indicates the length of the Probabilistic NAD Parameters block in octets	7
3	Number Of Stations: Indicates the number of stations participating on the network. Used in NAD calculations.	2 - 95 stations on the network
4	Number Of NAD Priorities: Number of priorities to be considered in R-NAD and H-NAD method.	1 - 8

TABLE E-XVIII. Probabilistic NAD parameters-Continued

OCTET	FIELD IDENTIFICATION	VALUE
5	Urgent Percent: The percentage of urgent (%U) frames expected in an average 24-hour period. Used in the H-NAD calculation.	0 - 100% This value plus Priority Percent value shall be less than or equal to 100%
6	Priority Percent: The percentage of priority (%P) frames expected in an average 24-hour period. Used in the H-NAD calculation.	0 - 100% This value plus Urgent Percent value shall be less than or equal to 100%
7	Traffic Load: The amount of network traffic expected. Used in the H-NAD calculation.	0 = Normal 1 = Heavy 2 = Light

E.4.3.7 Block 7, RE-NAD parameters.
These parameters (TABLE E-XIX) are required for stations in a network operating with RE-NAD. It is mandatory with the Join Accept message to provide joining stations with network access parameters if the network being joined is configured for RE-NAD. It is optional with the Parameter Update Request message and the Parameter Update message. This block is required in the Parameter Update message if it is being used to announce the network's access procedures are changing to RE-NAD.

TABLE E-XIX. RE-NAD parameters.

OCTET	FIELD IDENTIFICATION	VALUE
1	Block Number: Identifies specific data block.	7
2	Length: Indicates the length of the RE-NAD Parameters block in octets	14
3-4	Maximum Voice Factor: Upper bound on voice factor in seconds	0.300 – 10.000 sec in 1 msec increments
5-6	Minimum Voice Factor: Lower bound on voice factor in seconds	0.300 – 10.000 sec in 1 msec increments
7-8	Voice Factor Increment: Scheduler fast attack increment in seconds	0.000 – 10.000 sec in 1 msec increments
9-10	Voice Factor Decrement: Scheduler slow decay increment in seconds	0.000 – 10.000 sec in 1 msec increments
11-12	Maximum Scheduler Interval: Upper bound on scheduler interval in seconds	1.000 – 5.000 sec in 1 msec increments
13-14	Minimum Scheduler Interval: Lower bound on scheduler interval in seconds	1.000 – 3.000 sec in 1 msec increments

E.4.3.8 Block 8, Wait time.
This block (TABLE E-XX) is used with the Join Accept message and Parameter Update message to specify a delay. When used with the Join Accept message, it indicates how long the Joining station should wait after sending a Hello message before it can assume its entry to the network is accepted. When used with the Parameter Update message, it indicates when new operating parameters become effective.

TABLE E-XX. Wait time.

OCTET	FIELD IDENTIFICATION	VALUE
1	Block Number: Identifies specific data block	8
2	Length: Indicates the length of the Wait Time block in octets	3
3	Wait Time: Delay period in seconds.	1 - 255 seconds in 1 second increments

E.4.3.9 Block 9, Type 2 parameters.
This block (TABLE E-XXI) identifies individual or network operating parameters for stations capable of optional Type 2 operations. It may be used with the Join Accept message, Parameter Update Request message and Parameter Update message.

E.4.3.10 Block 10, Type 4 parameters.
Type 4 parameters (TABLE E-XXII) are required for stations in a network which are capable of Type 4 operations. It may be used with the Join Accept message, Parameter Update Request message and Parameter Update message.

E.4.3.11 Block 11, NAD ranking.
This block (TABLE E-XXIII) provides ranking of a station in a deterministic network access configured network. It is mandatory if the network is configured for either P-NAD or DAP-NAD. It may be used with the Join Accept message or the Parameter Update message. In the Parameter Update message, it may be repeated to identify ranking of each station in the network. In this case, this block will appear once for each station on the network and will be preceded by block 1 to identify the station to which the ranking applies.

E.4.3.12 Block 12, Intranet parameters.
The Intranet parameters (TABLE E-XXIV) shall be provided to joining stations to provide information for Intranet relaying within the local network. This block shall be included with the Join Accept and Parameter Update messages.

E.4.3.13 Block 13, Error.
Block 13 (TABLE E-XXV) is encoded in Block/Byte number pairs indicating the starting byte number of the field containing the error. Block 13 may be included with the Join Reject message to indicate the reasons that a Join Request is being rejected.

E.4.3.14 Block 14, Address designation parameters.
Block 14 (TABLE E-XXVI) provides for the exchange of addressing information between the NCS and the other stations participating in the network. This message may be used as a request by a station or by the NCS to notify any station of their link or IPv4 address in the network. This block may also be utilized by the NCS to provide a block of link or IPv4 addresses to a backup NCS.

TABLE E-XXI. Type 2 parameters.

OCTET	FIELD IDENTIFICATION	VALUE
1	Block Number: Identifies specific data block.	9
2	Length: Indicates the length of the Type 2 Parameters block in octets	12
3-4	ACK Timer: The amount of time, in seconds, before Waiting Acknowledgment procedures are initiated.	10 - 1800 seconds in 1 second increments
5	P-Bit Timer: The amount of time, in seconds, before Waiting Acknowledgment procedures are initiated when P-bit was set to 1.	10 - 60 seconds in 1 second increments
6-7	Reject Timer: The amount of time, in seconds, before re-sending the REJ or SREJ if no response is received.	20 - 3600 seconds in 1 second increments
8	Maximum number of retransmissions, N2: The maximum number of times an I frame may be re-transmitted.	0 - 5
9	K Window: The maximum number of outstanding I PDUs allowed on a connection.	1 - 127
10	K2 Threshold: The maximum number of unacknowledged I PDUs on a connection before an acknowledgment is requested.	1 - 127
11	K3 Threshold: The maximum number of unacknowledged I PDUs on a connection before an acknowledgment shall be sent.	1 - 127
12	Response Delay Timer percent: The amount of time, as a percent of the ACK Timer, that a station waits after an I PDU with its P-bit set to 0 is received before sending an acknowledgment.	0 – 99% = Delay in 1% increments

TABLE E-XXII. Type 4 parameters.

OCTET	FIELD IDENTIFICATION	VALUE
1	Block Number: Identifies specific data block	10
2	Length: Indicates the length of the Type 4 Parameters block in octets	7
3-4	ACK Timer: The amount of time, in seconds, before a DIA is retransmitted.	5.0 – 120.0 seconds
5	K Window: The maximum number of outstanding DIA frames allowed for a station.	5 - 20
6	Maximum number of retransmissions attempts: The maximum number of times a DIA frame may be re-transmitted.	0 - 5
7	Type 4 ACK List Length: The number of DIA frames remembered in the list used to detect and discard duplicates.	0 = No duplicate detection 1 – 255 = Number or frames remembered

TABLE E-XXIII. NAD ranking.

OCTET	FIELD IDENTIFICATION	VALUE
1	Block Number: Identifies specific data block	11
2	Length: Indicates the length of the NAD Ranking Parameters block in octets	3
3	Station Rank: Identifies the ranking of this station relative to other stations on the network. Used in P-NAD and DAP-NAD calculations to determine the actual order of network access.	1 - 127 with 1 being highest

TABLE E-XXIV. Intranet parameters.

OCTET	FIELD IDENTIFICATION	VALUE
1	Block Number: Identifies specific data block	12
2	Length: Indicates the length of the Intranet Parameters block in octets	11
3	Min Update Per: Topology updates should not be transmitted more often than once every Min_Update_Per.	0 = No Updates 1 - 255 = minutes in 1 minute increments

TABLE E-XXIV. Intranet parameters-Continued

OCTET	FIELD IDENTIFICATION	VALUE
4	Topology Update Precedence: The precedence of Topology Update messages.	0 = Routine 1 = Priority 2 = Immediate 3 = Flash 4 = Flash Override 5 = CRITIC/ECP 6 = Internet Control 7 = Network Control 8 - 255 = Undefined
5	Relayer Status: Indicates if the station is a relayer or non-relayer.	0 = No Relay 1 = Relay
6-7	ACK Timer (fixed factor): The base time to wait, in seconds, before retransmitting an unacknowledged Intranet message.	0 - 600 in seconds
8-9	ACK Timer (proportional factor): The amount of time, in seconds, to add to the fixed factor for each hop to the furthest destination of an Intranet message.	0 - 600 in seconds
10	Retransmit Count: The maximum number of retransmissions of an Intranet message.	1 - 4
11	Link Failure Threshold: The number of data link acknowledgment failures required to change a station's status to failed.	1 - 7

TABLE E-XXV. Error.

OCTET	FIELD IDENTIFICATION	VALUE
1	Block Number: Identifies specific data block	13
2	Length: Indicates the length of the Error block in octets	2 + 2n, where n = the number of errors
3	Message/Block Number 1: Indicates the message or block containing the first error.	1 through 12, 20 through 27
4	Byte Number 1: Indicates the first octet of the field within the message or block that contains the first error.	1 through 255
1 + 2n	Message/Block Number n: Indicates the message or block containing the nth error.	1 through 13, 20 through 27
2 + 2n	Byte Number n: Indicates the first octet of the field within the message or block that contains the nth error.	1 through 255

TABLE E-XXVI. Address designation parameters.

OCTET	FIELD IDENTIFICATION	VALUE
1	Block Number: Identifies specific data block	14
2	Length: Indicates the length of the Address Designation Parameters block in octets	11
3-6	Unique Identifier: Identifies the station for which these parameters apply.	0 = unknown or not applicable
7-10	IPv4 Address: The IPv4 address for the identified stations.	0 = unknown or not applicable
11	Link Address: Data link address for the identified station.	0 = unknown or not applicable 4 - 95 = data link address

E.5 XNP message exchange.
XNP messages shall be exchanged using a UI command frame as shown in FIGURE E-5.

FLAG	Source Address	Destination Address	Control Field	Intranet Header	XNP Information	FCS	FLAG

FIGURE E-5. UI frame containing XNP message.

E.5.1 Data Link addressing.
Data Link address 1 is a special address for a station to use while joining the network if it has not been pre-assigned a data link address. If a station has not been assigned a Data Link address, it shall use this special data link address for network entry until an individual Data Link address has been assigned or selected. Since multiple stations may be attempting to join the network at the same time, the Station Identifier field in each XNP message is used to uniquely identify the station.

Data Link address 2 is a special address reserved for the network control station. Joining stations, forwarders and relayers use the special address 2 to address the network control station. The forwarder shall provide the full source directed relay path to the network controller at the Intranet layer. The network controller shall use this same path in reverse to reach the joining station through the forwarder. The Station Identifier field in the XNP messages used to uniquely identify stations during the joining process.

E.5.2 Poll/Final bit.
Use of UI poll/final bits is allowed but not recommended for use with XNP Join Request, Join Accept and Join Reject messages because network timing parameters for Type 3 final-bit responses are either unknown or subject to change during the network joining process.

E.5.3 Network access.
MIL-STD-188-220 allows a network to choose among the network access delay methods defined in APPENDIX C. Each station that operates on the network shall use the same method. If the station does not know this information before joining the network, the Join Request message allows a station to learn the network access method. In the case that the network access method is unknown, a random method (R-NAD or RE-NAD) shall be used for the Join Request method. When R-NAD is used, the default number of stations shall be 7 unless another number is known.

E.6 Network joining procedures.
Joining procedures consist of providing operating parameters to the joining station by the designated network controller.

E.6.1 Joining concept.
In general, the basic network joining procedure depicted in FIGURE E-6 is followed. The joining station sends a Join Request message that contains its MIL-STD-188-220 capabilities and unique identifier. The responding network controller compares the joiner's capabilities with current network operating parameters. If an error is found which precludes acceptance into the network, the network controller returns a Join Reject message to the joiner. The Join Reject message may include all of the correct parameters in appropriate data blocks of the message and/or use the error message to identify errors. If the joiner can correct the errors, a new Join Request message with corrected parameters can be sent. If the errors are not correctable, automatic joining using XNP is not possible.

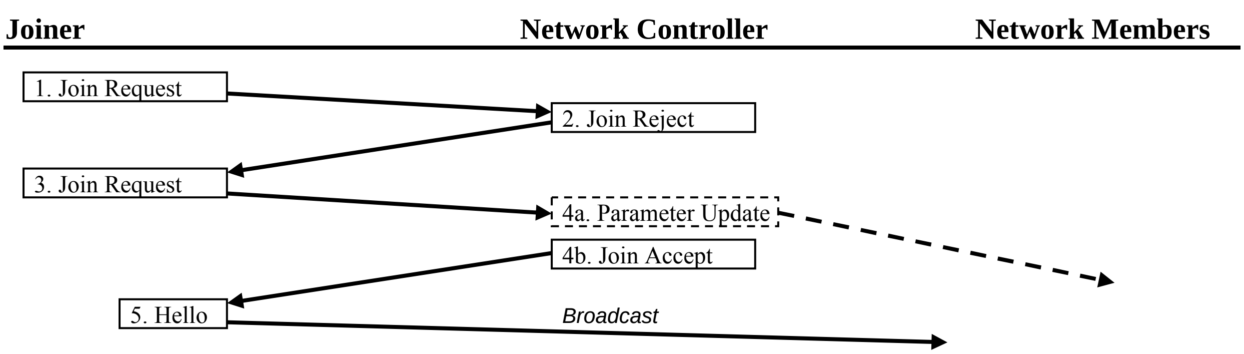


FIGURE E-6. Joining concept.

If there are no errors in the parameters contained in the Join Request message, a Join Accept message is sent by the network controller after entering the parameters for any empty or updated parameter fields. The network controller may have to update the data fields filled in by the joiner since it is possible that the joining station has capabilities above and beyond those being used within the network. If adding the joiner to the network will cause a change to the network operating parameters (e.g., number of stations), the network controller may announce the new network parameters with the Parameter Update message.

The Join Accept message contains an address bit map identifying data link addresses that can be selected by the joining station. When the joining station receives a Join Accept message response from the network controller, it shall broadcast a Hello message announcing entry to the network. Other members of the network shall update their topology tables upon receipt of the Hello message.

A network controller may send a Join Reject to remove any station from the network at any time. Other members of the network shall update their topology tables upon receipt of the Join Reject message.

When a station leaves a network, it shall send a Goodbye message. Other members of the network shall update their topology tables upon receipt of the Goodbye message.

E.6.2 Procedures for joining a network.
The procedure for joining a network is depicted in FIGURE E-7. To simplify the discussion and the figure, Join Reject and Parameter Update messages discussed in the basic Joining Concept are not included.

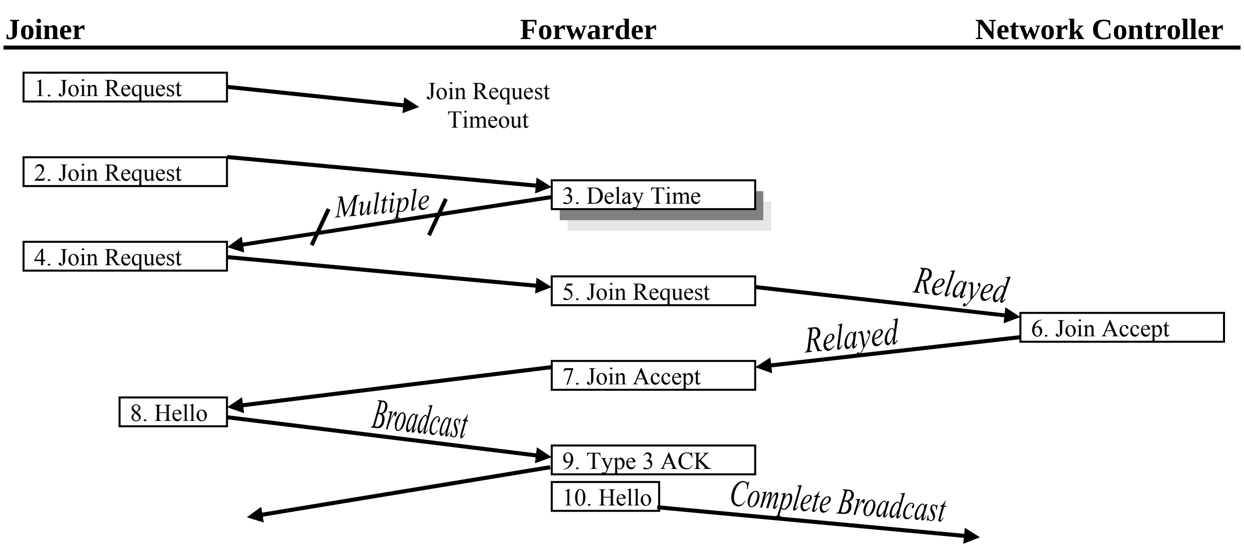


FIGURE E-7. Joining a network.

The joining station shall send a Join Request message to the network controller. The Join Request message shall be addressed to the network controller using the special data link address of 2 as the destination and the special data link address of 1 as the source in the UI frame. If the joining station is unable to contact the network controller because of distance or topology, there will be no response to the Join Request message. In this event, the joining station shall retransmit the Join Request message after the Join Response Timer expires until the Maximum Number of Join Retries has been exceeded or until either a Join Reject or Join Accept message is received.

If the maximum number of Join Retries is exceeded, the joining station shall then address a UI frame containing the Join Request message to the Global address. The joining station shall continue sending the Join Request message to the Global address after the Join Response Timer expires until a response is received from an existing network member.

All network members that receive the globally addressed Join Request message, and intend to participate in the joining procedure, shall send a Delay Time message with an XNP Forwarding Header in response to the joining station. The joining station shall select one of the responding stations as forwarder and resend the Join Request to the network controller using the forwarding parameters in the Forwarding Header received from the selected station. The selected forwarder shall relay this Join Request to the network controller and forward the network controller's response (Join Accept or Join Reject message) back to the joining station. The Join Accept message shall specify the data link address of the joining station.

The joining station shall expect the network controller response before expiration of the Delay Timer (the period of time specified in the selected forwarder's Delay Time message). If the Delay Timer expires, the joining station shall try each responder in turn in an attempt to contact the network controller.

When the joining station receives a Join Accept message response from the network controller, it shall prepare a Hello message announcing entry to the network. The Hello message shall use the joining station's assigned data link address (provided in the Join Accept message) as the source address and shall include both the forwarder's data link address and the Global multicast address as destinations in the UI frame. The UI frame carrying this Hello message shall have the P-bit set.

The forwarder shall return a Type 3 acknowledgment to the joining station and then complete the broadcast of the Hello message to all network members. This complete broadcast involves relaying the Hello message, including Forwarding Header, using appropriate Intranet procedures (e.g., Source Directed Relay). The forwarder shall set the maximum hop count in the Intranet Header of the message to restrict the amount of relaying.

E.6.3 <u>This paragraph was intentionally deleted.</u>

E.6.4 <u>Joining procedure examples.</u>

E.6.4.1 Fully connected network.
In this example, network controller is in direct line of sight to the joiner. The network is using data link Type 1 and Type 3 only and is using DAP-NAD. The joining station has all optional capabilities. Therefore the sequence of events is shown in FIGURE E-8 and is described in section E.6.4.1.1. Detailed message formats are provided in section E.6.4.1.2.

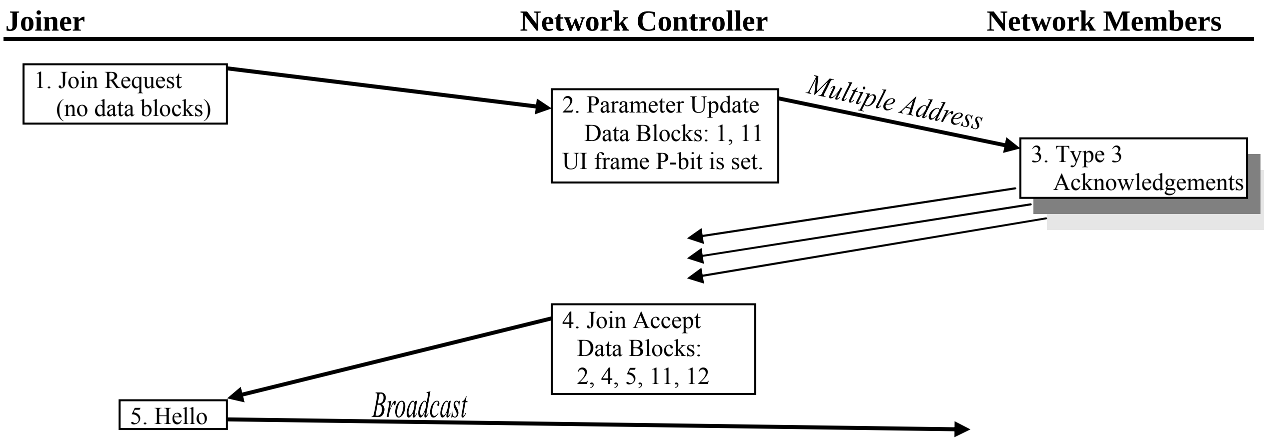


FIGURE E-8. Joining a fully connected network.

E.6.4.1.1 Sequence of events.

1. The joining station sends a UI frame with a Join Request message to the network controller requesting entry to the network. No data blocks are appended since the joining station does not have knowledge of hardware parameters, but does have all optional capabilities.

2. The network controller computes the ranking for DAP-NAD and transmits a Parameter Update message to all network members. This Parameter Update message includes blocks 1 and 11 to designate the order of NAD access for all stations in the network. It is sent with the P-bit set to 1 to provide some level of assurance that it has been received and implemented by all participants.

3. Each network participant sends a Type 3 Acknowledgment of the UI frame carrying the Parameter Update message to the network controller.

4. The network controller responds with a Join Accept message to the joiner with a Link Address to specify the address assigned to the joining station. Data block 2, block 4, block 5, and block 12 are appended to the Join Accept message to provide the network operating parameters to the joining station. The Join Accept also contains Blocks 1 and 11 to provide the relative NAD rankings for each network member.

5. The joining station sends a Hello message to announce its entry into the network.

E.6.4.1.2 Message formats.

1. Join Request Message

a. Transmission Header (see APPENDIX G TABLE G-XIII):

Selection Bits:		
FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)
Topology Update ID	0	(Initial)
Transmission Queue:		
T-bits	0	(No Info)
Trans. Queue Subfield	0	(Ignored)

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R Bit	0	(Command)
Address	1	(Net Entry)
Destination Address:		
Extension Bit	1	(Last one.)
Address	2	(Network Controller)
Control Field	3	(UI, ACK not required)

c. Intranet Header (see APPENDIX G TABLE G-IX):

Version #	0	(Current Version)
Message Type	6	(XNP)
Header Length	3	(Minimum)
Type of Service	48	(Priority, low delay)

d. XNP Message:

Version #	0	(Current Version)
Message Number	20	(Join Request Message)
Message Length	6	(Join Request Message Length)
Station Identifier	1234	(Number identifying the Joiner)
Terminator Block	255	

TABLE E-XXVII illustrates the construction of the XNP Join Request Message. Station Identifier 1234 is used for illustration.

TABLE E-XXVII. XNP join request message.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
XNP Message							
Version Number	8	0	00000000	00000000	00000000	0x00	0
Join Request Message							
Message Number	8	20	00010100	00010100	00010100	0x14	1
Message Length	8	6	00000110	00000110	00000110	0x06	2
Station Identifier	32	1234	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	0x00 0x00 0x04 0xD2	3 4 5 6
Terminator block	8	255	11111111	11111111	11111111	0xFF	7

2. Parameter Update Message

a. Transmission Header (see APPENDIX G TABLE G-XIII):

Selection Bits:		
FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)
Topology Update ID	0	(Initial)
Transmission Queue:		
T-bits	1	(DAP-NAD)
Data Link Precedence	0	(Urgent)
First Station Number	zz	

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R Bit	0	(Command)
Address	2	(Network Controller)
Destination Address(es)	[up to 16 data link addresses]	
Control Field	19	(UI, ACK required)

c. Intranet Header (see APPENDIX G TABLE G-IX):

Version #	0	(Current Version)
Message Type	6	(XNP)
Header Length	3	(Minimum)
Type of Service	240	(Network Control, low delay)

d. XNP Message:

Version #	0	(Current Version)
Message Number	26	(Parameter Update Message)
Message Length	8	(Parameter Update Message Length)
Parameter Update Identifier	1	(ID is 1 for this example)
Station Identifier	1234	(Number identifying the Joiner)
Link Address	12	(Joiner's assigned link address)

XNP Data Blocks

Data Block 1	Station Identification (Station #1)
Data Block 11	NAD Ranking (Station #1)
•	
•	
•	
Data Block 1	Station Ident. (Last station)
Data Block 11	NAD Ranking (Last station)
Terminator Block	255

TABLE E-XXVIII illustrates the construction of the XNP Parameter Update Message with data blocks. Four stations are used for this illustration. The Parameter Update Identifier is 1 for this example:

Station #1:
Station Identifier: 1225
Ranking: 1
Station #2:
Station Identifier: 1231
Ranking: 2

Station #3:
Station Identifier: 1244
Ranking: 4
Station #4:
Station Identifier: 1234 (new joiner)
Ranking: 3

TABLE E-XXVIII. XNP parameter update message with data blocks.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
XNP Message							
Version Number	8	0	00000000	00000000	00000000	0x00	0
XNP Parameter Update Message							
Message Number	8	26	00011010	00011010	00011010	0x1A	1
Message Length	8	8	00001000	00001000	00001000	0x08	2
Parameter Update Identifier	8	1	00000001	00000001	00000001	0x01	3
Station Identifier	32	1234	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	0x00 0x00 0x04 0xD2	4 5 6 7
Link Address	8	12	00001100	00001100	00001100	0x0C	8
XNP Data Blocks							
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	9
Block Length	8	6	00000110	00000110	00000110	0x06	10
Unique Id	32	1225	00000000 00000000 00000100 11001001	00000000 00000000 00000100 11001001	00000000 00000000 00000100 11001001	0x00 0x00 0x04 0xC9	11 12 13 14
NAD Ranking Block							

TABLE E-XXVIII. XNP parameter update message with data blocks - Continued.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
Block Number	8	11	00001011	00001011	00001011	0x0B	15
Block Length	8	3	00000011	00000011	00000011	0x03	16
Station Rank	8	1	00000001	00000001	00000001	0x01	17
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	18
Block Length	8	6	00000110	00000110	00000110	0x06	19
Unique Id	32	1231	00000000 00000000 00000100 11001111	00000000 00000000 00000100 11001111	00000000 00000000 00000100 11001111	0x00 0x00 0x04 0xCF	20 21 22 23
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	24
Block Length	8	3	00000011	00000011	00000011	0x03	25
Station Rank	8	2	00000010	00000010	00000010	0x02	26
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	27
Block Length	8	6	00000110	00000110	00000110	0x06	28
Unique Id	32	1244	00000000 00000000 00000100 11011100	00000000 00000000 00000100 11011100	00000000 00000000 00000100 11011100	0x00 0x00 0x04 0xDC	29 30 31 32
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	33
Block Length	8	3	00000011	00000011	00000011	0x03	34
Station Rank	8	4	00000100	00000100	00000100	0x04	35
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	36
Block Length	8	6	00000110	00000110	00000110	0x06	37
Unique Id	32	1234	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	0x00 0x00 0x04 0xD2	38 39 40 41
NAD Ranking Block							

TABLE E-XXVIII. XNP parameter update message with data blocks - Continued.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
Block Number	8	11	00001011	00001011	00001011	0x0B	42
Block Length	8	3	00000011	00000011	00000011	0x03	43
Station Rank	8	3	00000011	00000011	00000011	0x03	44
Terminator block	8	255	11111111	11111111	11111111	0xFF	45

3. Type 3 Acknowledgment

a. Transmission Header (see APPENDIX G TABLE G-XIII):

Selection Bits:		
FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)
Topology Update ID	y	(Each station's current #)
Transmission Queue:		
T-bits	1	(DAP-NAD)
Data Link Precedence	0	(Urgent)
First Station Number	zz	(Using old #)

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R Bit	1	(Response)
Address	xx	(Acknowledging station)
Destination Address:		
Extension Bit	1	(Last one)
Address	2	(Network Controller)
Control Field	51	(URR Response)

4. Join Accept Message

a. Transmission Header (see APPENDIX G TABLE G-XIII):

Selection Bits:		
FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)

Topology Update ID	0	(Initial)
Transmission Queue:		
T-bits	1	(DAP-NAD)
Data Link Precedence	1	(Priority)
First Station Number	zz	

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R Bit	1	(Response)
Address	2	(Network Controller)
Destination Address:		
Extension Bit	1	(Last one)
Address	1	(Net Entry)
Control Field	3	(UI, ACK not required)

c. Intranet Header (see APPENDIX G TABLE G-IX):

Version #	0	(Current Version)
Message Type	6	(XNP)
Header Length	3	(Minimum)
Type of Service	48	(Priority, low delay)

d. XNP Message:

Version #	0	(Current Version)
Message Number	21	(Join Accept Message)
Message Length	8	(Join Accept Message Length)
Parameter Update Identifier	1	(ID is 1 for this example)
Station Identifier	1234	(Number identifying the Joiner)
Link Address	12	[Joiner's assigned link address]

XNP Data Blocks:

Data Block 2	Basic Network Parameters
Data Block 4	Type 3 Network Parameters
Data Block 5	Deterministic NAD Parameters
Data Block 12	Intranet Parameters
Data Block 1	Station Identification (Station #1)
Data Block 11	NAD Ranking (Station #1)
•	
•	
•	
Data Block 1	Station Ident. (Last station)
Data Block 11	NAD Ranking (Last station)
Terminator Block	255

TABLE E-XXIX illustrates the construction of the XNP Join Accept Message with Data Blocks.

TABLE E-XXIX. XNP join accept message.

Field Name	**Length** (bits)	**Value** (Dec)	**Value** (Binary)	**Field Fragments**	**Octet Value** (Binary)	**Octet Value** (Hex)	**Octet Number**
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
XNP Message							
Version Number	8	0	00000000	00000000	00000000	0x00	0
XNP Join Accept Message							
Message Number	8	21	00010101	00010101	00010101	0x15	1
Message Length	8	8	00001000	00001000	00001000	0x08	2
Parameter Update Identifier	8	1	00000001	00000001	00000001	0x01	3
Station Identifier	32	1234	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	0x00 0x00 0x04 0xD2	4 5 6 7
Link Address	8	12	00001100	00001100	00001100	0x0C	8

TABLE E-XXIX. XNP join accept message - Continued.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
XNP Data Blocks							
Basic Network Parameters Block							
Block Number	8	2	00000010	00000010	00000010	0x02	9
Block Length	8	16	00010000	00010000	00010000	0x10	10
Individual/Network Capability	8	0	00000000	00000000	00000000	0x00	11
Link Address	8	12	00001100	00001100	00001100	0x0C	12
Station Class	8	3	00000011	00000011	00000011	0x03	13
NAD Methods	8	3	00000011	00000011	00000011	0x03	14
Group Address Bit Map							
127 - 120	8	255	11111111	11111111	11111111	0xFF	15
119 - 112	8	255	11111111	11111111	11111111	0xFF	16
111 - 104	8	255	11111111	11111111	11111111	0xFF	17
103 - 96	8	254	11111110	11111110	11111110	0xFE	18
Concatenation Capability	8	3	00000011	00000011	00000011	0x03	19
FEC/TDC/Scrambling Mode	8	3	00000011	00000011	00000011	0x03	20
Max. UI, DIA and I Info. Octets	16	3345	00001101 00010001	00001101 00010001	00001101 00010001	0x0D 0x11	21 22
Maximum Transmit Time	16	40	00000000 00101000	00000000 00101000	00000000 00101000	0x00 0x28	23 24
Type 3 Parameters Block							
Block Number	8	4	00000100	00000100	00000100	0x04	25
Block Length	8	5	00000101	00000101	00000101	0x05	26
Type 3 Retransmissions	8	2	00000010	00000010	00000010	0x02	27
Busy State Timer	16	60	00000000 00111100	00000000 00111100	00000000 00111100	0x00 0x3C	28 29
Deterministic NAD Parameter Block							
Block Number	8	5	00000101	00000101	00000101	0x05	30

TABLE E-XXIX. XNP join accept message - Continued.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
Block Length	8	6	00000110	00000110	00000110	0x06	31
Number of Stations	8	6	00000110	00000110	00000110	0x06	32
Number of NAD Priorities	8	4	00000100	00000100	00000100	0x04	33
Number of NAD Slots	8	6	00000110	00000110	00000110	0x06	34
NAD Slot Duration	16	1000	00000011 11101000	00000011 11101000	00000011 11101000	0x03 0xE8	35 36
Intranet Parameters Block							
Block Number	8	12	00001100	00001100	00001100	0x0C	37
Block Length	8	11	00001011	00001011	00001011	0x0B	38
Min Update Per.	8	30	00011110	00011110	00011110	0x1E	39
Topology Update Precedence	8	7	00000111	00000111	00000111	0x07	40
Relayer Status	8	0	00000000	00000000	00000000	0x00	41
ACK Timer (fixed)	16	100	00000000 01100100	00000000 01100100	00000000 01100100	0x00 0x64	42 43
ACK Timer (prop)	16	100	00000000 01100100	00000000 01100100	00000000 01100100	0x00 0x64	44 45
Retransmit Count	8	2	00000010	00000010	00000010	0x02	46
Link Failure Threshold	8	2	00000010	00000010	00000010	0x02	47
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	48
Block Length	8	6	00000110	00000110	00000110	0x06	49
Unique Id	32	1225	00000000 00000000 00000100 11001001	00000000 00000000 00000100 11001001	00000000 00000000 00000100 11001001	0x00 0x00 0x04 0xC9	50 51 52 53
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	54
Block Length	8	3	00000011	00000011	00000011	0x03	55
Station Rank	8	1	00000001	00000001	00000001	0x01	56

TABLE E-XXIX. XNP join accept message - Continued.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	57
Block Length	8	6	00000110	00000110	00000110	0x06	58
Unique Id	32	1231	00000000 00000000 00000100 11001111	00000000 00000000 00000100 11001111	00000000 00000000 00000100 11001111	0x00 0x00 0x04 0xCF	59 60 61 62
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	63
Block Length	8	3	00000011	00000011	00000011	0x03	64
Station Rank	8	2	00000010	00000010	00000010	0x02	65
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	66
Block Length	8	6	00000110	00000110	00000110	0x06	67
Unique Id	32	1244	00000000 00000000 00000100 11011100	00000000 00000000 00000100 11011100	00000000 00000000 00000100 11011100	0x00 0x00 0x04 0xDC	68 69 70 71
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	72
Block Length	8	3	00000011	00000011	00000011	0x03	73
Station Rank	8	4	00000100	00000100	00000100	0x04	74
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	75
Block Length	8	6	00000110	00000110	00000110	0x06	76
Unique Id	32	1234	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	0x00 0x00 0x04 0xD2	77 78 79 80
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	81
Block Length	8	3	00000011	00000011	00000011	0x03	82
Station Rank	8	3	00000011	00000011	00000011	0x03	83

TABLE E-XXIX. XNP join accept message - Continued.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
Terminator block	8	255	11111111	11111111	11111111	0xFF	84

5. Hello Message

a. Transmission Header (see APPENDIX G TABLE G-XIII):

Selection Bits:		
FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)
Topology Update ID	0	(Initial)
Transmission Queue:		
T-bits	1	(1: DAP-NAD)
Data Link Precedence	0	(0: Urgent)
First Station Number	zz	

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R Bit	0	(Command)
Address	1	(1: Net Entry - Joiner)
Destination Address:		
Extension Bit	1	(Last one)
Address	127	(Global Multicast)
Control Field	3	(3: UI, ACK not required)

c. Intranet Header (see APPENDIX G TABLE G-IX):

Version #	0	(Current Version)
Message Type	6	(XNP)
Header Length	3	(Minimum)
Type of Service	240	(Network Control, low delay)

d. XNP Message:

Version #	0	(Current Version)
Message Number	23	(Hello Message)
Message Length	7	(Hello Message Length)
Station Identifier	1234	(Number identifying the Joiner)

Link Address	12	(Data link address of the Joiner)
Terminator Block	255	

TABLE E-XXX illustrates the construction of the XNP Hello Message.

TABLE E-XXX. XNP hello message.

Field Name	**Length (bits)**	**Value (Dec)**	**Value (Binary)**	**Field Fragments**	**Octet Value (Binary)**	**Octet Value (Hex)**	**Octet Number**
			MSB 2^n LSB 2^0	**MSB 2^n LSB 2^0**	**MSB 2^n LSB 2^0**		
XNP Message							
Version Number	8	0	00000000	00000000	00000000	0x00	0
XNP Hello Message							
Message Number	8	23	00010111	00010111	00010111	0x17	1
Message Length	8	7	00000111	00000111	00000111	0x07	2
Station Identifier	32	1234	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	0x00 0x00 0x04 0xD2	3 4 5 6
Link Address	8	12	00001100	00001100	00001100	0x0C	7
Terminator block	8	255	11111111	11111111	11111111	0xFF	8

E.6.4.2 Disconnected joiner.

In this example the network controller is not in direct line of sight to the joiner. The network is using data link Types 1, 2 and 3, but not Type 4, and is using DAP-NAD. The joining station has all optional capabilities. Therefore the sequence of events is shown in FIGURE E-9 and is described in section E.6.4.2.1. Detailed message formats are provided in section E.6.4.2.2.

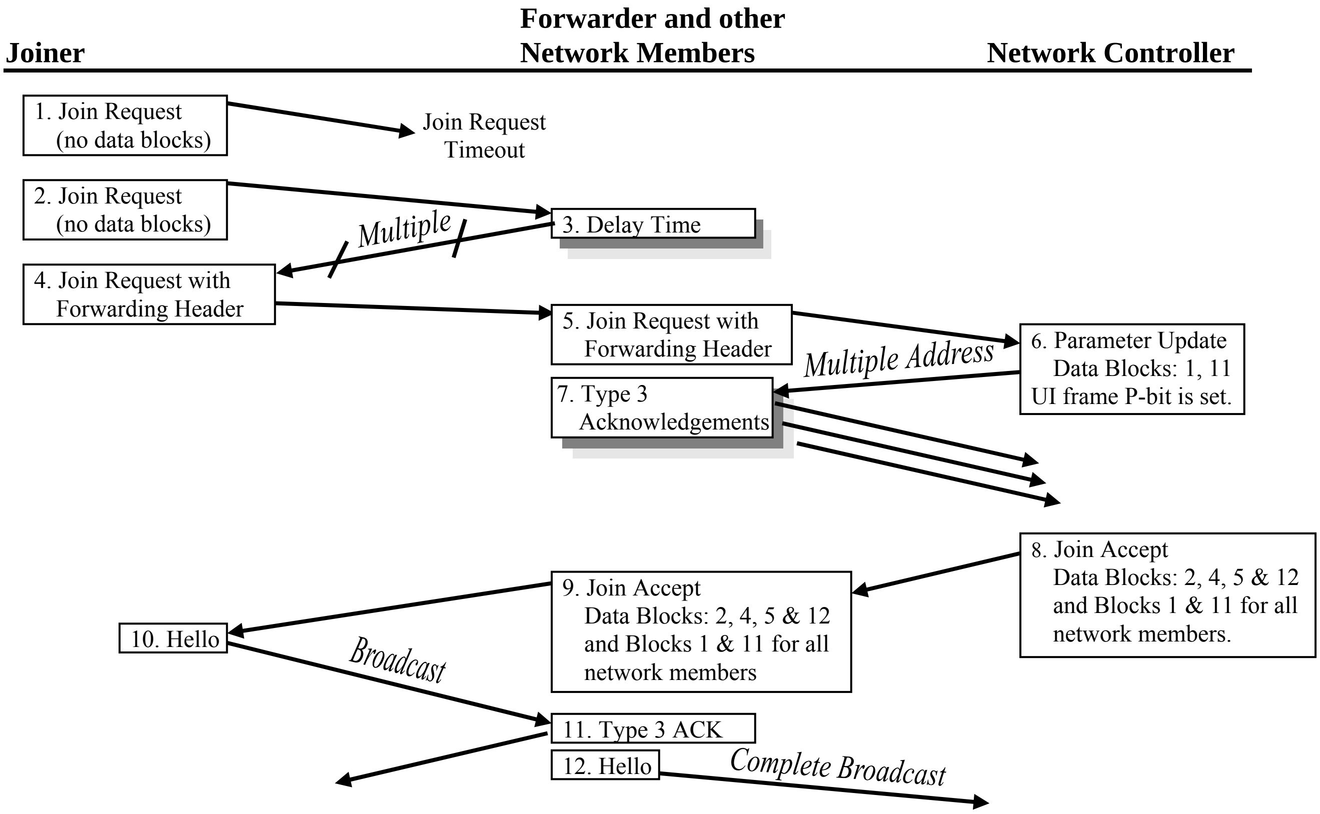


FIGURE E-9. Joining a disconnected network.

E.6.4.2.1 Sequence of events.

1. The joining station sends a UI frame with a Join Request message to the network controller requesting entry to the network. No data blocks are appended since the joining station does not have knowledge of hardware parameters, but does have all optional capabilities.

Because the joiner is not in direct line of sight with the network controller, network controller does not receive the Join Request and there is no response.

2. The joining station sends a UI Command with a Join Request message to the Global Multicast data link address requesting entry to the network. This Join Request message has a Forwarding Header identifying the network controller as the Destination.

3. The Join Request message is received by stations 34, 44, 25 and 31. These four stations send a Delay Time message to the joining station.

4. The joining station selects station 25 as the forwarder and uses this station to forward a Join Request message to the network controller.

5. Station 25 forwards the Join Request message to the network controller for the joining station.

6. The network controller computes the ranking for DAP-NAD and transmits a Parameter Update message to all network members. This Parameter Update message includes blocks 1 and 11 to designate the order of NAD access for all stations in the network. It is sent with the P-bit set to 1 to provide some level of assurance that it has been received and implemented by all participants.

All stations update to new station order.

7. Each network participant sends a Type 3 Acknowledgment of the UI frame carrying the Parameter Update message to the network controller.

8. The network controller responds with a Join Accept message to the joiner with a Link Address to specify the address assigned to the joining station. Data block 2, block 4, block 5, block 9 and block 12 are appended to the Join Accept message to provide the network operating parameters to the joining station. The Join Accept also contains Blocks 1 and 11 to provide the relative NAD rankings for each network member.

9. Station 25 forwards network controller's Join Accept message (and all data blocks) to the joining station.

10. The joining station sends a Hello message to announce its entry into the network. This Hello message is broadcast locally, and also addressed to forwarding station 25 so that it can be broadcast completely through the network.

11. Forwarding station 25 sends a Type 3 Acknowledgment for the UI frame carrying the Hello message to the joining station.

12. Station 25 forwards the Hello message throughout the network using Intranet Relay.

E.6.4.2.2 Message formats.

Five stations are used for the illustration:

Station 25:

Station Identifier: 1225
Ranking: 1
Link Address: 25

Station 31:
- Station Identifier: 1231
- Ranking: 2
- Link Address: 31

Station 44:
- Station Identifier: 1244
- Ranking: 4
- Link Address: 44

Station 34:
- Station Identifier: 1234
- Ranking: 3
- Link Address: 12

Station 55:
- Station Identifier: 1255 (new joiner)
- Ranking: 5

1. Join Request Message to Network Controller

a. Transmission Header (see APPENDIX G TABLE G-XIII):

Selection Bits:		
FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)
Topology Update ID	y	(Station's current #)
Transmission Queue:		
T-bits	0	(No Info)
Trans. Queue Subfield	0	(Ignored)

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R Bit	0	(Command)
Address	1	(Net Entry)
Destination Address:		
Extension Bit	1	(Last one)
Address	2	(Network Controller)
Control Field	3	(UI, ACK not required)

c. Intranet Header (see APPENDIX G TABLE G-IX):

Version #	0	(Current Version)
Message Type	6	(XNP)
Header Length	3	(Minimum)
Type of Service	48	(Priority, low delay)

d. XNP Message:

Version #	0	(Current Version)
Message Number	20	(Join Request Message)
Message Length	6	(Join Request Message Length)
Station Identifier	1255	(Number identifying the Joiner)
Terminator Block	255	

TABLE E-XXXI illustrates the construction of the XNP Join Request Message to Network Controller.

TABLE E-XXXI. XNP join request message to network controller.

Field Name	**Length (bits)**	**Value (Dec)**	**Value (Binary)**	**Field Fragments**	**Octet Value (Binary)**	**Octet Value (Hex)**	**Octet Number**
			MSB 2^n LSB 2^0	**MSB 2^n LSB 2^0**	**MSB 2^n LSB 2^0**		
XNP Message							
Version Number	8	0	00000000	00000000	00000000	0x00	0
Join Request Message							
Message Number	8	20	00010100	00010100	00010100	0x14	1
Message Length	8	6	00000110	00000110	00000110	0x06	2
Station Identifier	32	1255	00000000	00000000	00000000	0x00	3
			00000000	00000000	00000000	0x00	4
			00000100	00000100	00000100	0x04	5
			11100111	11100111	11100111	0xE7	6
Terminator block	8	255	11111111	11111111	11111111	0xFF	7

2. Join Request Message to Global Multicast Address

a. Transmission Header (see APPENDIX G TABLE G-XIII):

Selection Bits:		
FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)
Topology Update ID	0	(Initial)
Transmission Queue:		
T-bits	0	(No Info)
Trans. Queue Subfield	0	(Ignored)

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R Bit	0	(Command)
Address	1	(Net Entry)
Destination Address:		
Extension Bit	1	(Last one)
Address	127	(Global Multicast)
Control Field	3	(UI, ACK not required)

c. Intranet Header (see APPENDIX G TABLE G-IX):

Version #	0	(Current Version)
Message Type	6	(XNP)
Header Length	3	(Minimum)
Type of Service	48	(Priority, low delay)

d. XNP Message:

Version #	0	(Current Version)
Forwarding Header:		
Message Number	0	(Forwarding Header)
Source Address	1	(Net Entry)
Forwarder Address	0	(Unknown)
Destination Address	2	(Network Controller)
Message Number	20	(Join Request Message)
Message Length	6	(Join Request Message Length)
Station Identifier	1255	(Number identifying the Joiner)
Terminator Block	255	

TABLE E-XXXII illustrates the construction of the XNP Join Request Message to Global Multicast Address.

TABLE E-XXXII. XNP Join Request message to global multicast address.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
XNP Message							
Version Number	8	0	00000000	00000000	00000000	0x00	0
Forwarding Header							
Message Number	8	0	00000000	00000000	00000000	0x00	1
Source Address	8	1	00000001	00000001	00000001	0x01	2
Forwarder Address	8	0	00000000	00000000	00000000	0x00	3
Destination Address	8	2	00000010	00000010	00000010	0x02	4
Join Request Message							
Message Number	8	20	00010100	00010100	00010100	0x14	5
Message Length	8	6	00000110	00000110	00000110	0x06	6
Station Identifier	32	1255	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	0x00 0x00 0x04 0xE7	7 8 9 10
Terminator block	8	255	11111111	11111111	11111111	0xFF	11

3. Delay Time Message

a. Transmission Header (see APPENDIX G TABLE G-XIII):
Selection Bits:

FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)
Topology Update ID	y	(Station's current #)

Transmission Queue:		
T-bits	1	(DAP-NAD)
Data Link Precedence	1	(Priority)
First Station Number	zz	

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R	0	(Command)
Address	25	(Forwarder station 25)
Destination Address:		
Extension Bit	1	(Last one)
Address	1	(Net Entry)
Control Field	3	(UI, ACK not required)

c. Intranet Header (see APPENDIX G TABLE G-IX):

Version #	0	(Current Version)
Message Type	6	(XNP)
Header Length	3	(Minimum)
Type of Service	48	(Priority, low delay)

d. XNP Message:

Version #	0	(Current Version)
Forwarding Header:		
Message Number	0	(Forwarding Header)
Source Address	25	(Forwarder station 25)
Forwarder Address	25	(Forwarder station 25)
Destination Address	1	(Net Entry)
Message Number	27	(Delay Time Message)
Message Length	7	(Delay Time Message Length)
Station Identifier	1255	(Number identifying the Joiner)
Time	tttt	(Seconds)
Terminator Block	255	

TABLE E-XXXIII illustrates the construction of the XNP Delay Time Message.

TABLE E-XXXIII. XNP Delay time message.

Field Name	**Length (bits)**	**Value (Dec)**	**Value (Binary)**	**Field Fragments**	**Octet Value (Binary)**	**Octet Value (Hex)**	**Octet Number**
			MSB 2^n LSB 2^0	**MSB 2^n LSB 2^0**	**MSB 2^n LSB 2^0**		
XNP Message							
Version Number	8	0	00000000	00000000	00000000	0x00	0
Forwarding Header							
Message Number	8	0	00000000	00000000	00000000	0x00	1
Source Address	8	25	00011001	00011001	00011001	0x19	2
Forwarder Address	8	25	00011001	00011001	00011001	0x19	3
Destination Address	8	1	00000001	00000001	00000001	0x01	4
XNP Delay Time Message							
Message Number	8	27	00011011	00011011	00011011	0x1B	5
Message Length	8	7	00000111	00000111	00000111	0x07	6
Station Identifier	32	1255	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	0x00 0x00 0x04 0xE7	7 8 9 10
Time	8	100	01100100	01100100	01100100	0x64	11
Terminator block	8	255	11111111	11111111	11111111	0xFF	12

4. Join Request Message to Forwarder

a. Transmission Header (see APPENDIX G TABLE G-XIII):

Selection Bits:		
FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)
Topology Update ID	0	(Initial)

Transmission Queue:		
T-bits	0	(0: No Info)
Trans. Queue Subfield	0	(0: Ignored)

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R Bit	0	(Command)
Address	1	(Net Entry)
Destination Address:		
Extension Bit	1	(Last one)
Address	25	(Forwarder station 25)
Control Field	3	(UI, ACK not required)

c. Intranet Header (see APPENDIX G TABLE G-IX):

Version #	0	(Current Version)
Message Type	6	(XNP)
Header Length	3	(Minimum)
Type of Service	48	(Priority, low delay)

d. XNP Message :

Version #	0	(Current Version)
Forwarding Header:		
Message Number	0	(Forwarding Header)
Source Address	1	(Net Entry)
Forwarder Address	25	(Station 25)
Destination Address	2	(Network Controller)
Message Number	20	(Join Request Message)
Message Length	6	(Current Join Request Message Length)
Station Identifier	1255	(Number identifying the joiner)
Terminator Block	255	

TABLE E-XXXIV illustrates the construction of the XNP Join Request Message to Forwarder.

TABLE E-XXXIV. XNP Join Request message to forwarder.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
XNP Message							
Version Number	8	0	00000000	00000000	00000000	0x00	0
Forwarding Header							
Message Number	8	0	00000000	00000000	00000000	0x00	1
Source Address	8	1	00000001	00000001	00000001	0x01	2
Forwarder Address	8	25	00011001	00011001	00011001	0x19	3
Destination Address	8	2	00000010	00000010	00000010	0x02	4
Join Request Message							
Message Number	8	20	00010100	00010100	00010100	0x14	5
Message Length	8	6	00000110	00000110	00000110	0x06	6
Station Identifier	32	1255	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	0x00 0x00 0x04 0xE7	7 8 9 10
Terminator block	8	255	11111111	11111111	11111111	0xFF	11

5. Join Request Message to Network Controller from Forwarder

a. Transmission Header (see APPENDIX G TABLE G-XIII):

Selection Bits:		
FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)
Topology Update ID	y	(Station's current #)

Transmission Queue:		
T-bits	1	(DAP-NAD)
Data Link Precedence	1	(Priority)
First Station Number	zz	

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R Bit	0	(Command)
Address	25	(Forwarder station 25)
Destination Address:		
Extension Bit	1	(Last one)
Address	2	(Network Controller)
Control Field	3	(UI, ACK not required)

c. Intranet Header (see APPENDIX G TABLE G-IX):

Version #	0	(Current Version)
Message Type	6	(XNP)
Header Length	3	(Minimum)
Type of Service	48	(Priority, low delay)

d. XNP Message:

Version #	0	(Current Version)
Forwarding Header:		
Message Number	0	(Forwarding Header)
Source Address	1	(Net Entry)
Forwarder Address	25	
Destination Address	2	(Network Controller)
Message Number	20	(Join Request Message)
Message Length	6	(Join Request Message Length)
Station Identifier	1255	(Number identifying the Joiner)
Terminator Block	255	

TABLE E-XXXV illustrates the construction of the XNP Join Request Message to Network Controller from Forwarder.

TABLE E-XXXV. XNP Join Request message to network controller from forwarder.

Field Name	**Length** (bits)	**Value** (Dec)	**Value** (Binary)	**Field Fragments**	**Octet Value** (Binary)	**Octet Value** (Hex)	**Octet Number**
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
XNP Message							
Version Number	8	0	00000000	00000000	00000000	0x00	0
Forwarding Header							
Message Number	8	0	00000000	00000000	00000000	0x00	1
Source Address	8	1	00000001	00000001	00000001	0x01	2
Forwarder Address	8	25	00011001	00011001	00011001	0x19	3
Destination Address	8	2	00000010	00000010	00000010	0x02	4
Join Request Message							
Message Number	8	20	00010100	00010100	00010100	0x14	5
Message Length	8	6	00000110	00000110	00000110	0x06	6
Station Identifier	32	1255	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	0x00 0x00 0x04 0xE7	7 8 9 10
Terminator block	8	255	11111111	11111111	11111111	0xFF	11

6. Parameter Update Message

a. Transmission Header (see APPENDIX G TABLE G-XIII):
Selection Bits:

FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)
Topology Update ID	0	(Initial)

Transmission Queue:

T-bits	1	(DAP-NAD)
Data Link Precedence	0	(Urgent)
First Station Number	zz	

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R Bit	0	(Command)
Address	2	(Network Controller)
Destination Address(es)		[up to 16 data link addresses]
Control Field	19	(UI, ACK required)

c. Intranet Header (see APPENDIX G TABLE G-IX):

Version #	0	(Current Version)
Message Type	6	(XNP)
Header Length	3	(Minimum)
Type of Service	240	(Network Control, low delay)

d. XNP Message:

Version #	0	(Current Version)
Message Number	26	(Parameter Update Message)
Message Length	8	(Parameter Update Message Length)
Parameter Update Identifier	1	(ID is 1 for this example)
Station Identifier	1255	(Number identifying the Joiner)
Link Address	55	(Joiner's assigned link address)
XNP Data Blocks		
Data Block 1		Station Identification (Station #1)
Data Block 11		NAD Ranking (Station #1)
•		
•		
•		
Data Block 1		Station Ident. (Last station)
Data Block 11		NAD Ranking (Last station)
Terminator Block	255	

TABLE E-XXXVI illustrates the construction of the XNP Parameter Update Message.

TABLE E-XXXVI. XNP Parameter Update message.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
XNP Message							
Version Number	8	0	00000000	00000000	00000000	0x00	0
XNP Parameter Update Message							
Message Number	8	26	00011010	00011010	00011010	0x1A	1
Message Length	8	8	00001000	00001000	00001000	0x08	2
Parameter Update Identifier	8	1	00000001	00000001	00000001	0x01	3
Station Identifier	32	1255	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	0x00 0x00 0x04 0xE7	4 5 6 7
Link Address	8	55	00110111	00110111	00110111	0x37	8
XNP Data Blocks							
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	9
Block Length	8	6	00000110	00000110	00000110	0x06	10
Unique Id	32	1225	00000000 00000000 00000100 11001001	00000000 00000000 00000100 11001001	00000000 00000000 00000100 11001001	0x00 0x00 0x04 0xC9	11 12 13 14
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	15
Block Length	8	3	00000011	00000011	00000011	0x03	16
Station Rank	8	1	00000001	00000001	00000001	0x01	17
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	18
Block Length	8	6	00000110	00000110	00000110	0x06	19

TABLE E-XXXVI. XNP Parameter Update message - Continued.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
Unique Id	32	1231	00000000 00000000 00000100 11001111	00000000 00000000 00000100 11001111	00000000 00000000 00000100 11001111	0x00 0x00 0x04 0xCF	20 21 22 23
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	24
Block Length	8	3	00000011	00000011	00000011	0x03	25
Station Rank	8	2	00000010	00000010	00000010	0x02	26
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	27
Block Length	8	6	00000110	00000110	00000110	0x06	28
Unique Id	32	1244	00000000 00000000 00000100 11011100	00000000 00000000 00000100 11011100	00000000 00000000 00000100 11011100	0x00 0x00 0x04 0xDC	29 30 31 32
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	33
Block Length	8	3	00000011	00000011	00000011	0x03	34
Station Rank	8	4	00000100	00000100	00000100	0x04	35
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	36
Block Length	8	6	00000110	00000110	00000110	0x06	37
Unique Id	32	1234	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	0x00 0x00 0x04 0xD2	38 39 40 41
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	42
Block Length	8	3	00000011	00000011	00000011	0x03	43
Station Rank	8	3	00000011	00000011	00000011	0x03	44
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	45
Block Length	8	6	00000110	00000110	00000110	0x06	46

TABLE E-XXXVI. XNP Parameter Update message - Continued.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
Unique Id	32	1255	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	0x00 0x00 0x04 0xE7	47 48 49 50
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	51
Block Length	8	3	00000011	00000011	00000011	0x03	52
Station Rank	8	5	00000101	00000101	00000101	0x05	53
Terminator block	8	255	11111111	11111111	11111111	0xFF	54

7. Type 3 Acknowledgment to UI Carrying Parameter Update Message

a. Transmission Header (see APPENDIX G TABLE G-XIII):
Selection Bits:
FEC 1 (Yes)
TDC 1 (Yes)
Scrambling 0 (No)
Topology Update ID y (Each station's current #)
Transmission Queue:
T-bits 1 (DAP-NAD)
Data Link Precedence 0 (Urgent)
First Station Number zz (Using old ranking)

b. Link Layer Header (see APPENDIX G TABLE G-X):
Source Address:
C/R Bit 1 (Response)
Address xxxxxxx (Acknowledging station)
Destination Address:
Extension Bit 1 (Last one)
Address 2 (Network Controller)
Control Field 51 (URR response)

8. Join Accept Message to Forwarder

a. Transmission Header (see APPENDIX G TABLE G-XIII):
Selection Bits:

FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)
Topology Update ID	0	(Initial)
Transmission Queue:		
T-bits	1	(DAP-NAD)
Data Link Precedence	1	(Priority)
First Station Number	zz	

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R Bit	0	(Command)
Address	2	(Network Controller)
Destination Address:		
Extension Bit	1	(Last one)
Address	25	(Forwarder station 25)
Control Field	3	(UI, ACK not required)

c. Intranet Header (see APPENDIX G TABLE G-IX):

Version #	0	(Current Version)
Message Type	6	(XNP)
Header Length	3	(Minimum)
Type of Service	240	(Network Control, low delay)

d. XNP Message:

Version #	0	(Current Version)
Forwarding Header:		
Message Number	0	(Forwarding Header)
Source Address	2	(Network Controller)
Forwarder Address	25	(Station 25)
Destination Address	1	(Net Entry)
Message Number	21	(Join Accept Message)
Message Length	8	(Join Accept Message Length)
Parameter Update Identifier	1	(ID is 1 for this example)
Station Identifier	1255	(Number identifying the Joiner)
Link Address	55	[Joiner's assigned link address]

XNP Data Blocks:

Data Block 2	Basic Network Parameters
Data Block 4	Type 3 Network Parameters
Data Block 5	Deterministic NAD Parameters
Data Block 9	Type 2 Parameters
Data Block 12	Intranet Parameters
Data Block 1	Station Identification (Station #1)

Data Block 11	NAD Ranking (Station #1)
•	
•	
•	
Data Block 1	Station Ident. (Last station)
Data Block 11	NAD Ranking (Last station)
Terminator Block	255

TABLE E-XXXVII illustrates the construction of the XNP Join Accept Message to Forwarder.

TABLE E-XXXVII. XNP Join Accept message to forwarder.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
XNP Message							
Version Number	8	0	00000000	00000000	00000000	0x00	0
Forwarding Header							
Message Number	8	0	00000000	00000000	00000000	0x00	1
Source Address	8	2	00000010	00000010	00000010	0x02	2
Forwarder Address	8	25	00011001	00011001	00011001	0x19	3
Destination Address	8	1	00000001	00000001	00000001	0x01	4
XNP Join Accept Message							
Message Number	8	21	00010101	00010101	00010101	0x15	5
Message Length	8	8	00001000	00001000	00001000	0x08	6
Parameter Update Identifier	8	1	00000001	00000001	00000001	0x01	7

TABLE E-XXXVII. XNP Join Accept message to forwarder-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
Station Identifier	32	1255	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	0x00 0x00 0x04 0xE7	8 9 10 11
Link Address	8	55	00110111	00110111	00110111	0x37	12
XNP Data Blocks							
Basic Network Parameters Block							
Block Number	8	2	00000010	00000010	00000010	0x02	13
Block Length	8	16	00010000	00010000	00010000	0x10	14
Individual/Network Capability	8	1	00000001	00000001	00000001	0x01	15
Link Address	8	55	00110111	00110111	00110111	0x37	16
Station Class	8	3	00000011	00000011	00000011	0x03	17
NAD Methods	8	3	00000011	00000011	00000011	0x03	18
Group Address Bit Map							
127 - 120	8	255	11111111	11111111	11111111	0xFF	19
119 - 112	8	255	11111111	11111111	11111111	0xFF	20
111 - 104	8	255	11111111	11111111	11111111	0xFF	21
103 - 96	8	254	11111110	11111110	11111110	0xFE	22
Concatenation Capability	8	3	00000011	00000011	00000011	0x03	23
FEC/TDC/Scrambling Mode	8	3	00000011	00000011	00000011	0x03	24
Max. UI, DIA and I Info. Octets	16	3345	00001101 00010001	00001101 00010001	00001101 00010001	0x0D 0x11	25 26
Maximum Transmit Time	16	40	00000000 00101000	00000000 00101000	00000000 00101000	0x00 0x28	27 28
Type 3 Parameters Block							
Block Number	8	4	00000100	00000100	00000100	0x04	29
Block Length	8	3	00000011	00000011	00000011	0x03	30
Type 3 Retransmissions	8	2	00000010	00000010	00000010	0x02	31

TABLE E-XXXVII. XNP Join Accept message to forwarder-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
Busy State Timer	16	60	00000000 00111100	00000000 00111100	00000000 00111100	0x00 0x3C	32 33
Deterministic NAD Parameter Block							
Block Number	8	5	00000101	00000101	00000101	0x05	34
Block Length	8	6	00000110	00000110	00000110	0x06	35
Number of Stations	8	6	00000110	00000110	00000110	0x06	36
Number of NAD Priorities	8	4	00000100	00000100	00000100	0x04	37
Number of NAD Slots	8	6	00000110	00000110	00000110	0x06	38
NAD Slot Duration	16	1000	00000011 11101000	00000011 11101000	00000011 11101000	0x03 0xE8	39 40
Type 2 Parameters Block							
Block Number	8	9	00001001	00001001	00001001	0x09	41
Block Length	8	13	00001101	00001101	00001101	0x0D	42
ACK Timer	16	120	00000000 01111000	00000000 01111000	00000000 01111000	0x00 0x78	43 44
P-Bit Timer	8	10	00001010	00001010	00001010	0x0A	45
Reject Timer	16	160	00000000 10100000	00000000 10100000	00000000 10100000	0x00 0xA0	46 47
Max. Transmissions, N2	8	2	00000010	00000010	00000010	0x02	48
K Window	8	127	01111111	01111111	01111111	0x7F	49
K2 Threshold	8	127	01111111	01111111	01111111	0x7F	50
K3 Threshold	8	127	01111111	01111111	01111111	0x7F	51
Response Delay Timer Percent	8	64	01000000	01000000	01000000	0x40	52
Intranet Parameters Block							
Block Number	8	12	00001100	00001100	00001100	0x0C	53
Block Length	8	11	00001011	00001011	00001011	0x0B	54

TABLE E-XXXVII. XNP Join Accept message to forwarder-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
Min Update Per.	8	30	00011110	00011110	00011110	0x1E	55
Topology Update Precedence	8	7	00000111	00000111	00000111	0x07	56
Relayer Status	8	0	00000000	00000000	00000000	0x00	57
ACK Timer (fixed)	16	100	00000000 01100100	00000000 01100100	00000000 01100100	0x00 0x64	58 59
ACK Timer (prop)	16	100	00000000 01100100	00000000 01100100	00000000 01100100	0x00 0x64	60 61
Retransmit Count	8	2	00000010	00000010	00000010	0x02	62
Link Failure Threshold	8	2	00000010	00000010	00000010	0x02	63
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	64
Block Length	8	6	00000110	00000110	00000110	0x06	65
Unique Id	32	1225	00000000 00000000 00000100 11001001	00000000 00000000 00000100 11001001	00000000 00000000 00000100 11001001	0x00 0x00 0x04 0xC9	66 67 68 69
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	70
Block Length	8	3	00000011	00000011	00000011	0x03	71
Station Rank	8	1	00000001	00000001	00000001	0x01	72
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	73
Block Length	8	6	00000110	00000110	00000110	0x06	74
Unique Id	32	1231	00000000 00000000 00000100 11001111	00000000 00000000 00000100 11001111	00000000 00000000 00000100 11001111	0x00 0x00 0x04 0xCF	75 76 77 78
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	79
Block Length	8	3	00000011	00000011	00000011	0x03	80
Station Rank	8	2	00000010	00000010	00000010	0x02	81
Station ID Block							

TABLE E-XXXVII. XNP Join Accept message to forwarder-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
Block Number	8	1	00000001	00000001	00000001	0x01	82
Block Length	8	6	00000110	00000110	00000110	0x06	83
Unique Id	32	1244	00000000 00000000 00000100 11011100	00000000 00000000 00000100 11011100	00000000 00000000 00000100 11011100	0x00 0x00 0x04 0xDC	84 85 86 87
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	88
Block Length	8	3	00000011	00000011	00000011	0x03	89
Station Rank	8	4	00000100	00000100	00000100	0x04	90
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	91
Block Length	8	6	00000110	00000110	00000110	0x06	92
Unique Id	32	1234	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	00000000 00000000 00000100 11010010	0x00 0x00 0x04 0xD2	93 94 95 96
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	97
Block Length	8	3	00000011	00000011	00000011	0x03	98
Station Rank	8	3	00000011	00000011	00000011	0x03	99
Station ID Block							
Block Number	8	1	00000001	00000001	00000001	0x01	100
Block Length	8	6	00000110	00000110	00000110	0x06	101
Unique Id	32	1255	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	0x00 0x00 0x04 0xE7	102 103 104 105
NAD Ranking Block							
Block Number	8	11	00001011	00001011	00001011	0x0B	106
Block Length	8	3	00000011	00000011	00000011	0x03	107
Station Rank	8	5	00000101	00000101	00000101	0x05	108
Terminator block	8	255	11111111	11111111	11111111	0xFF	109

9. Join Accept Message to Joiner from Forwarder

a. Transmission Header (see APPENDIX G TABLE G-XIII):

Selection Bits:		
FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)
Topology Update ID	y	(Forwarder's current #)
Transmission Queue:		
T-bits	1	(DAP-NAD)
Data Link Precedence	1	(Priority)
First Station Number	zz	

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R Bit	0	(Command)
Address	25	(Forwarder station 25)
Destination Address:		
Extension Bit	1	(Last one)
Address	1	(Net Entry)
Control Field	3	(UI, ACK not required)

c. Intranet Header (see APPENDIX G TABLE G-IX):

Version #	0	(Current Version)
Message Type	6	(XNP)
Header Length	3	(Minimum)
Type of Service	48	(Priority, low delay)

d. XNP Message (see TABLE E-XXXVII):

Version #	0	(Current Version)
Forwarding Header:		
Message Number	0	(Forwarding Header)
Source Address	2	(Network Controller)
Forwarder Address	25	(Station 25)
Destination Address	1	(Net Entry)
Message Number	21	(Join Accept Message)
Message Length	8	(Join Accept Message Length)
Parameter Update Identifier	1	(ID is 1 for this example)
Station Identifier	1255	(Number identifying the Joiner)
Link Address	55	[Joiner's assigned link address]

XNP Data Blocks:

Data Block 2	Basic Network Parameters
Data Block 4	Type 3 Network Parameters
Data Block 5	Deterministic NAD Parameters
Data Block 9	Type 2 Parameters
Data Block 12	Intranet Parameters
Data Block 1	Station Identification (Station #1)
Data Block 11	NAD Ranking (Station #1)
•	
•	
•	
Data Block 1	Station Ident. (Last station)
Data Block 11	NAD Ranking (Last station)
Terminator Block	255

10. Hello Message from Joiner

a. Transmission Header (see APPENDIX G TABLE G-XIII):

Selection Bits:		
FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)
Topology Update ID	0	(Initial)
Transmission Queue:		
T-bits	1	(DAP-NAD)
Data Link Precedence	0	(Urgent)
First Station Number	zz	

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R Bit	0	(Command)
Address	1	(Joiner)
Destination Addresses:		
Extension Bit	0	(More)
Address	25	(Forwarder station 25)
Extension Bit	1	(Last one)
Address	127	(Global Multicast)
Control Field	19	(UI, ACK required)

c. Intranet Header (see APPENDIX G TABLE G-IX):

Version #	0	(Current Version)
Message Type	6	(XNP)
Header Length	3	(Minimum)
Type of Service	240	(Network Control, low delay)

d. XNP Message:

Version #	0	(Current Version)
Forwarding Header:		
Message Number	0	(Forwarding Header)
Source Address	1	(Joiner)
Forwarder Address	25	(Station 25)
Destination Address	127	(Global Broadcast)
Message Number	23	(Hello Message)
Message Length	7	(Hello Message Length)
Station Identifier	1255	(Number identifying the Joiner)
Link Address	55	(Data link address of Joiner)
Terminator Block	255	

TABLE E-XXXVIII illustrates the construction of the XNP Hello Message from Joiner.

TABLE E-XXXVIII. XNP Hello message from joiner.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
XNP Message							
Version Number	8	0	00000000	00000000	00000000	0x00	0
Forwarding Header							
Message Number	8	0	00000000	00000000	00000000	0x00	1
Source Address	8	1	00000001	00000001	00000001	0x01	2
Forwarder Address	8	25	00011001	00011001	00011001	0x19	3
Destination Address	8	127	01111111	01111111	01111111	0x7F	4
XNP Hello Message							
Message Number	8	23	00010111	00010111	00010111	0x17	5
Message Length	8	7	00000111	00000111	00000111	0x07	6
Station Identifier	32	1255	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	00000000 00000000 00000100 11100111	0x00 0x00 0x04 0xE7	7 8 9 10
Link Address	8	55	00110111	00110111	00110111	0x37	11
Terminator block	8	255	11111111	11111111	11111111	0xFF	12

11. Type 3 Acknowledgment to UI Carrying Hello Message

a. Transmission Header (see APPENDIX G TABLE G-XIII):

Selection Bits:		
FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)
Topology Update ID	y	(Each station's current #)

Transmission Queue:		
T-bits	1	(DAP-NAD)
Data Link Precedence	0	(Urgent)
First Station Number	zz	(Using old ranking)

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R Bit	1	(Response)
Address	25	(Forwarder station 25)
Destination Address:		
Extension Bit	1	(Last one)
Address	xx	(Joiner)
Control Field	51	(URR response)

12. Hello Message from Forwarder

a. Transmission Header (see APPENDIX G TABLE G-XIII):

Selection Bits:		
FEC	1	(Yes)
TDC	1	(Yes)
Scrambling	0	(No)
Topology Update ID	0	(Initial)
Transmission Queue:		
T-bits	1	(DAP-NAD)
Data Link Precedence	0	(Urgent)
First Station Number	zz	

b. Link Layer Header (see APPENDIX G TABLE G-X):

Source Address:		
C/R Bit	0	(Command)
Address	25	(Forwarder station 25)
Destination Address:		
Extension Bit	1	(Last one)
Address	127	(Global Multicast)
Control Field	3	(UI, ACK not required)

c. Intranet Header (see APPENDIX G TABLE G-IX):

Version #	0	(Current Version)
Message Type	6	(XNP)
Header Length	3	(Minimum, assuming Relaying is not required)
Type of Service	240	(Network Control, low delay)

d. XNP Message:

Version #	0	(Current Version)
Forwarding Header:		
Message Number	0	(Forwarding Header)
Source Address	55	(Joiner)
Forwarder Address	25	(Station 25)
Destination Address	127	(Global Broadcast)
Message Number	23	(Hello Message)
Message Length	7	(Hello Message Length)
Station Identifier	1255	(Number identifying the Joiner)
Link Address	55	
Terminator Block	255	

TABLE E-XXXIX illustrates the construction of the XNP Hello Message from Forwarder.

TABLE E-XXXIX. XNP Hello message from forwarder.

Field Name	**Length (bits)**	**Value (Dec)**	**Value (Binary)**	**Field Fragments**	**Octet Value (Binary)**	**Octet Value (Hex)**	**Octet Number**
			MSB 2^n LSB 2^0	**MSB 2^n LSB 2^0**	**MSB 2^n LSB 2^0**		
XNP Message							
Version Number	8	0	00000000	00000000	00000000	0x00	0
Forwarding Header							
Message Number	8	0	00000000	00000000	00000000	0x00	1
Source Address	8	55	00110111	00110111	00110111	0x37	2
Forwarder Address	8	25	00011001	00011001	00011001	0x19	3
Destination Address	8	127	01111111	01111111	01111111	0x7F	4
XNP Hello Message							
Message Number	8	23	00010111	00010111	00010111	0x17	5

TABLE E-XXXIX. XNP Hello message from forwarder-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0		
Message Length	8	7	*0*0000111	*0*0000111	*0*0000111	0x07	6
Station Identifier	32	1255	*0*0000000	*0*0000000	*0*0000000	0x00	7
			00000000	00000000	00000000	0x00	8
			00000100	00000100	00000100	0x04	9
			11100111	11100111	11100111	0xE7	10
Link Address	8	55	*0*0110111	*0*0110111	*0*0110111	0x37	11
Terminator block	8	255	*1*1111111	*1*1111111	*1*1111111	0xFF	12

APPENDIX F

GOLAY CODING ALGORITHM

F.1 General.

F.1.1 Scope.
This appendix contains amplifying information in support of MIL-STD-188-220.

F.1.2 Application.
This appendix is not a mandatory part of MIL-STD-188-220. The information contained herein is intended for guidance only.

F.2 Applicable documents.
None.

F.3 Forward error correction.
The FEC method requires the receiver to detect and automatically correct errors in a received block of information. The number of errors the receiver can detect and correct depends on the coding method. The information bits (k) are separated into blocks that contain both information bits and code bits. The length of the block, including the information and code bits, is (n). The code is described as (n, k), where n is the length of the block and k is the number of information bits in the block.

F.4 Golay code.
The Golay code is a linear, block, perfect, and cyclic (23,12) code capable of correcting any combination of three or fewer errors in a block of 23 digits. The generator polynomial for this code is

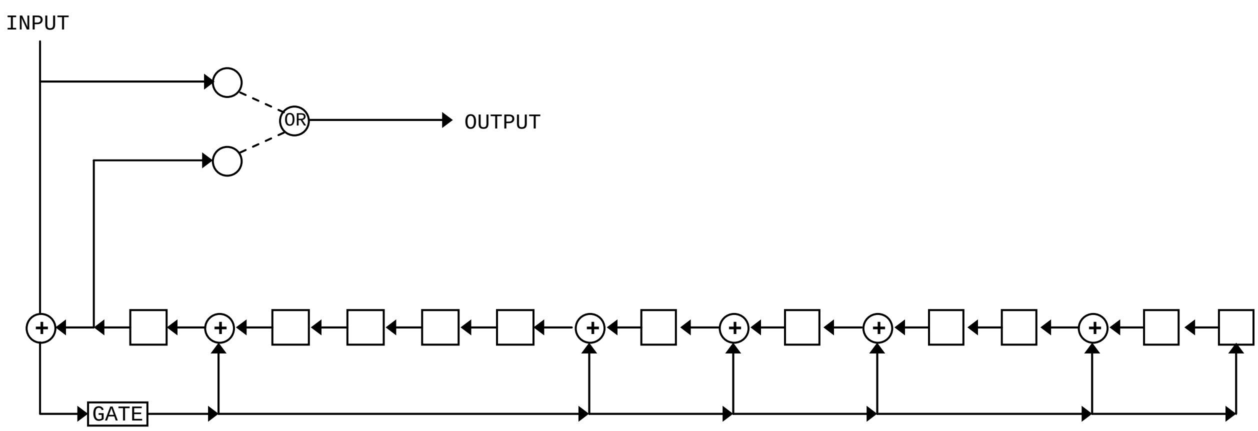
$$g(x) = x^{11} + x^{10} + x^6 + x^5 + x^4 + x^2 + 1$$

where g(x) is a factor of $x^{23} + 1$

F.4.1 Half-rate Golay code.
The half-rate Golay code (24,12) is formed by adding a fill bit to the Golay (23,12) code. The fill bit is not checked on reception. The (24,12) code is preferable to the (23,12) because it has a code rate of exactly one-half. This code rate simplifies system timing.

F.4.2 Golay code implementation.
The Golay code may be implemented in either hardware or software. The hardware implementation uses shift-registers for encoding and decoding, as described in F.4.2.1 and F.4.2.2, respectively. The software implementation uses a generator matrix and conversion table, as described in F.4.2.3.

F.4.2.1 Hardware implementation.
Golay code encoding can be performed with an 11-stage feedback shift register with feedback connections selected according to the coefficients of g(x). A shift register corresponding to the coefficients of g(x) is shown in FIGURE F-1. The k information bits are located at the beginning of the n symbol block code. With the gate open, the information bits are loaded into the shift register stages and simultaneously into the output channel. At this time the shift register contains the check symbols. With the gate closed, register contents are then shifted onto the output channel. The last n - k symbols are the check symbols that form the whole codeword.



Encoder for $g(x) = 1 + x^2 + x^4 + x^5 + x^6 + x^{10} + x^{11}$

FIGURE F-1. Shift register encoding for the (23,12) Golay code.

F.4.2.2 Hardware decoding.
The Golay code is decoded using a number of techniques such as the error-trapping process developed by T. Kasami. The Kasami error-trapping decoder for the Golay code is shown in

FIGURE F-2. It works as follows:

a. Gates 1, 3, and 5 are opened, and gates 2 and 4 are closed. The received codeword r(x) is then shifted into both the 23-stage shift register and the syndrome register. At the same time, the previously corrected codeword is shifted out to the user. The syndrome

$$S(x) = S_0 + S_1x + . . . + S_{10}x^{10}$$

is then formed and subjected to threshold tests.

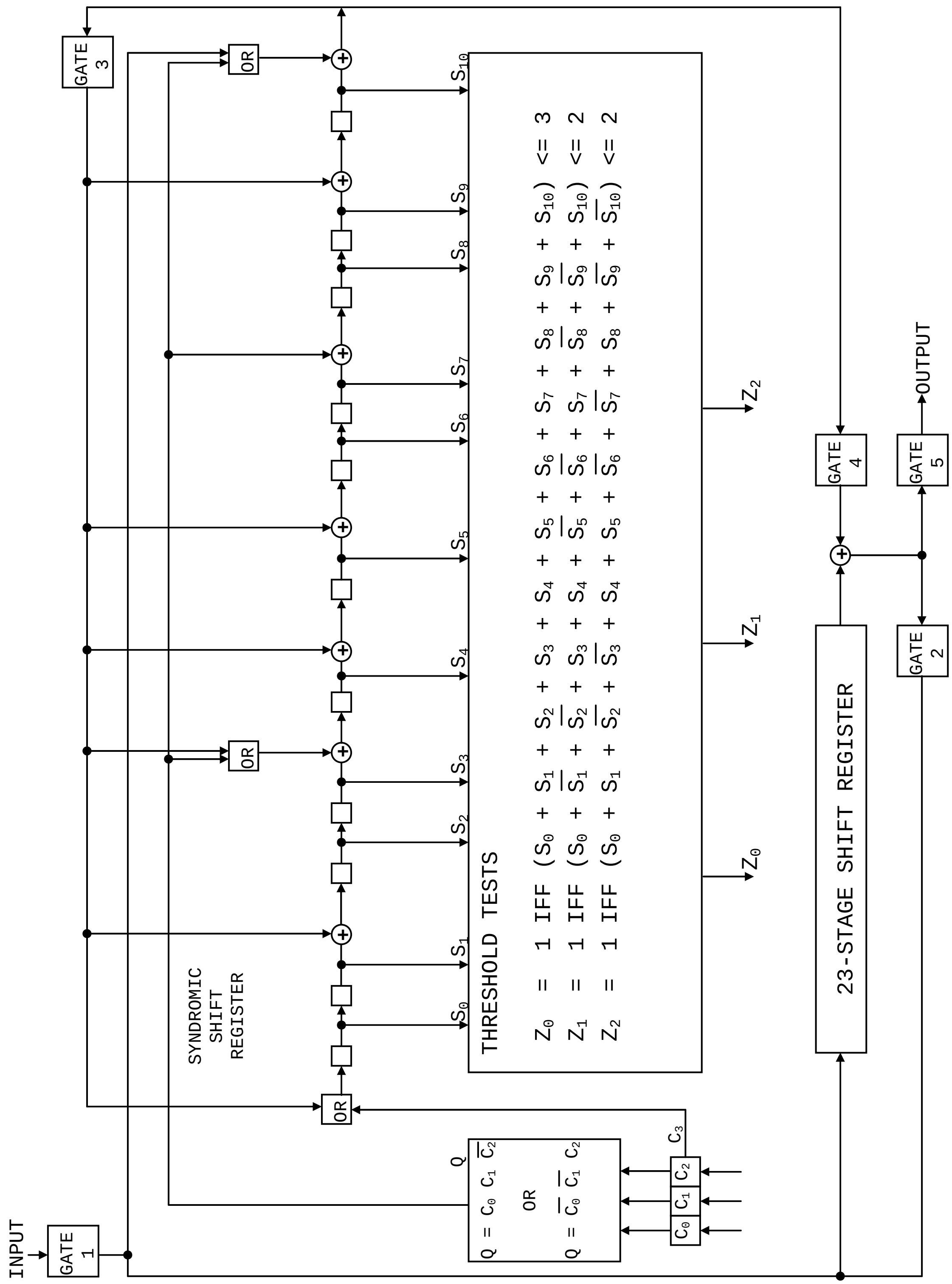


FIGURE F-2. Kasami error-trapping decoder for the (24,12) Golay code.

b. Gates 1, 4, and 5 are closed and gate 2 is opened. Gate 3 remains open. The threshold tests occur in the following order:

1. If Z_0 is unity, then all the errors are confined to the 11 high-order positions of r(x), and S(x) matches the errors. Z_0 opens gate 4 and closes gate 3. Contents of both the 23-stage shift register and the syndrome shift register are then shifted 11 times, and the errors are corrected. Then gate 4 is closed and the contents of the 23-stage shift register are shifted until the received codeword is in its original position. The decoder then goes to step 3 below.

2. If Z_1 is unity, the error pattern in S(x) is the same as the errors in the 11 high-order bits of the codeword r(x), and a single error exists at location x^5. Gate 4 is opened and gate 3 is closed. The counter is preloaded with a count of 2, and both the syndrome shift register and the 23-stage shift register are shifted until the error in x^5 is corrected. Then gate 4 is closed, and the contents of the 23-stage shift register are shifted until the received codeword is in its original position. The decoder then goes to step 3.

3. If Z_2 is unity, the error pattern in S(x) is the same as the errors in the 11 high-order bits of the codeword r(x), and there is a single error in location x^6. The same steps are followed as in b (above) except that the counter is preloaded with a count of 3. The decoder then goes to step 3.

4. If neither of the three thresholds is unity, the decoder goes directly to step 3.

c. Gates 1, 4, and 5 are closed, and gates 2 and 3 are opened. Contents of both the 23-stage shift register and the syndrome shift register are then shifted once to the right. The decoder then goes to step 2.

d. This action continues until step 3 has been executed 46 times. Then the decoder returns to step 1 to process the next received codeword.

The decoder always yields an output. The output is correct if there were 3 or fewer errors in the received codeword, and erroneous if there were more than 3 errors in the codeword.

F.4.2.3 <u>Software implementation.</u>
The transmitting DMTD shall generate the check bits using the following generator polynomial:

$$g(x)= x^{11} + x^{10} + x^6 + x^5 + x^4 + x^2 + 1$$

Note that using modulo 2 addition,

$$x^{23}+1=(x^{11}+x^{10}+x^{6}+x^{5}+x^{4}+x^{2}+1)(x^{11}+x^{9}+x^{7}+x^{6}+x^{5}+x+1)(x+1)$$

The 11 check bits shall be as derived from the generator matrix G, shown in FIGURE F-3, where the matrix contains the coefficients of the polynomials on the left.

	X 22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	X 0
$x^{11} * g(x) =$	1	1	0	0	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
$x^{10} * g(x) =$	0	1	1	0	0	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0
$x^{9} * g(x) + x^{11} * g(x) =$	1	1	1	1	0	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
$x^{8} * g(x) + x^{10} * g(x) =$	0	1	1	1	1	0	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
$x^{7} * g(x) + x^{9} * g(x) =$	0	0	1	1	1	1	0	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0
$(x^{6} + x^{8} + x^{11}) * g(x) =$	1	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
$(x^{5} + x^{7} + x^{10}) * g(x) =$	0	1	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0
$(x^{4} + x^{6} + x^{9}) * g(x) =$	0	0	1	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0
$(x^{3} + x^{5} + x^{8} + x^{11}) * g(x) =$	1	1	0	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0
$(x^{2} + x^{4} + x^{7} + x^{10} + x^{11}) * g(x) =$	1	0	1	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0
$(x + x^{3} + x^{6} + x^{9} + x^{10} + x^{11}) * g(x) =$	1	0	0	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0
$(1 + x^{2} + x^{5} + x^{8} + x^{9} + x^{10} + x^{11}) * g(x) =$	1	0	0	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1

= G

Parity (columns 22–12) Identity (columns 11–0)

FIGURE F-3. Generator matrix G.

By interchanging the I and P columns to obtain matrix T, shown in FIGURE F-4, that is,

$$G=[P,I]_{(12 \times 23)} = >[I,P]_{(12 \times 23)} = T$$

the transmission order and value of the code word bits can be obtained by matrix multiplication (modulo 2 addition without carry) as follows:

$$\underset{(1\times12)}{\left[Ib_1 \;\; \text{INFO BITS} \;\; Ib_{12} \right]} * \underset{(12\times23)}{\left[I,P \right]} = \underset{(1\times23)}{\left[\text{INFO BITS, CHECK BITS} \right]}$$

FIRST BIT TRANSMITTED

FIRST BIT TRANSMITTED

$$T = \begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 1 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 1 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 1 & 0 & 1 & 1 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 1
\end{bmatrix}$$

(columns 1–12: **I**; columns 13–23: **P**)

FIGURE F-4. Matrix T.

APPENDIX G

PACKET CONSTRUCTION AND BIT ORDERING

G.1 General.

G.1.1 Scope.

This appendix illustrates the construction of packets starting with the Application Layer Protocol Data Unit (PDU) and VMF Message data buffers and ending with the data link bit order of transmission and physical layer PDU. However this example excludes the S/R protocol. The focus of this example is to show correct formatting of the MIL-STD-188-220 subnetwork.

G.1.2 Application.

This appendix is a mandatory part of this document. The bit ordering defined herein shall be utilized by all implementers.

G.1.3 Clarification of examples

Throughout this standard, many examples are provided as guidance only. In the event that an example is inconsistent with the text and DSPICS of the standard, the text description/DSPICS takes precedence over the example. Should a user detect any inconsistent examples, they should notify the CNRWG so that the example can be updated for a future release of the standard. It should also be noted that while all examples should be accurate in relation to the feature they are explaining, some of the examples provided may not reflect changes made to unrelated sections of the standard (e.g. examples to illustrate the use of XNP reflect the current version of XNP, but may not reflect the current version of the Intranet Header).

G.2 Applicable documents.

a. RFC 768: User Datagram Protocol

b. RFC 791: Internet Protocol -- DARPA Internet Program Protocol Specification

c. MIL-STD-2045-47001D: Interoperability Standard for Connectionless Data Transfer -- Application Standard

G.3 PDU construction.

This section provides examples illustrating the construction and bit ordering of a VMF message through the Application Layer, the Transport Layer, the Network Layer, Link Layer and Physical Layer. For clarity, each layer will be discussed separately and then combined for actual transmission. The same representations will be utilized for each layer:

- the MSB (2^n bit) is represented with an italicized font and
- the LSB (2^0 bit) is shown to the RIGHT in the Value (binary) column.

This representation is carried into the other columns to identify the beginning and end of each of the fields as the bits are moved into individual octets. Note that the bit markings for MSB and LSB are on a field basis, not on an octet basis. Single bit fields are treated as LSB. In addition, since some layers (e.g. transport) are based on commercial standards, the representation from the appropriate RFC will also be included. In all cases, we will start with a figure which illustrates the interaction with upper/lower communication layers, followed by a figure showing the exchange between communication layers. There will be a table showing the construction of the PDU. This will be followed by a table showing the construction of each octet and a figure showing the serial representation of this particular PDU as it would appear at physical layer.

Each layer typically adds value and its own header to an outgoing message. This process is illustrated in FIGURE G-1.

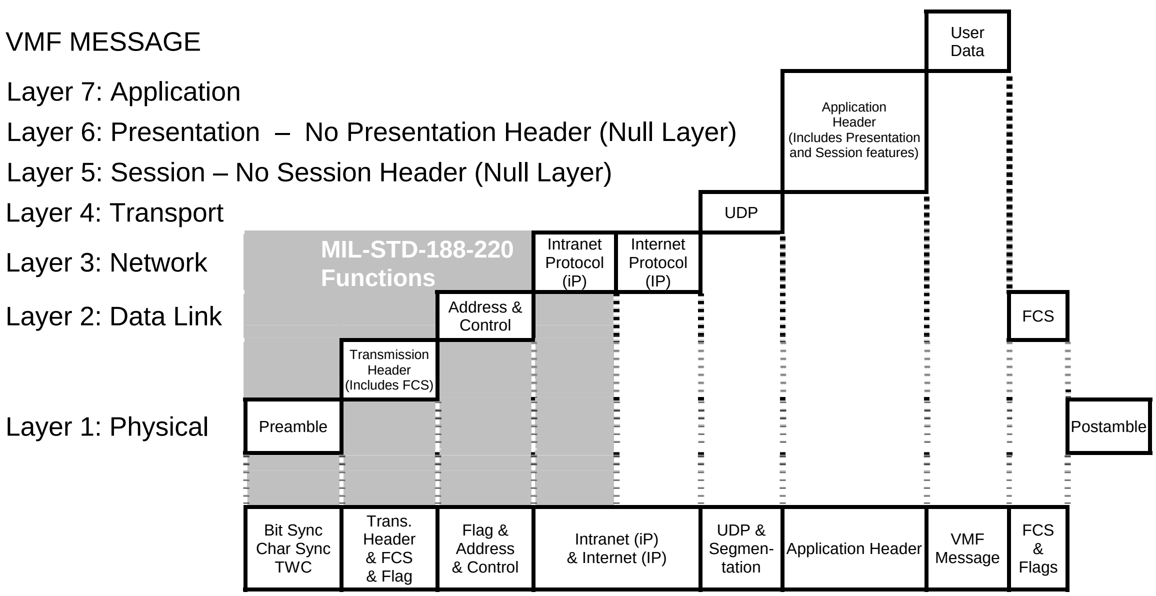


FIGURE G-1. PDU construction.

An application header is added to the VMF message at application layer. For this protocol, layers 5 and 6 are null layers, and no processing or headers are present. The Application Layer handles these functions. The transport layer adds its header. Although the standard calls out TCP, UDP and segmentation/reassembly, only UDP is illustrated in this appendix. Next, the network layer adds the IP header and the Intranet header. The message is now passed to the data link layer which adds both a header and a trailer. Finally, the physical layer adds its header resulting in the final PDU for transmission. Note that this example does not include TCP, segmentation & reassembly, or COMSEC.

G.3.1 <u>VMF message data exchange.</u>

The relationship of the VMF Messaging Services to other communication layers is shown in FIGURE G-2. A layered communication model is used in this example for consistency with the principles of the ISO OSI reference model. The model discussed here is tailored to focus attention specifically on VMF Messaging Services, and the data it produces. A user of VMF Messaging Services exchanges Message Content with its peer at another node by sending and receiving the Message Content via the VMF Messaging Services. VMF Messaging Services sends and receives the Message Content by converting the Message Content to Message Data and exchanging the Message Data with its peer at another node. The VMF Message Data is sent and received via lower communication layers. The lower communication layers send and receive the VMF Message Data transparently over a variety of communications media. Note that VMF Messaging Services would ordinarily use Application Layer services from the lower communication layers to send and receive Message Data. The Message Data would then appear in the Application Layer PDU's VMF message.

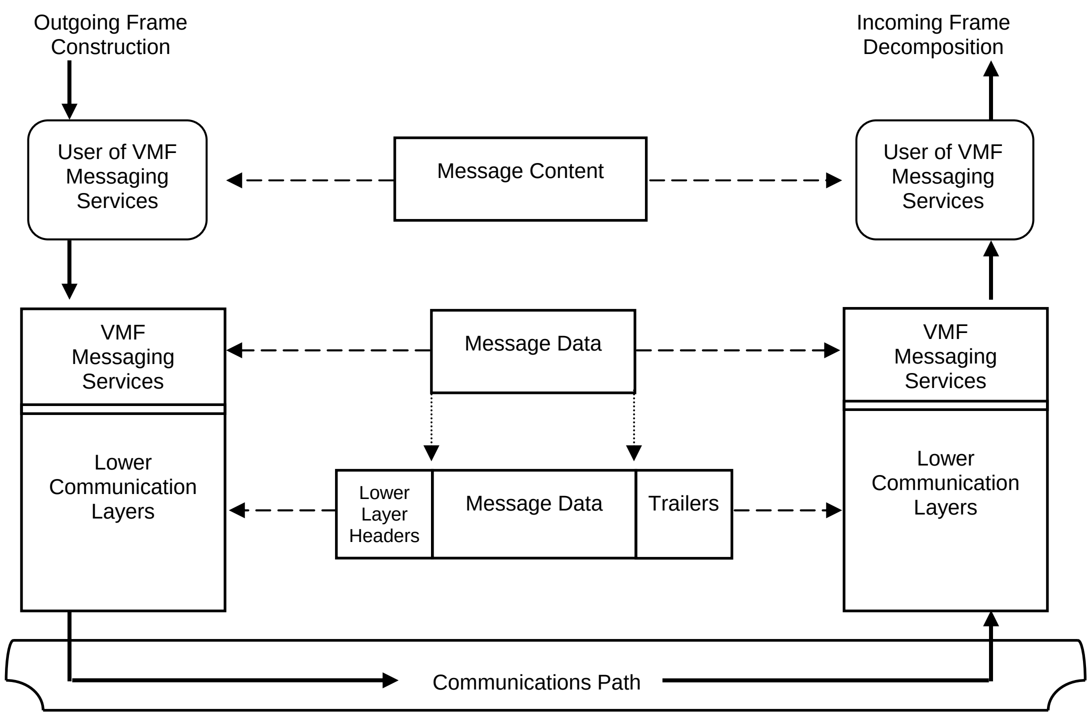


FIGURE G-2. VMF message services interaction with other communication layers.

The format of the Message Data is defined in terms of the actual data buffer or data stream used to exchange the Message Data between the VMF Messaging Services and the lower communication layers. The rationale for using the Message Data's data buffer/stream to define the format is: 1) for consistency with industry standard commercial communications hardware and software (e.g., UNIX implementations of TCP/IP), which exchange data with other software when sending or receiving as a buffer or stream of octets; 2) to provide a definition independent of the specifics of any other communication layer, consistent with the OSI ISO model principle of making communication layers independent; and 3) to avoid differences in the bit representations used to implement communications on different media. For example, on Ethernet LAN media each octet is sent LSB first, but on FDDI media each octet is sent MSB first. To achieve a universal definition of the Message Data format, its representation is defined independent of the other communication layers. The relationship of the Message Data's data buffer/stream to the VMF Messaging Services is depicted in FIGURE G-3.

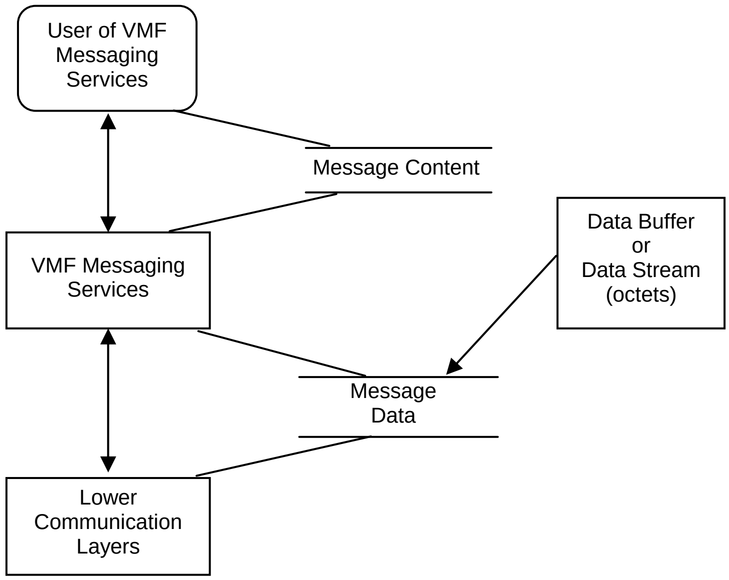


FIGURE G-3. Exchange of message data between communication layers.

G.3.1.1 <u>Example of VMF message data construction.</u>
The construction of VMF Message Data is illustrated by the example in TABLE G-I. The first four columns of the table provide a description of each field in the example, the field length in bits, and the value of the field in both decimal (Dec) and binary representations. The last three columns show the physical encoding of the VMF Message Data. In the fifth column, Field Fragments, the bits of each field are placed in octets. The bit(s) of each field are positioned in an octet such that the LSB of the field is positioned in the least significant unencoded bit of the octet, the next LSB of the field is placed in the next least significant unencoded bit of the octet, and repeated until all of the bits of the field have been encoded. When an octet is filled before all the bits of a field are encoded, the process is continued encoding the next octet with the remaining bits of the field. This field/octet encoding procedure is performed starting with the first field and octet, and repeated for each successive field and individual octet, in order, until the encoding is completed. When a field has groups, the field encoding procedure is performed starting with the first group, and repeated for each successive group and individual octet, in order, until the encoding of the field is completed. The Target Number field illustrates the encoding of a field with groups. Note the LSB of a field or octet is defined as the bit having the weight of 2^0 when the field or octet is represented as a numeric value. X's are used to identify bits that are not associated with the field being encoded. The sixth column, Octet Value - Binary, assembles the bits contributed by successive fields into complete octets, represented in binary. The seventh column, Octet Value – Hex, represents the octet value in hexadecimal (Hex). The last column, Octet Number, numbers the octets from first to last starting with 0.

When all fields have been encoded, any remaining unencoded bits in the last octet are filled with zeroes (zero padded). Each VMF Message is individually encoded and zero padded. This example is a factitious VMF message – K15.99.

TABLE G-I. Example of K15.99 VMF message like data construction

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^7 LSB 2^0	MSB 2^7 LSB 2^0		
Field1	5	0	*00000*	xxx*00000*			
FPI (Field2)	1	1	1	XX1XXXXX			
Field2 (ASCII CHAR)	7	66(B)	1000010	10XXXXXX	101*00000*	A0	1
				XXX*10000*			
FPI (Field3)	1	1	1	XX1XXXXX			
Field3 (A1234)	21						
Subfield 1 (ASCII CHAR)	7	65 (A)	1000001	01XXXXXX	01111000	78	2
				XXX*10000*			
Subfield 2 (Dec)	14	1234	00010011010010	010XXXXX	010*10000*	50	3
				10011010	10011010	9A	4
				XXXXX*000*			
FPI (Field4)	1	0	0	XXXX0XXX			
Field4	21	NA					
GPI (Group1)	1	0	0	XXX0XXXX			
Field5	5	NA					
Field6	6	NA					
Field7	6	NA					
FPI (Field8)	1	0	0	XX0XXXXX			
Field8	7	NA					
GPI (Group2)	1	0	0	X0XXXXXX			
Field9	24	NA					
Field10	32	NA					
Field11	5	NA					
Field12	5	NA					
Field13	6	NA					
Field14	6	NA					
(Zero Padding)	1	0	0	0XXXXXXX	0000*0000*	00	5

FIGURE G-4 illustrates the octets arranged in a serial format as they would appear at the physical layer, with LSB first.

Octet 0	Octet 1	Octet 2	Octet 3	Octet 4
2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7
00000101	00011110	00001010	01011001	00000000

FIGURE G-4. Serial representation of PDU.

G.3.2 <u>Application Layer data exchange.</u>
The relationship of the Application Layer to other communication layers is shown in FIGURE G-5. A layered communication model is used in this example for consistency with the principles of the ISO OSI reference model. The model discussed here is tailored to focus attention specifically on the Application Layer, and the data it produces. A user of the Application Layer exchanges a VMF message with its peer at another node by sending and receiving the VMF message via the Application Layer. The Application Layer sends and receives the VMF message transparently by producing and exchanging an Application Layer Protocol Data Unit (PDU) with its peer at another node. The Application Layer PDU consists of the Application Header concatenated with the VMF message, and is sent and received via lower communication layers. The lower communication layers send and receive the VMF message transparently over a variety of communications media.

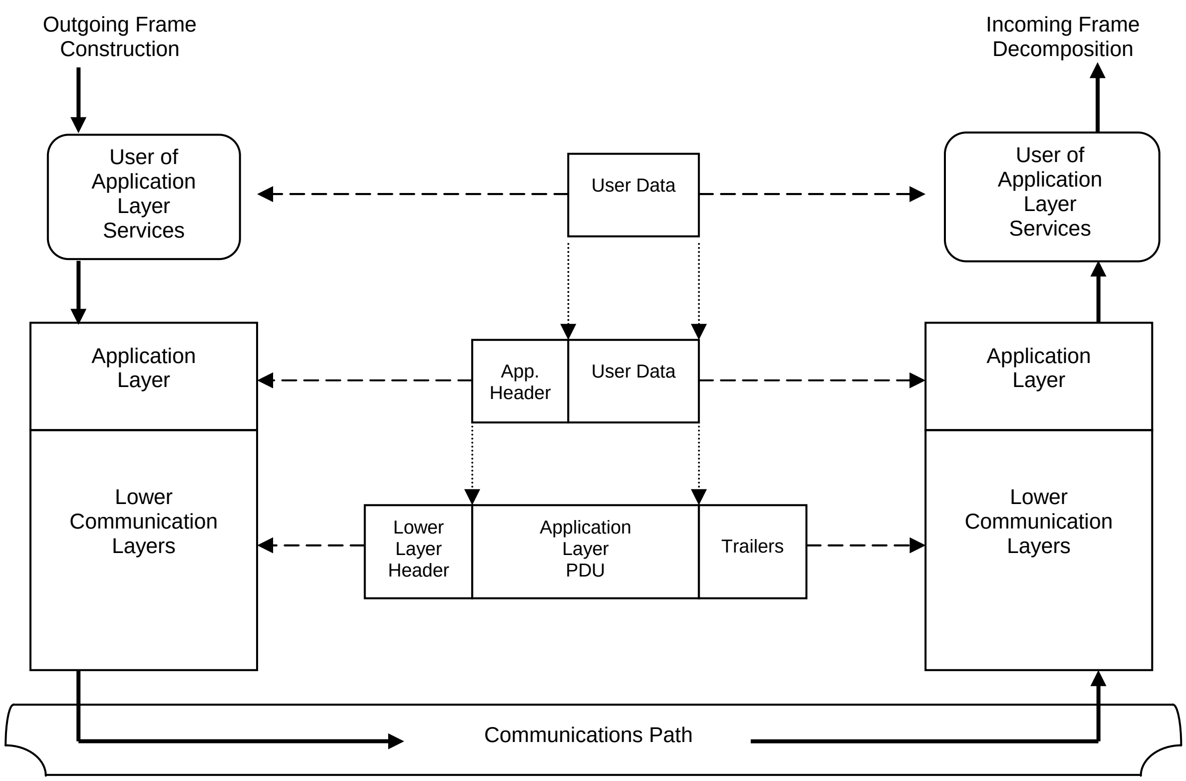


FIGURE G-5. Application Layer interaction with other communication layers.

The format of the Application Layer PDU is defined in terms of the actual data buffer or data stream used to exchange the PDU between the Application Layer and the lower communication layers. The rationale for using the PDU's data buffer/stream to define the format is 1) for consistency with industry standard commercial communications hardware and software (e.g., UNIX implementations of TCP/IP), which exchange data with other software when sending or receiving as a buffer or stream of octets; 2) to provide a definition independent of the specifics of any other communication layer, consistent with the OSI ISO model principle of making communication layers independent; and 3) to avoid differences in the bit representations used to implement communications on different media. For example, on Ethernet LAN media each octet is sent LSB first, but on FDDI media each octet is sent MSB first. To achieve a universal definition of the PDU format, its representation is defined independent of the other communication layers. The relationship of the Application Layer PDU's data buffer/stream to the Application Layer is depicted in FIGURE G-6.

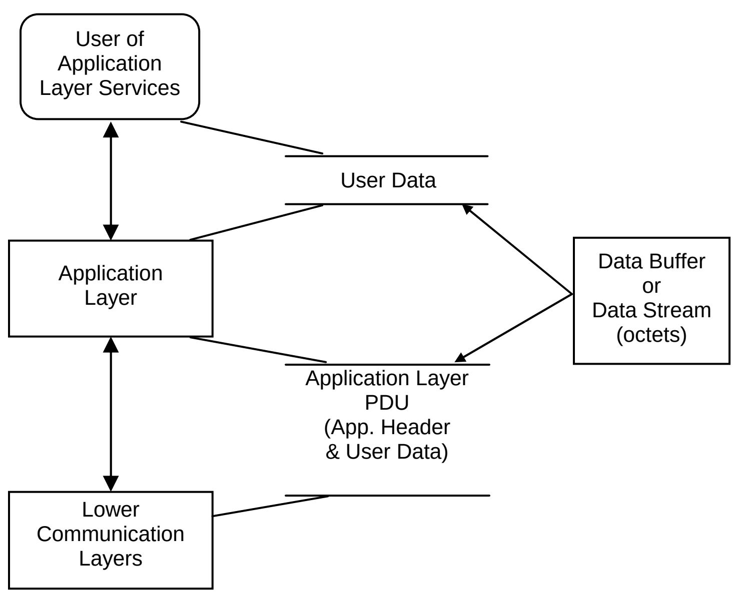


FIGURE G-6. Exchange of application layer PDU between communication layers.

G.3.2.1 <u>Example of Application Layer PDU.</u>

The construction of an Application Layer PDU is illustrated by the example in TABLE G-II. The first four columns of the table provide a description of each field in the example, the field length in bits, and the value of the field in both Dec and binary representations. The last four columns show the physical encoding of the Application Layer PDU. In the fifth column, Field Fragments, the bits of each field are placed in octets. The bit(s) of each field are positioned in an octet such that the LSB of the field is positioned in the least significant unencoded bit of the octet, the next LSB of the field is placed in the next least significant unencoded bit of the octet, and repeated until all of the bits of the field have been encoded. When an octet is filled before all the bits of a field are encoded, the process is continued encoding the next octet with the remaining bits of the field. This field/octet encoding procedure is performed starting with the first field and octet, and repeated for each successive field and individual octet, in order, until the encoding is completed. When a field has groups, the field encoding procedure is performed starting with the first group, and repeated for each successive group and individual octet, in order, until the encoding of the field is completed. The URN field illustrates the encoding of a field with groups. Note the LSB of a field or octet is defined as the bit having the weight of 2^0 when the field or octet is represented as a numeric value. X's are used to identify bits that are not associated with the field being encoded. The sixth column, Octet Value - Binary, assembles the bits contributed by successive fields into complete octets, represented in binary. The seventh column, Octet Value, represents the octet value in binary that should be submitted to the Transport layer. The last column, Octet Number, numbers the octets from first to last starting with 0.

When all fields have been encoded, any remaining unencoded bits in the last octet are filled with zeroes (zero padded). The Application Header is encoded and zero padded. The VMF message is encoded and zero padded before it is passed to the Application Layer to have the Application Header added.

TABLE G-II. Example construction of the application header.

Syntax	Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Number
				MSB ***2^n*** **LSB** **2^0**	**MSB** **2^n** **LSB** **2^0**	**MSB** **2^n** **LSB** **2^0**	
	Version	4	3	*0*011	xxxx*0*011		
FPI	Compression Type	1	0	0	xxx0xxxx		
GPI	Presence Indicator (Originator)	1	1	1	xx1xxxxx		
FPI	Presence Indicator (URN)	1	1	1	x1xxxxxx		
	URN (Originator)	24	23	*0*00000000000000000010111	1xxxxxxx 00001011 00000000 x*0*000000	1110*0*011 00001011 00000000	0 1 2
FPI	Presence Indicator (Unit Name)	1	0	0	0xxxxxxx	0*0*000000	3

TABLE G-II. Example construction of the application header-Continued

Syntax	Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Number
				MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	
GPI	Presence Indicator (Recipient)	1	1	1	xxxxxxx1		
GRI	Group Repeat Indicator (Recipient)	1	0	0	xxxxxx0x		
FPI	Presence Indicator (URN)	1	1	1	xxxxx1xx		
	URN (Recipient URN)	24	124	000000000000000001111100	11100xxx 00000011 00000000 xxxxx000	11100101 00000011 00000000	4 5 6
FPI	Presence Indicator (Unit Name)	1	0	0	xxxx0xxx		
GPI	Group Presence Indicator (Information)	1	0	0	xxx0xxxx		
FPI	Field Presence Indicator (Header Size)	1	0	0	xx0xxxxx		
GPI	Group Presence Indicator (FUTURE USE 1)	1	0	0	x0xxxxxx		
GPI	Group Presence Indicator (FUTURE USE 2)	1	0	0	0xxxxxxx	00000000	7
GPI	Group Presence Indicator (FUTURE USE 3)	1	0	0	xxxxxxx0		
GPI	Group Presence Indicator (FUTURE USE 4)	1	0	0	xxxxxx0x		
GPI	Group Presence Indicator (FUTURE USE 5)	1	0	0	xxxxx0xx		

TABLE G-II. Example construction of the application header-Continued

Syntax	Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Number
				MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	
GRI	Group Repeat Indicator (Message)	1	0	0	xxxx0xxx		
	User Message Format	4	2	0010	0010xxxx	00100000	8
FPI	Field Presence Indicator (Message Standard Version)	1	0	0	xxxxxxx0		
GPI	Group Presence Indicator (Message Identification)	1	1	1	xxxxxx1x		
	Functional Area Designator	4	15	1111	xx1111xx		
	Message Number	7	99	1100011	11xxxxxx xxx11000	11111110	9
FPI	Presence Indicator (Message Subtype #)	1	0	0	xx0xxxxx		
FPI	Presence Indicator (File Name)	1	0	0	x0xxxxxx		
FPI	Presence Indicator (Message Size)	1	0	0	0xxxxxxx	00011000	10
	Operation Indicator	2	0	00	xxxxxx00		
	Retransmit Indicator	1	0	0	xxxxx0xx		
	Message Precedence Code	3	7	111	xx111xxx		
	Security Classification	2	0	00	00xxxxxx	00111000	11
FPI	FPI for Control/Release Marking	1	0	0	xxxxxxx0		
GPI	GPI for Originator DTG	1	1	1	xxxxxx1x		
	Year	7	4	0000100	000100xx xxxxxxx0	00010010	12
	Month	4	2	0010	xxx0010x		

TABLE G-II. Example construction of the application header-Continued

Syntax	Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Number
				MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	
	Day	5	14	01110	110xxxxx xxxxxxx01	11000100	13
	Hour	5	8	01000	x01000xx		
	Minute	6	32	100000	0xxxxxxx xxx10000	00100001	14
	Second	6	16	010000	000xxxxx xxxxx010	00010000	15
FPI	DTG Extension	1	0	0	xxxx0xxx		
GPI	GPI for Perishability DTG	1	0	0	xxx0xxxx		
GPI	GPI for ACK Request Group	1	0	0	xx0xxxxx		
GPI	GPI for Response Data Group	1	0	0	x0xxxxxx		
GPI	GPI for Reference Message Data	1	0	0	0xxxxxxx	00000010	16
GPI	Group Presence Indicator (FUTURE USE 6)	1	0	0	xxxxxxx0		
GPI	Group Presence Indicator (FUTURE USE 7)	1	0	0	xxxxxx0x		
GPI	Group Presence Indicator (FUTURE USE 8)	1	0	0	xxxxx0xx		
GPI	Group Presence Indicator (FUTURE USE 9)	1	0	0	xxxx0xxx		
GPI	Group Presence Indicator (FUTURE USE 10)	1	0	0	xxx0xxxx		

TABLE G-II. Example construction of the application header-Continued

Syntax	Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Number
				MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	
GPI	GPI for Security Parameters Information	1	0	0	xx0xxxxx		
GPI	Group Presence Indicator (FUTURE USE 11)	1	0	0	x0xxxxxx		
GPI	Group Presence Indicator (FUTURE USE 12)	1	0	0	0xxxxxxx	00000000	17
GPI	Group Presence Indicator (FUTURE USE 13)	1	0	0	xxxxxxx0		
GPI	Group Presence Indicator (FUTURE USE 14)	1	0	0	xxxxxx0x		
GPI	Group Presence Indicator (FUTURE USE 15)	1	0	0	xxxxx0xx		
	(Zero Padding)	5	0	000000	00000xxx	00000000	18

The Application Header is followed by the VMF message. The VMF message is shown as a single 10-octet message to complete the Application Layer PDU. FIGURE G-7 provides an illustration of the Application Header, as it would appear in serial form at the lower layers.

Octet 0	Octet 1	Octet 2	…	Octet 13	Octet 14	Octet 15	Octet 16	Octet 17	Octet 18
2^0 2^7	2^0 2^7	2^0 2^7		2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7
11000111	11010000	00000000		00100011	10000100	00001000	01000000	00000000	00000000

FIGURE G-7. Application header (octets).

APPENDIX G

Any of the ASCII fields (e.g. Unit Name) in the application header can be terminated by either an end of text marker, or by using the maximum number of bits. TABLE G-III shows how to format the Unit Name when the Unit Name is used as part of the originator address group. The Unit Name and URN are mutually exclusive inside the address group – never send both, Unit Name and URN, in an address group. However if the address group has a Group Repeat Indicator (GRI) each of the repeatable address groups can be different address types (e.g. Unit Name or URN).

TABLE G-III. Example of a unit name as originator.

Syntax	Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Number
				MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	MSB 2^n LSB 2^0	
	Version	4	3	*0011*	xxxx*0011*		
FPI	Compression Type	1	0	0	xxx0xxxx		
GPI	Presence Indicator (Originator)	1	1	1	xx1xxxxx		
FPI	Presence Indicator (URN)	1	0	0	x0xxxxxx		
FPI	Presence Indicator (Unit Name)	1	1	1	1xxxxxxx	10000011	0
	Unit Name (Originator)	448 Max	"UNITA"				
	"U"	7	85	*1*010101	x*1*010101		
	"N"	7	78	*1*001110	0xxxxxxx xx*1*00111	0*1*010101	1
	"I"	7	73	*1*001001	01xxxxxx xxx*1*0010	01*1*00111	2
	"T"	7	84	*1*010100	100xxxxx xxxx*1*010	100*1*0010	3
	"A"	7	65	*1*000001	0001xxxx xxxxx*1*00	0001*1*010	4
	End of text marker (ANSI ASCII DEL)	7	127	*1*111111	11111xxx xxxxxx*1*1	11111*1*00	5
GPI	Presence Indicator (Recipient)	1	1	1	xxxxx1xx		
encode rest of the message							

G.3.3 Transport Layer data exchange.
The relationship of the Transport Layer to other communication layers is shown in **FIGURE G-8**. A user of the Transport Layer exchanges data with its peer at another node by sending and receiving the Application Layer PDU via the Transport Layer. The Transport Layer sends and receives the Application Layer PDU transparently by producing and exchanging a Transport Layer Protocol Data Unit (PDU) with its peer at another node. The Transport Layer PDU consists of the Transport Header concatenated with the Application Layer PDU, and is sent and received via lower layer communication layers. The lower communication layers send and receive the Transport PDU transparently over a variety of communications media.

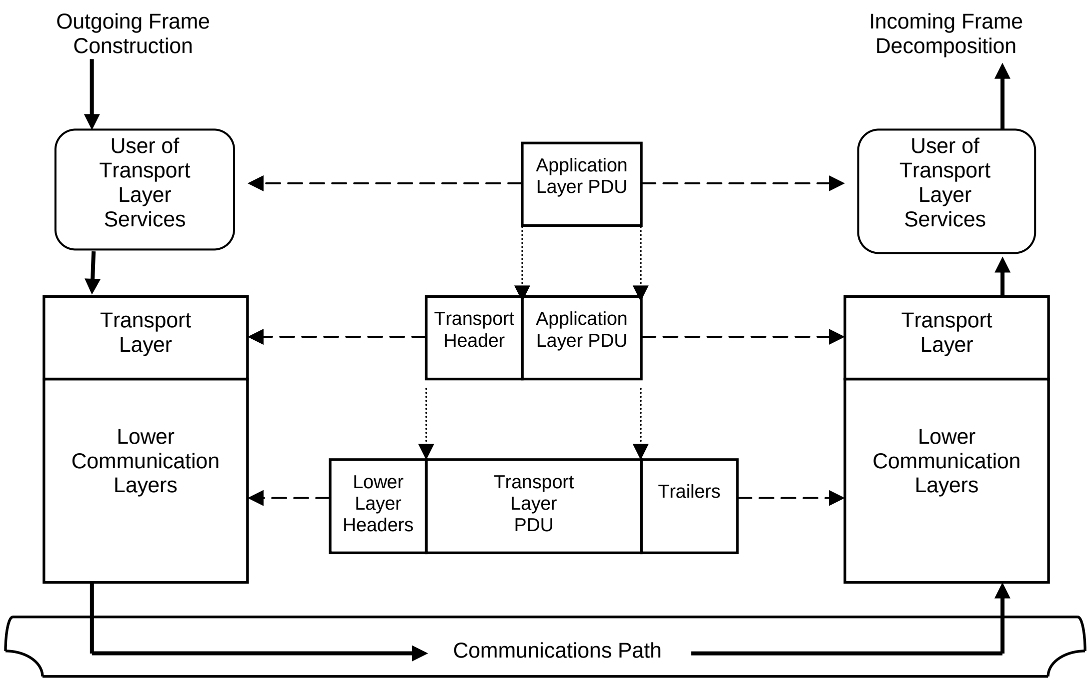


FIGURE G-8 Transport layer interaction with other communication layers.

The relationship of the Transport Layer PDU's data buffer/stream to the Application Layer is depicted in FIGURE G-9. The Transport Layer PDU is defined as a buffer or stream of octets consisting of the VMF message, Application Header and Transport Header.

G.3.3.1 An example of Segmentation / Reassembly (S/R) Data Segment construction.
S/R is described by MIL-STD-2045-47001, APPENDIX C. The S/R Data Segment from MIL-STD-2045-47001, APPENDIX C, consists of 12 octets as shown in FIGURE G-10 with the example values to be used for this appendix. Since MIL-STD-2045-47001, APPENDIX C, treats bit 0 as MSB, FIGURE G-10 and FIGURE G-11 show B_0 as MSB. For this example, the Source Port has a value of 5000, Destination Port has a value of 1581, the Type (3 bits) equals 2, HLEN (12 bits) equals 3, P/F (1 bit) equals 1, the Serial Number has a value of 16000, the Segment Number equals 260, and the Last Segment Number equals 300. MIL-STD-188-220 typically treats the LSB as bit 0.

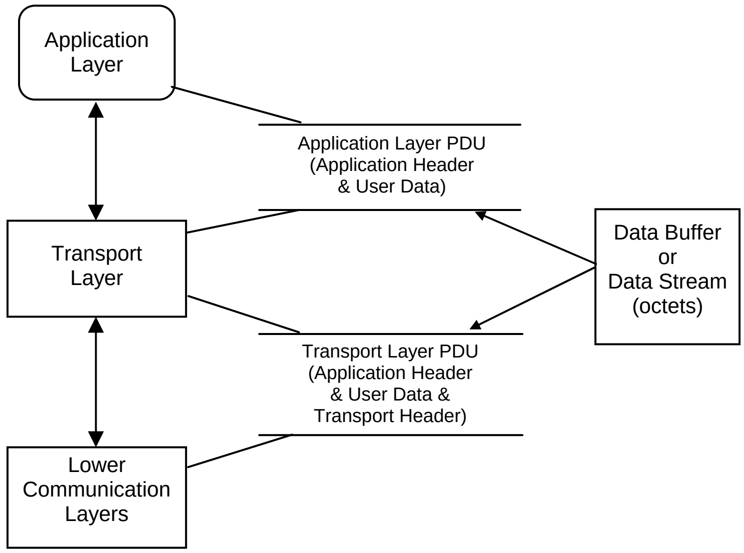


FIGURE G-9. Exchange of transport layer PDU between communication layers.

MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB
0	7	8	15	16	23	24	31
Source Port				Destination Port			
Type	HLEN		P/F	Serial Number			
Segment Number				Last Segment Number			
Data Portion							

FIGURE G-10. S/R Data Segment

FIGURE G-11 illustrates the twelve octets comprising S/R with the binary bit patterns. Each octet is marked to show both the MSB and LSB of each octet. It demonstrates how each of the octets are arranged and passed in order to next layer.

Octet 0		Octet 1		Octet 2		Octet 3	
B_0	B_7	B_8	B_{15}	B_{16}	B_{23}	B_{24}	B_{31}
2^7	2^0	2^7	2^0	2^7	2^0	2^7	2^0
00010011		10001000		***0***0000110		00101101	
Source Port (5000)				**Destination Port (1581)**			

Octet 4		Octet 5		Octet 6		Octet 7	
B_0	B_7	B_8	B_{15}	B_{16}	B_{23}	B_{24}	B_{31}
2^7	2^0	2^7	2^0	2^7	2^0	2^7	2^0
010***0***00000		0000011***1***		***0***0111110		10000000	
Type (2) HLEN (3) P/F (1)				**Serial Number (16000)**			

Octet 8		Octet 9		Octet 10		Octet 11	
B_0	B_7	B_8	B_{15}	B_{16}	B_{23}	B_{24}	B_{31}
2^7	2^0	2^7	2^0	2^7	2^0	2^7	2^0
00000001		00000100		***0***0000001		00101100	
Segment Number (260)				**Last Segment Number (300)**			

FIGURE G-11. Octet representation of S/R Data Segment.

The construction of a S/R Data Segment is illustrated by the example in TABLE G-IV. The first four columns of the table provide a description of each field in both decimal and binary representations. The last two columns show the physical encoding of the S/R Layer PDU. In the fifth column, Field Fragments, the bits of each field are placed in octets. The bits(s) of each field are positioned in an octet such that the MSB of the field is positioned in the most significant unencoded bit of the octet, the next MSB of the field is placed in the next most significant unencoded bit of the octet, and repeated until all of the bits of the field have been encoded. When an octet is filled before all the bits of a field are encoded, the process is continued encoding the next octet with the remaining bits of the field. This field/octet encoding procedure is performed starting with the first field and octet, and repeated for each successive field and individual octet, in order, until the encoding is completed. X's are used to identify bits that are not associated with the field being encoded. The sixth column, Octet Value - Binary, assembles the bits contributed by successive fields into complete octets, represented in binary. The last column, Octet Number, numbers the octets from first to last starting with 0.

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TABLE G-IV. Example construction of S/R Data Segment.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Number
			MSB **LSB** *2^n* 2^0	**MSB** **LSB** 2^7 2^0	**MSB** **LSB** 2^7 2^0	
Source Port	16	5000	***0***001001110001000	***0*** 0 0 1 0 0 1 1 1 0 0 0 1 0 0 0	***0*** 0 0 1 0 0 1 1 1 0 0 0 1 0 0 0	0 1
Destination Port	16	1581	***0***000011000101101	***0*** 0 0 0 0 1 1 0 0 0 1 0 1 1 0 1	***0*** 0 0 0 0 1 1 0 0 0 1 0 1 1 0 1	2 3
Type	3	2	***0***10	***0*** 1 0 x x x x x		
HLEN	12	3	***0***00000000011	x x x ***0*** 0 0 0 0 0 0 0 0 0 1 1 x	***0*** 1 0 ***0*** 0 0 0 0	4
P/F	1	1	***1***	x x x x x x x ***1***	0 0 0 0 0 1 1 ***1***	5
Serial Number	16	16000	***0***011111010000000	***0*** 0 1 1 1 1 1 0 1 0 0 0 0 0 0 0	***0*** 0 1 1 1 1 1 0 1 0 0 0 0 0 0 0	6 7
Segment Number	16	260	***0***000000100000100	***0*** 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0	***0*** 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0	8 9
Last Segment Number	16	300	***0***000000100101100	***0*** 0 0 0 0 0 0 1 0 0 1 0 1 1 0 0	***0*** 0 0 0 0 0 0 1 0 0 1 0 1 1 0 0	10 11

TABLE G-V illustrates the twelve octets of the S/R Data Segment showing the binary value of the octet, the octet number (0-11) and the field represented by each octet. Note that the bit with the bold italicized font identifies the MSB (2^n) of the field, not the octet.

TABLE G-V. Octet representation of S/R header.

Octet Value (Binary)	Octet Number	Field Name
2^7 2^0		
0 0 0 1 0 0 1 1	0	**Source Port**
1 0 0 0 1 0 0 0	1	**Source Port**
0 0 0 0 0 1 1 0	2	**Destination Port**
0 0 1 0 1 1 0 1	3	**Destination Port**
0 1 0 ***0*** 0 0 0 0	4	**Type & HLEN**
0 0 1 1 1 1 1 0	6	**Serial Number**
1 0 0 0 0 0 0 0	7	**Serial Number**
0 0 0 0 0 0 0 1	8	**Segment Number**
0 0 0 0 0 1 0 0	9	**Segment Number**
0 0 0 0 0 0 0 1	10	**Last Segment Number**
0 0 1 0 1 1 0 0	11	**Last Segment Number**

FIGURE G-12 provides a serial representation of the S/R header, as it would appear at the physical layer.

Octet 0	Octet 1	Octet 2	Octet 3	Octet 4	Octet 5	Octet 6	Octet 7
2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7
1 1 0 0 1 0 0 ***0***	0 0 0 1 0 0 0 1	0 1 1 0 0 0 0 ***0***	1 0 1 1 0 1 0 0	0 0 0 0 ***0*** 0 1 ***0***	***1*** 1 1 0 0 0 0 0	0 1 1 1 1 1 0 ***0***	0 0 0 0 0 0 0 1

Octet 8	Octet 9	Octet 10	Octet 11
2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7
1 0 0 0 0 0 0 ***0***	0 0 1 0 0 0 0 0	1 0 0 0 0 0 0 ***0***	0 0 1 1 0 1 0 0

FIGURE G-12. Serial representation of S/R Data Segment.

G.3.3.2 <u>An example of UDP header construction.</u>
UDP is described by RFC 768. The UDP header from RFC 768 consists of 8 octets as shown in FIGURE G-14 with the example values to be used for this appendix. Since the RFC treats bit 0 as MSB, FIGURE G-13 and FIGURE G-14 show B_0 as MSB. For this example, the source has a value of 1581, destination of 1581, length of 32 and the checksum equals 12427. MIL-STD-188-220 typically treats the LSB as bit 0.

0 7	8 15	16 23	24 31
UDP Source (1581)		UDP Destination (1581)	
UDP Length (32)		UDP Checksum (12427)	

FIGURE G-13. UDP header.

FIGURE G-14 illustrates the eight octets comprising UDP with the binary bit patterns. Each octet is marked to show both the MSB and LSB of each octet. It demonstrates how each of the octets are arranged and passed in order to next layer.

Octet 0		Octet 1		Octet 2		Octet 3	
B_0	B_7	B_8	B_{15}	B_{16}	B_{23}	B_{24}	B_{31}
2^7	2^0	2^7	2^0	2^7	2^0	2^7	2^0
*0*0000110		00101101		*0*0000110		00101101	
UDP Source (1581)				**UDP Destination (1581)**			

Octet 4		Octet 5		Octet 6		Octet 7	
B_0	B_7	B_8	B_{15}	B_{16}	B_{23}	B_{24}	B_{31}
2^7	2^0	2^7	2^0	2^7	2^0	2^7	2^0
*0*0000000		00100000		*0*0110000		10001011	
UDP Length (32)				**UDP Checksum (12427)**			

FIGURE G-14. Octet representation of UDP header.

The construction of a Transport Layer Header is illustrated by the example in TABLE G-VI. The first four columns of the table provide a description of each field in both Dec and binary representations. The last two columns show the physical encoding of the Transport Layer PDU. In the fifth column, Field Fragments, the bits of each field are placed in octets. The bits(s) of each field are positioned in an octet such that the MSB of the field is positioned in the most significant unencoded bit of the octet, the next MSB of the field is placed in the next most significant unencoded bit of the octet, and repeated until all of the bits of the field have been encoded. When an octet is filled before all the bits of a field are encoded, the process is continued encoding the next octet with the remaining bits of the field. This field/octet encoding procedure is performed starting with the first field and octet, and repeated for each successive field and individual octet, in order, until the encoding is completed. The sixth column, Octet Value - Binary, assembles the bits contributed by successive fields into complete octets, represented in binary. The last column, Octet Number, numbers the octets from first to last starting with 0.

TABLE G-VI. Example construction of UDP header.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Number
			MSB 2^{15} **LSB** 2^0	**MSB** 2^7 **LSB** 2^0	**MSB** 2^7 **LSB** 2^0	
UDP Source	16	1581	*0*000011000101101	*0* 0 0 0 0 1 1 0 0 0 1 0 1 1 0 1	*0* 0 0 0 0 1 1 0 0 0 1 0 1 1 0 1	0 1
UDP Destination	16	1581	*0*000011000101101	*0* 0 0 0 0 1 1 0 0 0 1 0 1 1 0 1	*0* 0 0 0 0 1 1 0 0 0 1 0 1 1 0 1	2 3
UDP Length	16	32	*0*000000000100000	*0* 0 0 0 0 0 0 0 0 0 100000	*0* 0 0 0 0 0 0 0 0 0 100000	4 5
UDP Checksum	16	12427	*0*01100010001011	*0*0110000 10001011	*0*0110000 10001011	6 7

TABLE G-VII illustrates the eight octets of the Transport Header showing the binary value of the octet, the octet number (0-7) and the field represented by each octet. Note that the bit with the bold italicized font identifies the MSB (2^n) of the field, not the octet.

TABLE G-VII. Octet representation of UDP header.

Octet Value (Binary)	Octet Number	Field Name
2^7 2^0		
0 0 0 0 0 1 1 0	0	**Source**
0 0 1 0 1 1 0 1	1	**Source**
0 0 0 0 0 1 1 0	2	**Destination**
0 0 1 0 1 1 0 1	3	**Destination**
0 0 0 0 0 0 0 0	4	**Length**
0 0 100000	5	**Length**
*0*0110000	6	**Checksum**
10001011	7	**Checksum**

FIGURE G-15 provides a serial representation of the UDP header, as it would appear at the physical layer.

Octet 0	Octet 1	Octet 2	Octet 3	Octet 4	Octet 5	Octet 6	Octet 7
2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7
0 1 1 0 0 0 0 *0*	1 0 1 1 0 1 0 0	0 1 1 0 0 0 0 *0*	1 0 1 1 0 1 0 0	0 0 0 0 0 0 0 *0*	00000100	00011*0*0	11010001

FIGURE G-15. Serial representation of UDP header.

G.3.4 <u>Network Layer data exchange.</u>
The relationship of the Network Layer to other communication layers is shown in FIGURE G-16. A user of the Network Layer exchanges data with its peer at another node by sending and receiving the Transport Layer PDUs via the Network Layer. The Network Layer sends and receives the Transport Layer PDUs transparently by producing and exchanging a Network Layer PDU. The Network Layer PDU consists of the Network Headers concatenated with the Transport Layer PDU, and is sent and received via lower layer communication layers. The lower communication layers send and receive the Network Layer PDU transparently over a variety of communications media.

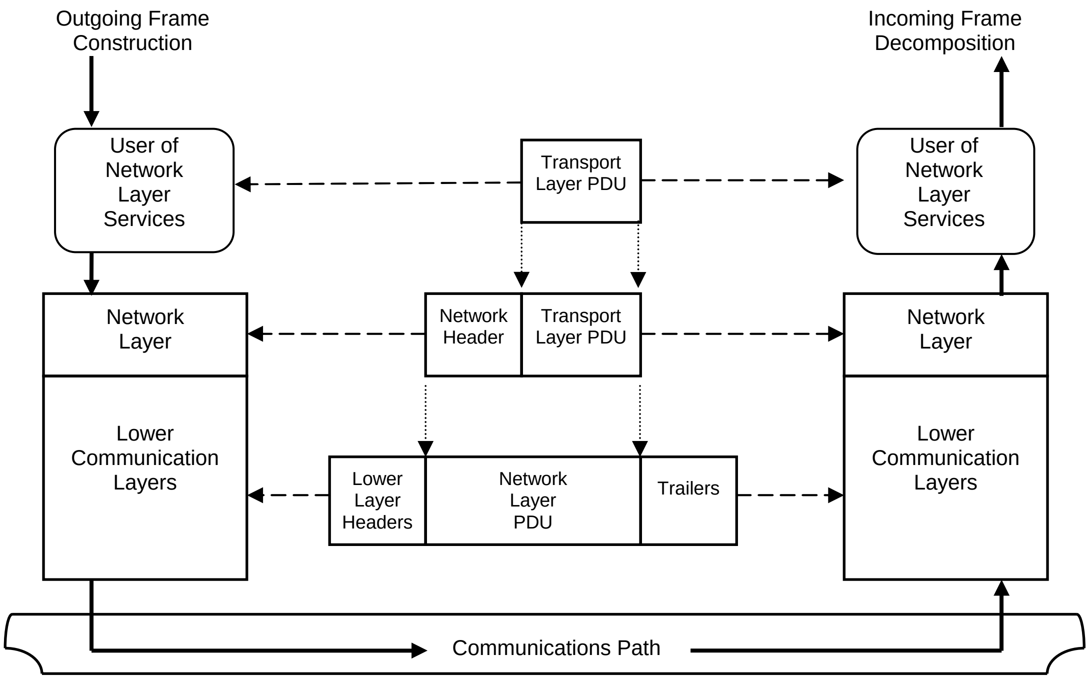

FIGURE G-16. Network layer interaction with other communication layers.

The relationship of the Network Layer PDU's data buffer/stream to the Transport Layer is depicted in FIGURE G-17. The Network Layer PDU is defined as a buffer or stream of octets consisting of the VMF message, Application Header, Transport Header and Network Headers. There are two Network Headers in the Network Layer PDU when using MIL-STD-188-220.

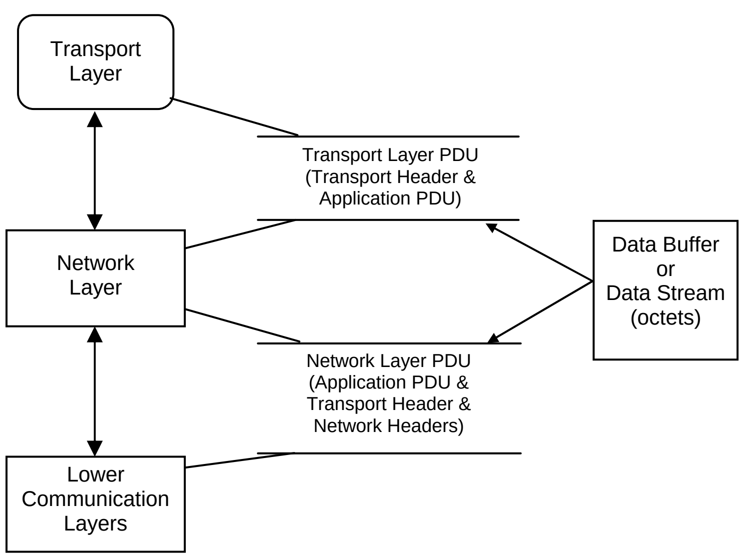

FIGURE G-17. Exchange of network layer PDU between communication layers.

The Internet Protocol (IP) is described by RFC 791. The IP header from RFC 791 is shown in FIGURE G-18 with the example values, in parentheses, to be used for this appendix.

<table>
<tr><td colspan="2">0
0 1 2 3 4 5 6 7</td><td colspan="2">1
8 9 0 1 2 3 4 5</td><td colspan="2">2
6 7 8 9 0 1 2 3</td><td colspan="2">3
4 5 6 7 8 9 0 1</td></tr>
<tr><td>Ver (4)</td><td>IHL (5)</td><td colspan="2">Type of Service (0)</td><td colspan="4">Total Length (52)</td></tr>
<tr><td colspan="4">Identification (1)</td><td>Flag (0)</td><td colspan="3">Fragment Offset (0)</td></tr>
<tr><td colspan="2">Time to Live (50)</td><td colspan="2">Protocol (17)</td><td colspan="4">Header Checksum (4091)</td></tr>
<tr><td colspan="8">Source Address (192.31.124.65)</td></tr>
<tr><td colspan="8">Destination Address (192.31.124.61)</td></tr>
</table>

FIGURE G-18. IP header.

G.3.4.1 Example of Internet Layer header.

The construction of an Internet Layer Header is illustrated by the example in TABLE G-VIII. The first four columns of the table provide a description of each field in the example, the field length in bits, and the value of the field in both decimal and binary representations. The last three columns show the physical encoding of the Internet Layer Header. In the fifth column, Field Fragments, the bits of each field are placed in octets. The bit(s) of each field are positioned in an octet such that the MSB of the field is positioned in the most significant unencoded bit of the octet, the next MSB of the field is placed in the next most significant unencoded bit of the octet, and repeated until all of the bits of the field have been encoded. When an octet is filled before all the bits of a field are encoded, the process is continued encoding the next octet with the remaining bits of the field. This field/octet encoding procedure is performed starting with the first field and octet, and repeated for each successive field and individual octet, in order, until the encoding is completed. X's are used to identify bits that are not associated with the field being encoded. The sixth column, Octet Value - Binary, assembles the bits contributed by successive fields into complete octets, represented in binary. The last column, Octet Number, numbers the octets from first to last starting with 0.

TABLE G-VIII. Example construction of IP header.

Field Name	**Length (bits)**	**Value (Dec)**	**Value (Binary)** 2^n 2^0	**Field Fragments** 2^n 2^0	**Octet Value (Binary)** 2^n 2^0	**Octet Number**
Version	4	4	0100	0100xxxx		
Internet Header Length	4	5	0101	xxxx0101	01000101	0
Type of Service	8	0	00000000	00000000	00000000	1
Length	16	52	0000000000110100	00000000 00110100	00000000 00110100	2 3

TABLE G-VIII. Example construction of IP header -Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary) 2^n 2^0	Field Fragments 2^n 2^0	Octet Value (Binary) 2^n 2^0	Octet Number
Identification	16	1	0000000000000001	00000000 00000001	00000000 00000001	4 5
Flags	3	0	000	000xxxxx		
Fragmentation Offset	13	0	0000000000000	xxx00000 00000000	00000000 00000000	6 7
Time to Live	8	50	00110010	00110010	00110010	8
Protocol	8	17	00010001	00010001	00010001	9
Header Checksum	16	4091	0000111111111011	00001111 11111011	00001111 11111011	10 11
Source Address	32	192.31.124.65	1100000000011111 0111110001000001	11000000 00011111 01111100 01000001	11000000 00011111 01111100 01000001	12 13 14 15
Destination Address	32	192.31.124.61	1100000000011111 0111110000111101	11000000 00011111 01111100 00111101	11000000 00011111 01111100 00111101	16 17 18 19

FIGURE G-19 illustrates the Internet Header demonstrating the relationship between the individual bits (B^0 - B^7), the bit weighting (2^7 - 2^0), the individual fields and the example bit patterns associated with each field.

<table>
<tr><th colspan="2">Octet 0</th><th>Octet 1</th><th>Octet 2</th><th>Octet 3</th></tr>
<tr><td colspan="2">B_0 B_7</td><td>B_0 B_7</td><td>B_0 B_7</td><td>B_0 B_7</td></tr>
<tr><td colspan="2">2^7 2^0</td><td>2^7 2^0</td><td>2^7 2^0</td><td>2^7 2^0</td></tr>
<tr><td colspan="2">0 1 0 0 0 1 0 1</td><td>0 0 0 0 0 0 0 0</td><td>0 0 0 0 0 0 0 0</td><td>0 0 1 1 0 1 0 0</td></tr>
<tr><td>Ver (4)</td><td>IHL (5)</td><td>Type of Service (0)</td><td colspan="2">Total Length (52)</td></tr>
</table>

<table>
<tr><th>Octet 4</th><th>Octet 5</th><th colspan="2">Octet 6</th><th>Octet 7</th></tr>
<tr><td>B_0 B_7</td><td>B_0 B_7</td><td colspan="2">B_0 B_7</td><td>B_0 B_7</td></tr>
<tr><td>2^7 2^0</td><td>2^7 2^0</td><td colspan="2">2^7 2^0</td><td>2^7 2^0</td></tr>
<tr><td>0 0 0 0 0 0 0 0</td><td>0 0 0 0 0 0 1</td><td>0 0 0</td><td>0 0 0 0 0</td><td>0 0 0 0 0 0 0 0</td></tr>
<tr><td colspan="2">Identification (1)</td><td>Flag (0)</td><td colspan="2">Fragment Offset (0)</td></tr>
</table>

FIGURE G-19. Octet representation of IP header.

Octet 8	Octet 9	Octet 10	Octet 11
B_0 B_7	B_0 B_7	B_0 B_7	B_0 B_7
2^7 2^0	2^7 2^0	2^7 2^0	2^7 2^0
0 0 1 1 0 0 1 0	0 0 0 1 0 0 0 1	0 0 0 0 1 1 1 1	1 1 1 1 1 0 1 1
Time (50)	**Protocol (17)**	**Header Checksum (4091)**	

Octet 12	Octet 13	Octet 14	Octet 15
B_0 B_7	B_0 B_7	B_0 B_7	B_0 B_7
2^7 2^0	2^7 2^0	2^7 2^0	2^7 2^0
1 1 0 0 0 0 0 0	0 0 0 1 1 1 1 1	0 1 1 1 1 1 0 0	0 1 0 0 0 0 0 1
Source Address (192.31.124.65)			

Octet 16	Octet 17	Octet 18	Octet 19
B_0 B_7	B_0 B_7	B_0 B_7	B_0 B_7
2^7 2^0	2^7 2^0	2^7 2^0	2^7 2^0
1 1 0 0 0 0 0 0	0 0 0 1 1 1 1 1	0 1 1 1 1 1 0 0	0 0 1 1 1 1 0 1
Destination Address (192.31.124.61)			

FIGURE G-19. Octet representation of IP header-Continued

G.3.4.2 Example of Intranet Layer header.
The construction of an Intranet Layer Header is illustrated by the example in FIGURE G-19. The first four columns of the table provide a description of each field in the example, the field length in bits, and the value of the field in both decimal and binary representations. The last three columns show the physical encoding of the Intranet Layer Header. In the fifth column, Field Fragments, the bits of each field are placed in octets. The bit(s) of each field are positioned in an octet such that the LSB of the field is positioned in the least significant unencoded bit of the octet, the next LSB of the field is placed in the next least significant unencoded bit of the octet, and repeated until all of the bits of the field have been encoded. When an octet is filled before all the bits of a field are encoded, the process is continued encoding the next octet with the remaining bits of the field. This field/octet encoding procedure is performed starting with the first field and octet, and repeated for each successive field and individual octet, in order, until the encoding is completed. X's are used to identify bits that are not associated with the field being encoded. The sixth column, Octet Value - Binary, assembles the bits contributed by successive fields into complete octets, represented in binary. The last column, Octet Number, numbers the octets from first to last starting with 0. This example only illustrates the Intranet Header fields that are be transmitted as a minimum.

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TABLE G-IX. Example construction of Intranet header (minimum).

Field Name	Length (bits)	Value (Dec)	Value (Binary) 2^n … 2^0	Field Fragments 2^7 … 2^0	Octet Value (Binary) 2^7 … 2^0	Octet Number
Version Number	4	0	0000	xxxx0000		
Message Type	4	4	0100	0100xxxx	01000000	0
Intranet Header Length	8	3	00000011	00000011	00000011	1
Type of Service	8	0	00000000	00000000	00000000	2

The Intranet Layer is defined in 5.4.1 and is shown in FIGURE G-20 with the example values used in this appendix.

Octet 0		Octet 1	Octet 2
2^0 … 2^7		2^0 … 2^7	2^0 … 2^7
0 0 0 0	0 0 1 0	1 1 0 0 0 0 0 0	0 0 0 0 0 0 0 0
Version (0)	**Message Type (4)**	**Intranet Header Length (3)**	**Type of Service (0)**

FIGURE G-20. Intranet header.

FIGURE G-21 provides a serial representation of the Network Layer PDU as it would appear at the physical layer.

Intranet header			**IP header**				
Octet 0	**Octet 1**	**Octet 2**	**Octet 3**	**Octet 4**	**Octet 5**	**Octet 6**	**Octet 7**
2^0 … 2^7	2^0 … 2^7	2^0 … 2^7	2^0 … 2^7	2^0 … 2^7	2^0 … 2^7	2^0 … 2^7	2^0 … 2^7
00000010	11000000	00000000	10100010	00000000	00000000	00101100	00000000

IP header (continued)							
Octet 8	**Octet 9**	**Octet 10**	**Octet 11**	**Octet 12**	**Octet 13**	**Octet 14**	**Octet 15**
2^0 … 2^7	2^0 … 2^7	2^0 … 2^7	2^0 … 2^7	2^0 … 2^7	2^0 … 2^7	2^0 … 2^7	2^0 … 2^7
10000000	00000000	00000000	01001100	10001000	11110000	11011111	00000011

IP header (continued)						**IP header (end)**
Octet 16	**Octet 17**	**Octet 18**	**Octet 19**	**Octet 20**	**Octet 21**	**Octet 22**
2^0 … 2^7	2^0 … 2^7	2^0 … 2^7	2^0 … 2^7	2^0 … 2^7	2^0 … 2^7	2^0 … 2^7
11111000	00111110	10000010	00000011	11111000	00111110	10111100

FIGURE G-21. Serial representation of network layer PDU.

G.3.5 This paragraph was intentionally deleted and left blank for paragraph conformity.

G.3.6 Data Link Layer data exchange.
The relationship of the Data Link Layer to other communication layers is shown in FIGURE G-22. A user of the Data Link Layer exchanges the Network Layer PDU with its peer at another node by sending and receiving the Network PDU via the Data Link Layer. The Data Link Layer sends and receives the VMF message transparently by producing and exchanging a Data Link Layer PDU with its peer at another node. The Data Link Layer PDU consists of the Transmission Header, and Data Link Frame Header, Network PDU, and the Data Link Frame Trailer, and is sent and received via the Physical layer. The Physical layer sends and receives the VMF message transparently over a variety of communications media.

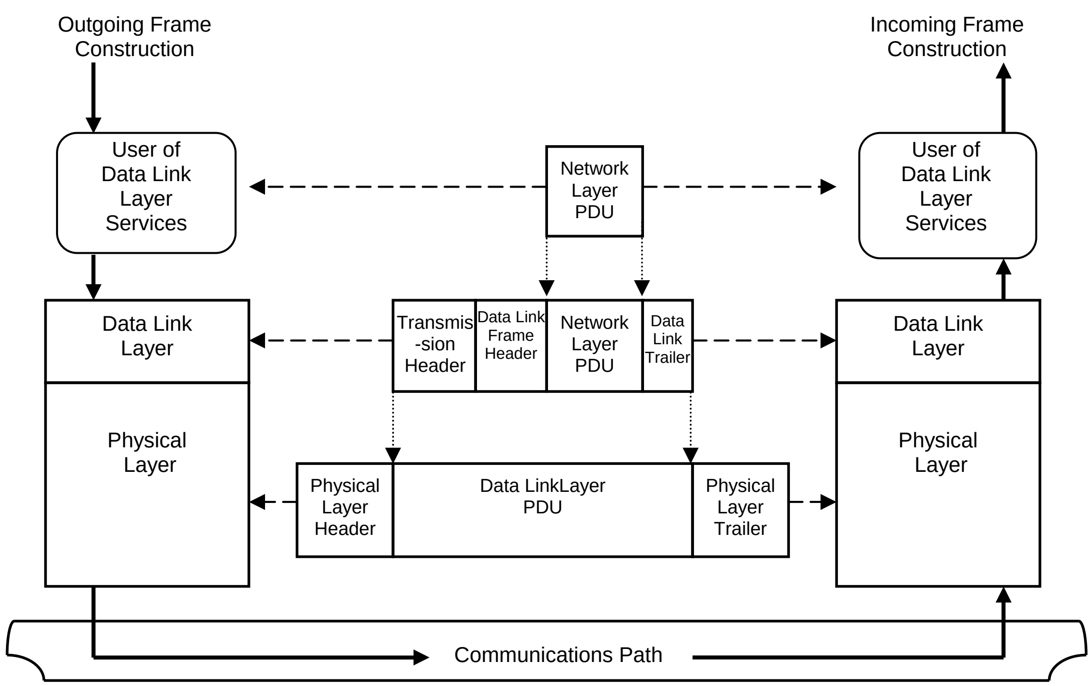

FIGURE G-22. Data link layer interaction with other communication layers.

The format of the Data Link Layer PDU is defined in terms of the actual data buffer or data stream used to exchange the PDU between the Network Layer and the Physical Layer. The relationship of the Data Link Layer PDU's data buffer/stream to the Intranet Layer is depicted in FIGURE G-23. The Data Link Layer PDU is defined as a buffer or stream of octets consisting of the Transmission Header, Data Link Frame Header, Network PDU and Data Link Layer trailer.

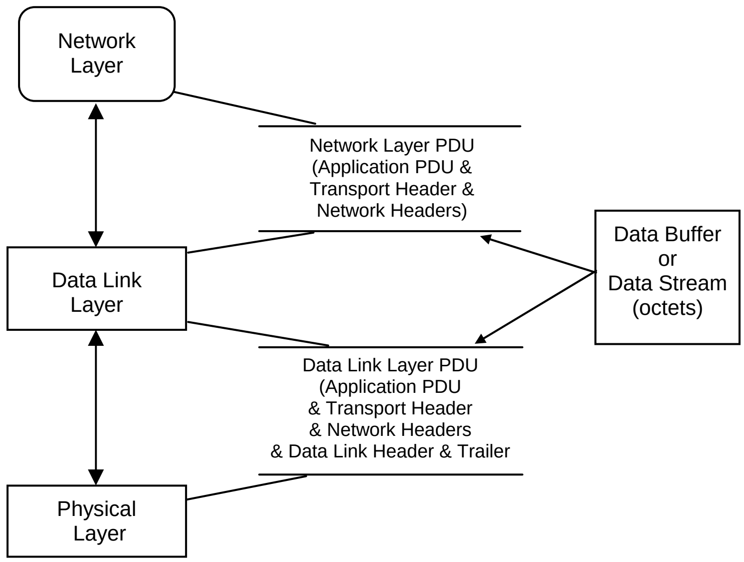

FIGURE G-23. Exchange of data link layer PDU between communication layers.

G.3.6.1 Example of Data Link Layer PDU.
The Data Link Layer PDU consists of the Transmission Header, Data Link Frame Header, followed by the information field and Data Link Frame Trailer as shown in FIGURE G-24. The information field consists of the Network PDU described previously (VMF message, Application Header, Transport Header, IP Header and Intranet Header).

Trans-mission Header	Data Link Frame Header	Information Field	Data Link Frame Trailer

FIGURE G-24. Data Link Layer PDU.

TABLE G-X illustrates the Data Link Frame Header, and TABLE G-XI illustrates the Data Link Frame Trailer. The first four columns of the tables provide a description of each field in the example, the field length in bits, and the value of the field in both decimal and binary representations. The last three columns show the bit serial physical Transmission order of the Data Link Frame as a sequence of octets with the bits of each octet transmitted LSB first. In the fifth column, Field Fragments, the bits of each field are placed in octets, in accordance with 5.3.4.3.1. The bit(s) of each field, other than the FCS field, are positioned in an octet such that the LSB of the field is positioned in the least significant unencoded bit of the octet, the next LSB of the field is placed in the next least significant unencoded bit of the octet, and repeated until all of the bits of the field have been encoded. The bit(s) of FCS fields are positioned in an octet such that the MSB of the field is positioned in the least significant unencoded bit of the octet, the next MSB of the FCS field is placed in the next least significant unencoded bit of the octet, and repeated until all of the bits of the FCS field have been encoded. When an octet is filled before all the bits of a field are encoded, the process is continued encoding the next octet with the remaining bits of the field. This field/octet encoding procedure is performed starting with the first field and octet, and repeated for each successive field and individual octet, in order, until the encoding is completed. The sixth column, Octet Value - Binary, assembles the bits contributed by successive fields into complete octets, represented in binary and transmitted LSB first. The last column, Octet Number, numbers the octets in the order in which they will be transmitted, from first to last starting with 0.

TABLE G-X. Example construction of Data Link frame header.

Field Name	**Length (bits)**	**Value (Dec)**	**Value (Binary)**	**Field Fragments**	**Octet Value (Binary)**	**Octet Number**
			2^n 2^0	2^7 2^0	2^7 2^0	
Flag	8	126	01111110	01111110	01111110	0
Command/Response Bit	1	0	0	xxxxxxxx0		
Source Address	7	7	0000111	0000111x	00001110	1
Extension Bit	1	1	1	xxxxxxx1		
Destination Address	7	4	0000100	0000100x	00001001	2
Control Field	8	19	00010011	00010011	00010011	3

TABLE G-XI. Example construction of Data Link frame trailer.

Field Name	**Length (bits)**	**Value (Dec)**	**Value (Binary)**	**Field Fragments**	**Octet Value (Binary)**	**Octet Number**
			2^n 2^0	2^7 2^0	2^7 2^0	
Frame Check Sequence (transmitted MSB first)	32	3404065258	1100101011100101 1110100111101010	01010011 10100111 10010111 01010111	01010011 10100111 10010111 01010111	0 1 2 3
Flag	8	126	01111110	01111110	01111110	4

TABLE G-XII illustrates the octets comprising the Data Link Frame showing the actual bit serial physical transmission order of the fields from the previous examples for each layer, the octet number based on each individual layer, and the octet number based on entire Data Link Frame.

The first column, labeled Octet Value – Binary, shows the bits contributed by successive fields as completed octets represented in Binary and transmitted LSB first. The last column, Octet Number (Entire Transaction), numbers the octets in the order in which they will be transmitted, from first to last octet starting with 0. This data is shown in serial representation as it would be transmitted in FIGURE G-25.

TABLE G-XII. Octets comprising Data Link frame.

Octet Value (Binary) 2^7 2^0	**Nomenclature**	**Octet Number (Individual Layer)**	**Octet Number (Entire Transaction)**
01111110	**Flag**	0	0
00001110	**Source Address**	1	1
00001001	**Destination Address**	2	2
00010011	**Control Field**	3	3
01000000		0	4
00000011	***INTRANET HEADER***	1	5
00000000		2	6
01000101		0	7
00000000		1	8
00000000		2	9
00110100		3	10
00000000		4	11
00000001		5	12
00000000		6	13
•	***IP HEADER***	•	•
•		•	•
01111100		18	25
00111101		19	26
00000110		0	27
00101101		1	28
00000110		2	29
•	***UDP HEADER***	•	•
•		•	•
10001011		7	34

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TABLE G-XII. Octets comprising Data Link frame - Continued.

Octet Value (Binary) 2^7 2^0	Nomenclature	Octet Number (Individual Layer)	Octet Number (Entire Transaction)
11100011		0	35
00001011		1	36
•		•	•
•		•	•
00011000		10	45
00111000		11	46
00010010	*APPLICATION HEADER*	12	47
11000100		13	48
•		•	•
•		•	•
00000000		17	52
00000000		18	53
10100000		0	54
01111000		1	55
01010000		2	56
10011010		3	57
•	***factitious VMF message like – K15.99 message***	•	•
•		•	•
00000000		4	58
01010011	**Note: FCS transmitted MSB First** **FCS**	0	59
10100111		1	60
10010111		2	61
01010111		3	62
01111110	**Flag**	0	63

DATA LINK FRAME HEADER				INTRANET HEADER				IP	
0	1	2	3	4		5	6	7	
2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7		2^0 2^7	2^0 2^7	2^0 2^7	
FLAG	SRC	DST	CNTL	V	T	LEN	TOS	L	V
01111110	01110000	10010000	11001000	0000	0010	11000000	00000000	1010	0010

IP (cont.)							
8	9	10	11	12	13		14
2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7		2^0 2^7
TOS	Total Length		Identification		Offset	Flag	Offset
00000000	00000000	00101100	00000000	10000000	00000	000	00000000

IP (cont.)		UDP			
25	26	27	28	29	30
2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7
DESTINATION		SOURCE		DESTINATION	
00111110	10111100	01100000	10110100	01100000	10110100

APP. HEADER		
34	35	36
2^0 2^7	2^0 2^7	2^0 2^7
CHKSM	GPI-FPI-ORIG	
00001000	11000111	11010000

APP. HEADER			
45	46	47	48
2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7
Message Number, Subtype, Size- etc.			GPI-DTG
00011000	00011100	01001000	00100011

APP. HEADER		VMF MESSAGE			
52	53	54	55	56	57
2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7
Security & Future group-etc.		CF-etc.	GROUP-etc		
00000000	00000000	00000101	00011110	00001010	01011001

LINK FRAME TRAILER					
58	59	60	61	62	63
2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7
Pad	FCS				FLAG
00000000	11001010	11100101	11101001	11101010	01111110

FIGURE G-25. Serial representation of Data Link Layer PDU.

G.3.6.1.1 Zero bit insert/v36 scramble/FEC/TDC of the data link frame.
The Data Link Frame is zero filled to prevent any part of the data accidentally being interpreted as a Frame Flag. Also in our example scrambling, FEC and TDC are being used. FIGURE G-26

shows some of the example data before applying zero-bit insertion, scrambling, FEC or TDC. After zero-bit insertion, scrambling, FEC and TDC, the fields are not easy to identify; therefore field names are not shown.

Octet 0	Octet 1	Octet 2	Octet 3	Octet 4	Octet 5
2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7
0x7E	0x70	0x90	0xC8	0x02	0xC0

Octet 58	Octet 59	Octet 60	Octet 61	Octet 62	Octet 63
2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7	2^0 2^7
0x00	0xCA	0xE5	0xE9	0xEA	0x7E

FIGURE G-26. Data before zero bit insertion in transmission order.

The following is a Hex dump of the data link frame in the different stages: (a) zero-bit inserted, (b) scrambled, (c) FEC, and (d) TDC:

Note: In the following dumps the 16 bit values are in transmission order (LSB first). The TWC in the physical layer is defined in words and fields are no longer easily distinguishable.

a. Data after zero bit insertion (520 bits plus 8 padding bits)
0x7e70 0x90c8 0x02c0 0x00a2 0x0000 0x4c00 0x8000 0x004c 0x88f0 0xdf01 0xf60f 0x9040 0x7d83 0xe5e3 0x05a3 0x05a0 0x0026 0x9526 0x3e40 0x0002 0x9f00 0x0000 0x08fb 0x181c 0x4823 0x8408 0x4000 0x0005 0x1e0a 0x5900 0xcae5 0xe9ea 7e00

b. Data after V.36 scrambling (520 bits plus 8 padding bits)
0x8f80 0x872a 0xa161 0x7a0a 0xbfaa 0x3ffa 0x8db6 0x879b 0x715d 0x31d1 0xe628

0x7e1e 0xde57 0x1553 0xf5be 0x05b2 0x5520 0xa903 0xbcb80xdfcf 0x0c91 0x2a79 0xde6e

0xaffa 0x1efc 0x501b 0x19c60x9ddd 0x2d9b 0x16f9 0xb233 0xf35d 0x0000

c. Data after FEC(Golay 24,12) (1056 bits)
Golay (24,12) is derived from Golay (23,12): See F 4.1 for details.

0x8f8a 0x5a08 0x7898 0x2aae 0x8616 0x140a 0x7a0b 0xf0ab 0xf3e8 0xaa37 0xdeff 0xad82

0x8dbd 0x4268 0x71ca 0x9b76 0xf215 0xd6f0 0x31d4 0x001e 0x6c92 0x2877 0xf0e1

0xe82e 0xde57 0x0871 0x5ffc 0x53f2 0xa05b 0xe990 0x05b2 0xec25 0x53ea 0x20ab

0x9090 0x3a14 0xbcb6 0xf88d 0xf7d4 0xcf01 0xa6c9 0x1218 0x2a71 0x3c9d 0xe88a

0x6ea5 0x42ff 0xad82 0x1ef9 0xbec5 0x04b0 0x1b19 0x2e9c 0x 662a 0x9dd9 0x5ed2

0xd48c 0x9b150x5a6f 0x9796 0xb233 0x0b3f 0x32e0 0x5d0c 0xaa00 0x0000

d. Data after TDC(16,24) (1152 bits)

0x87a1 0x0941 0x2f4b 0x193c 0xefe6 0x9194 0xbf24 0x85b9 0xa599 0x447f 0x67e7

0x56fa 0xe985 0x33be 0xae32 0x0fc2 0x6f76 0x8ef2 0x0c33 0xca36 0xd641 0x2201 0xb3e5

0x0000 0x81f5 0xf033 0x468b 0xf185 0x90ff 0x8ce7 0xb02b 0x7c75 0x3ac7 0xf44c 0x3bcf

0xedd8 0x5305 0xc0c3 0xefd0 0xd66b 0x7ee5 0x4cc0 0x6caa 0x53d8 0xcc9c 0x496a

0x0425 0x0000 0x5e8a 0x452a 0x01ca 0xbeea 0xbb6a 0xd96a 0xa7ca 0x6b6a 0x8d0a

0x9c0a 0x90ca 0xafca 0xa82a 0x572a 0x11ca 0xab8a 0xc5ea 0x0a4a 0xf0ea 0xcb8a 0xbe2a

0xad0a 0xbb2a 0x0000

G.3.6.1.2 Construction of the transmission header.

The Transmission Header precedes the data link frame and formatted as defined in TABLE G-XIII.

TABLE G-XIII. Example construction of Data Link transmission header.

Field Name	**Length (bits)**	**Value (Dec)**	**Value (Binary)** 2^n 2^0	**Field Fragments** 2^7 2^0	**Octet Value (Binary)** 2^7 2^0	**Octet Number**
Flag	8	126	01111110	01111110	01111110	0
FEC	1	1	1	xxxxxxx1		
TDC	1	1	1	xxxxxx1x		
Scramble	1	1	1	xxxxx1xx		
MIL-STD-188-220 Version	3	0	000	xx000xxx		
Transmit Queue	10	0	0000000000	00xxxxxx 00000000	00000111 00000000	1 2

APPENDIX G

TABLE G-XIII. Example construction of Data Link transmission header-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary) 2^n … 2^0	Field Fragments 2^7 … 2^0	Octet Value (Binary) 2^7 … 2^0	Octet Number
FCS	32	471931248	0001110000100001 0001100101110000	00011100 00100001 00011001 01110000	00111000 10000100 10011000 00001110	3 4 5 6
Flag	8	126	01111110	01111110	01111110	7

G.3.6.1.3 Zero bit insert/v36 scramble/FEC of the transmission header.
The Transmission Header is zero inserted to prevent any part of the data accidentally being interpreted as a Frame Flag. After zero-bit insertion, the fields are not easy to identify; therefore field names are not shown. The following is a Hex dump of the Transmission Header of zero-bit inserted:

Transmission Header after zero bit insertion (64 bits)
0x7ee0 0x001c 0x2119 0x707e

G.3.6.1.4 Completed Data Link Layer PDU to be passed to the Physical Layer.
The data link layer passes the Data Link Layer PDU to the Physical Layer. The elements of a Data Link Layer PDU include one transmission header and one or more PDUs. The following complete data link PDU (consisting of transmission header and Data Link frame) will be passed to the Physical Layer:

Complete Data Link Layer PDU

a. Transmission Header (64 bits):

0x7ee0 0x001c 0x2119 0x707e

b. Data Link Layer Frame (1152 bits):
0x87a1 0x0941 0x2f4b 0x193c 0xefe6 0x9194 0xbf24 0x85b9 0xa599 0x447f 0x67e7

0x56fa 0xe985 0x33be 0xae32 0x0fc2 0x6f76 0x8ef2 0x0c33 0xca36 0xd641 0x2201 0xb3e5

0x0000 0x81f5 0xf033 0x468b 0xf185 0x90ff 0x8ce7 0xb02b 0x7c75 0x3ac7 0xf44c 0x3bcf

0xedd8 0x5305 0xc0c3 0xefd0 0xd66b 0x7ee5 0x4cc0 0x6caa 0x53d8 0xcc9c 0x496a

0x0425 0x0000 0x5e8a 0x452a 0x01ca 0xbeea 0xbb6a 0xd96a 0xa7ca 0x6b6a 0x8d0a

0x9c0a 0x90ca 0xafca 0xa82a 0x572a 0x11ca 0xab8a 0xc5ea 0x0a4a 0xf0ea 0xcb8a 0xbe2a

0xad0a 0xbb2a 0x0000

G.3.7 Physical Layer data exchange.
The relationship of the Physical Layer to other communication layers is shown in FIGURE G-27. A user of the Physical Layer exchanges the Data Link Layer PDU with its peer at another node by sending and receiving the Data Link PDU via the Physical Layer. Note that one byte of 00 (8 bits of 0s) was appended after the final data link layer frame.

7

1	**2**	**3**	**85**	**86**	**87**
0x64f2	0xf296	0x905e	0x0abb	0x2a00	0x0000
0110010011110010	1111001010010110	1001000001011110	0000101010111011	0010101000000000	0000000000000000

FIGURE G-27. Serial representation of Physical Layer transmission unit.

G.3.7.1 Physical Layer processing example.
The Physical Layer encodes data submitted by the data link layer in a format to meet the physical media's requirements. This example does not address the electrical or mechanical functions normally associated with the physical layer protocols. At the Physical Layer the transmission header is extracted and the TWC is calculated, the Transmission header is FEC & TDC encoded except when packet mode is used. Note the other Physical Layer functions (COMSEC, DMTD, etc) are not shown in this example.

TWC	*Transmission Header*	*Data Link Frame*

G.3.7.1.1 Transmit word count (TWC).
TWC is calculated across the Data Link frame plus the size of the encoded Transmission Header & TWC size (encoded Transmission Header & TWC [10.5 16-bit words]). Therefore this Physical Layer PDU's TWC would be calculated as follows:

TWC = encoded Data Link frame + encoded Transmission Header and TWC
TWC = 72 words + 10.5 words (rounded up to nearest word)
TWC = 83 words

TWC (83)	*Transmission Header*	*Data Link Frame*

Transmission header including TWC (76 bits plus 4 padding bits)
0xca07 0xee00 0x01c2 0x1197 0x07e0

G.3.7.1.2 FEC & TDC of Transmission Header.
The Transmission Header has FEC & TDC encoding applied. Below is the Transmission Header in the different stages of FEC & TDC:

a. Transmission header/with TWC after FEC (Golay 24,12) (168 bits plus 8 padding bits)
Golay (24,12) is derived form Golay (23,12): See F 4.1 for details.
0xca0f 0x587e 0xe806 0x0000 0x001c 0x20c8 0x1191 0xfe70 0x75a4 0xe005 0x2600

b. Transmission header with TWC after TDC (7,24) (168 bits plus 8 padding bits)
0x838d 0x1aed 0x0a30 0x0448 0x8950 0x6c10 0xe047 0x1d30 0x3c49 0x89d2 0x8000

G.3.7.1.3 The Physical Layer PDU.
Complete message including 64-bit frame synchronization, TWC, transmission header, and Data Link frame. (Total: 1392 bits including 8 padded trailer bits):

0x64f2 0xf296 0x905e 0xadd9 0x838d 0x1aed 0x0a30 0x0448 0x8950 0x6c10 0xe047
0x1d30 0x3c49 0x89d2 0x8087 0xa109 0x412f 0x4b19 0x3cef 0xe691 0x94bf 0x2485
0xb9a5 0x9944 0x7f67 0xe756 0xfae9 0x8533 0xbeae 0x320f 0xc26f 0x768e 0xf20c
0x33ca 0x36d4 0x4122 0x01b3 0xe500 0x00810xf5f0 0x3346 0x8bf1 0x8590
0xff8c0xe7b0 0x2b7c 0x753a 0xc7f4 0x4c3b 0xcfed 0xd853 0x05c0 0xc3ef 0xd0d6
0x6b7e 0xe54c 0xc06c 0xaa53 0xd8cc 0x9c49 0x6a04 0x2500 0x005e 0x8a45 0x2a01
0xcabe 0xeabb 0x6ad9 0x6aa7 0xca6b 0x6a8d 0x0a9c 0x0a90 0xcaaf 0xcaa8 0x2a57
0x2a11 0xcaab 0x8ac5 0xea0a 0x4af0 0xeacb 0x8abe 0x2aad 0x0abb 0x2a00 0x0000

APPENDIX H

INTRANET TOPOLOGY UPDATE

H.1 General.

H.1.1 Scope.

This appendix describes a procedure for active intranet topology updates. The intranet is defined as all processors and CNRs within a single transmission channel.

H.1.2 Application.

This appendix is a mandatory part of MIL-STD-188-220 for systems implementing Intranet message type 2, Topology Update. The information contained herein is intended for compliance.

H.2 Applicable documents.

This section is not applicable to this appendix.

H.3 Problem overview.

FIGURE H-1 shows a sample extended CNR network. Each node labeled A through H is considered to be a radio with an associated communication processor. The dotted ovals indicate subsets of connectivity. FIGURE H-2 is a link diagram of the sample network. Assuming the nodes know nothing about neighbor nodes that are more than 1 hop away, they need to exchange connectivity information. The topology update packet is used to exchange topology information to build up a more complete view of the intranet's topology at every node.

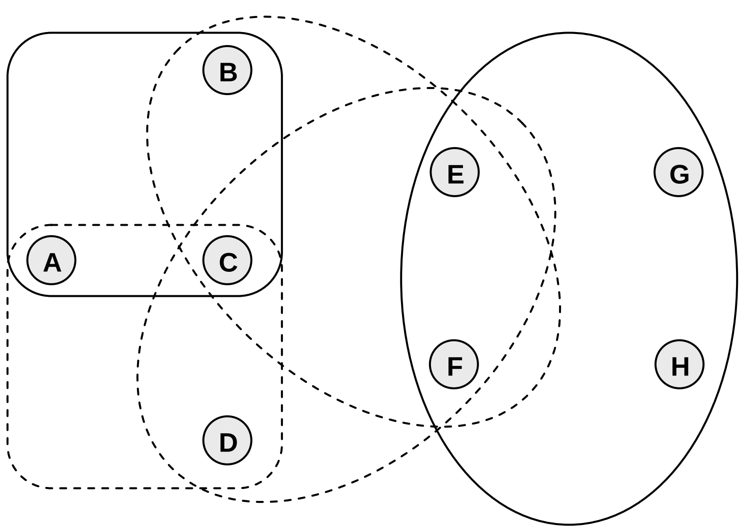


FIGURE H-1. Sample intranet.

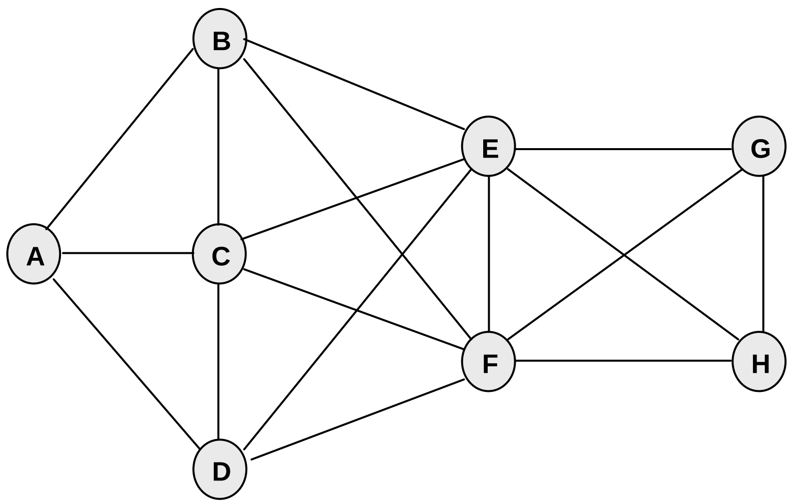


FIGURE H-2. Link diagram of sample network.

H.3.1 Routing trees.

Each node should store topology information as a routing tree graph. Considering the network in FIGURE H-3, FIGURE H-4 shows the routing tree for nodes A and C prior to the exchange of any topology information. The routing trees for A and C contain only their nearest neighbors - those nodes which they can talk to directly. Similar graphs would exist for all other nodes.

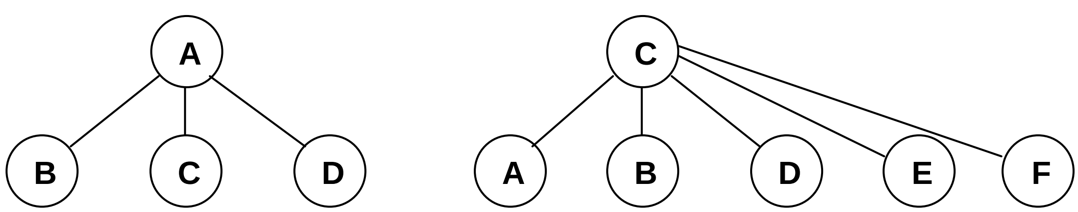


FIGURE H-3. Routing tree for nodes A and C.

H.4 Topology updates.

H.4.1 Exchanging routing trees.

Nodes in the network gain more topology information by multicasting their individual routing trees to their nearest neighbor nodes. This exchange of routing trees will percolate more complete topology information through the network. For example, assume the routing trees for all nodes in FIGURE H-4 initially contain only nearest neighbors (nodes who are in direct communication with the given node). If node C multicasts its topology information to all nodes one hop away (those which are nearest neighbors), all neighbor nodes integrate C's routing tree into their own. Node A would integrate the graph for Node C into its routing tree as shown in FIGURE H-4.

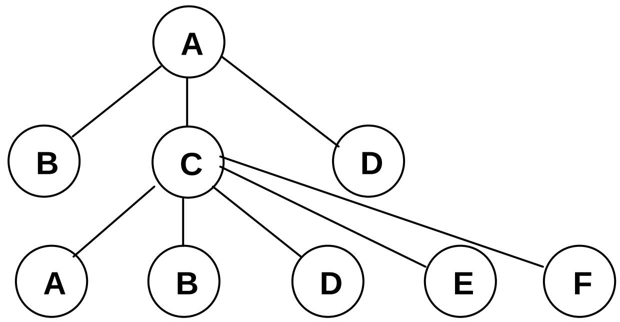


FIGURE H-4. Concatenated routing tree for node A.

Before the routing tree is saved, Node A prunes any successive instances of itself. For instance, in FIGURE H-4, the link from A to C is the same as the link from C to A; therefore, the link from C to A is removed. All redundant identical links are also pruned. These are links with the order of the end points reversed.

H.4.2 Topology tables.
The topology table for A is shown in TABLE H-I. It assumes no nodes are in quiet mode, all nodes can participate in relay, and all links have a cost of 1. The actual link layer addresses for the nodes would be placed into the table in place of the symbols A, B, C, etc. The extension bit in the address octet would always be set to 0 for topology updates.

TABLE H-I. Topology table for node A.

Node Address	Node Predecessor	Hops	Cost	NR	Quiet
B	A	1	1	0	0
C	A	1	1	0	0
D	A	1	1	0	0
B	C	2	1	0	0
D	C	2	1	0	0
E	C	2	1	0	0
F	C	2	1	0	0

There are two entries for node B indicating that there are two paths from A to B. This table could be immediately copied to the respective fields of a topology update packet. The predecessor address is not included in the topology update packet for nearest neighbor nodes because the predecessor is, by definition, the originator node.

H.4.3 Sparse routing trees.
Exchanging full routing tree tables provides full topology information; however, the amount of data in the routing tree gets very large, especially for fully connected nets. The number of links in a fully connected net with n nodes is n(n-1)/2. Although full routing trees should be stored by a node, exchanging these routing trees may consume too much bandwidth. A smaller copy of the full routing tree (called a sparse routing tree) should be prepared for transmission to neighbor nodes. To reduce the number of branches in the routing tree, some of the paths to duplicate nodes on the tree are pruned according to following rules:

a. Only the shortest paths from the root node to another node are retained.

b. For redundant paths from a root node to another node which are the same length (same number of links in the routing tree), at most 2 are retained. Some redundancy in paths is necessary for volatile networks.

For the previous example, the path from C to B and C to D would be pruned, since there are already shorter paths from A to C and A to D. The pruning yields the sparse routing tree in FIGURE H-5 and TABLE H-II.

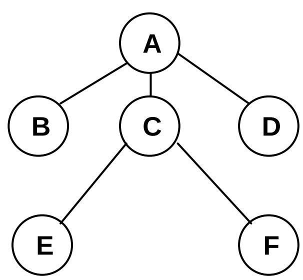


FIGURE H-5. Sparse routing tree for node A.

TABLE H-II. Sparse routing tree for node A.

Node Address	Node Predecessor	Hops	Cost	NR	Quiet
B	A	1	1	0	0
C	A	1	1	0	0
D	A	1	1	0	0
E	C	2	1	0	0
F	C	2	1	0	0

The final routing tree for Node A, after all the nodes exchange their sparse routing trees, is shown in FIGURE H-6 and TABLE H-III. Note that FIGURE H-6 shows more than 2 paths between nodes G and A and H and A; however, the sparse routing tree table, which is the information actually transmitted, shows only two entries for nodes G and H. The pruning rules stated above have not been violated. They have been applied to the entries in the sparse routing table. The sparse routing graph is deduced from the table. Thus, quite a few redundant paths can be derived from the structure of the sparse routing table.

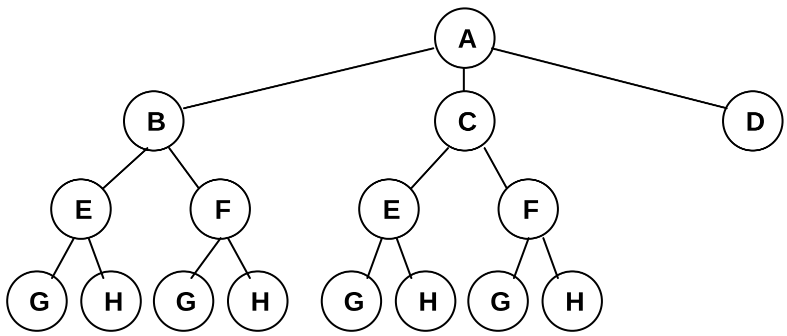


FIGURE H-6. Final routing tree for node A.

TABLE H-III. Final routing tree for node A.

Node Address	Node Predecessor	Hops	Cost	NR	Quiet
B	A	1	1	0	0
C	A	1	1	0	0
D	A	1	1	0	0
E	B	2	1	0	0
F	B	2	1	0	0
E	C	2	1	0	0
F	C	2	1	0	0
G	E	3	1	0	0
H	E	3	1	0	0
G	F	3	1	0	0
H	F	3	1	0	0

H.4.4 Rules for exchanging topology updates.
Topology update packets are transmitted exclusively using a global multicast address.

H.4.4.1 Topology update triggers.

Topology updates are triggered for node I by the following:

a. Node I detects a failed link and the link is to a node that is not a static node (link quality = 7)

b. Node I detects a new or recovered link and the link is to a node that is not a static node (link quality = 7)

c. Node I detects a change in the quality of a link - applicable only if link costs are used.

d. Node I receives a topology update from another node which modifies its sparse routing tree.

e. Node I changes its Quiet Mode status and wishes to announce this change.

f. Node I changes its relay capability status.

g. Node I receives a topology update request.

H.4.4.2 Sending topology update messages.
Optimally, topology updates should be concatenated with other traffic for queuing by the link layer. Topology Update Messages are sent to the global multicast address using Type 1 Unnumbered Information Frames which are not acknowledged. The precedence of the Topology Update Message is user configurable.

The updates should be transmitted no more often than once every MIN_UPDATE_PER. MIN_UPDATE_PER is measured in minutes and is set by the network administrator when the nodes are configured. The network administrator can disable topology update transmission by setting MIN_UPDATE_PER to zero. Update packets are superseded by newer packets if they have not been queued at the link layer.

H.4.4.3 Sending Topology Update ID indication PDUs.
If a network is using Topology Updates (e.g. MIN_UPDATE_PER is not equal to zero), then after MIN_UPDATE_PER/2 time has expired, the station shall transmit a Topology Update ID indication PDU indicating the most recent Topology Update ID. Optimally the Topology Update ID indication PDU should be concatenated with other traffic for queuing by the link layer and should not initiate a transmission. However, if no transmissions occur for a total of MIN_UPDATE_PER time, the Topology Update ID indication PDU may be transmitted as a single un-concatenated PDU.

H.4.5 Non-relayers.
In the Topology Update broadcast by non-relayers, the non-relayer indicates its status by setting the NR bit to one in its entry of the Topology Update message. Additionally, the non-relayer includes all one-hop, and only one-hop, neighbors (because relaying by this node is not

permitted). Non-relayer nodes remain in the sparse routing trees; however, they shall not have any subsequent branches. Their entries in the routing table shall have the NR bit set to 1.

H.4.6 Quiet nodes.
Nodes in the quiet state may appear in the sparse routing tables and in update packets with the QUIET bit set to 1; however, they shall not have any subsequent branches in the routing tree. Nodes wishing to announce that they are entering quiet mode shall add a separate entry into the sparse routing table and update packets with NODE ADDRESS and NODE PREDECESSOR set to their own address and the QUIET bit set to 1.

H.4.7 Topology update request messages.
The Topology Update Request Message is triggered whenever there is a mismatch between the topology update ID received from a station and the value that had been stored previously. The Topology Update Request message may also be sent whenever a data link transmission is detected from a previously unknown neighbor. The Topology Update Request message uses a Type 1 Unnumbered Information frame which is not acknowledged and is addressed according to 5.4.1.1.7, 5.4.1.1.9 and 5.4.1.3. The Topology Update Request message is addressed to specific stations at the Intranet layer and may be sent to the global multicast address at the data link layer. The precedence of the Topology Update Request Message is user-configurable. The Topology Update Request Message may be sent no more often than MIN_UPDATE_PER/2. This constant allows up to two requests to be sent to a node while the node is waiting for the MIN_UPDATE_PER timer to expire.

APPENDIX I

SOURCE DIRECTED RELAY

I.1 General.

I.1.1 Scope.

This appendix describes a procedure for relaying packets across a CNR intranet using source directed routes. The intranet is defined as all processors and CNRs within a single transmission channel.

I.1.2 Application.

This appendix is a mandatory part of MIL-STD-188-220. The information contained herein is intended for compliance.

I.1.3 Clarification of examples

Throughout this standard, many examples are provided as guidance only. In the event that an example is inconsistent with the text and DSPICS of the standard, the text description/DSPICS takes precedence over the example. Should a user detect any inconsistent examples, they should notify the CNRWG so that the example can be updated for a future release of the standard. It should also be noted that while all examples should be accurate in relation to the feature they are explaining, some of the examples provided may not reflect changes made to unrelated sections of the standard (e.g. examples to illustrate the use of XNP reflect the current version of XNP, but may not reflect the current version of the Intranet Header).

I.2 Applicable documents.

None.

I.3 Problem overview.

Intranet relaying is required when nodes in an intranet need to communicate, but are not nearest neighbors capable of hearing one another's radio transmissions.

I.4 Procedure.

I.4.1 Forward routing.

Source Directed Relay provides a simple non-dynamic procedure for relaying a packet from an originator to one or more destinations. The source shall calculate the path through the intranet network to reach each destination. These paths are based on the topology and connectivity table. The specific source directed route for each destination shall be encoded into the intranet header. If the routes for two or more destinations share common links along the paths, the two paths should be merged together. As a result of this, the resulting paths should not have any common nodes.

The address of successive relayers, destinations and their associated status bytes are placed in the intranet header in order of progressing through the routing tree. Nodes which are one hop away and destinations only are placed into the Intranet Header first with their DES bit set to 1. The next entries into the Intranet Header are the relay paths which may include nodes which are relayers and destinations. Each relay path starting at the source is completed before another relay path with its origin at the source is begun. Within the status byte for each relayer the REL bit is set to 1 and S/D is set to 0. If the relayer is also a destination in addition to being a relayer, the DES bit is set to 1. If there are multiple destinations that are not relayers following a relayer, each of these destination addresses and their status bytes should be listed in the header after the relay node sequentially in the order of their appearance in the path. Within this group the extension bit within the destination/relay address field is not used. The last address can be determined from the Intranet header length. The last address in a group can be determined from the DIS field of the Destination/Relay Status Byte defined in 5.4.1.1.7

All destinations in the relay path that are required to provide end-to-end intranet acknowledgments have set the ACK bit in their status bytes to 1. For all destinations, the DISTANCE field is set to the number of hops between the originator and the ultimate destination host for the relay.

I.4.2 End-to-end intranet acknowledgments.

End-to-End intranet acknowledgments are formed by the *i*th final destination nodes upon receipt of an intranet header with ACK bit set in DESTINATION STATUS BYTE for the *i*th destination. The MESSAGE ID for the packet to be acknowledged is retained. The message type is set to 1. The path between the originator node and the *i*th destination is reversed. All intermediate destinations are removed. The path will contain one originator, one destination and the relayers. The DES bit in the status bytes for all relayers is set to 0, indicating they perform relay only. No data is carried with an end-to-end acknowledgment packet, just the intranet header.

I.5 Examples.

To illustrate Source Directed Relay procedures consider the sample network link diagram in FIGURE I-1 and final routing tree in FIGURE I-2. TABLE I-I gives specific addresses for the nodes labeled A, B, C, D, E, F, G and H. To maintain consistency with other sections of MIL-STD-188-220, the most significant bit (MSB) is presented to the left of the figures in this appendix.

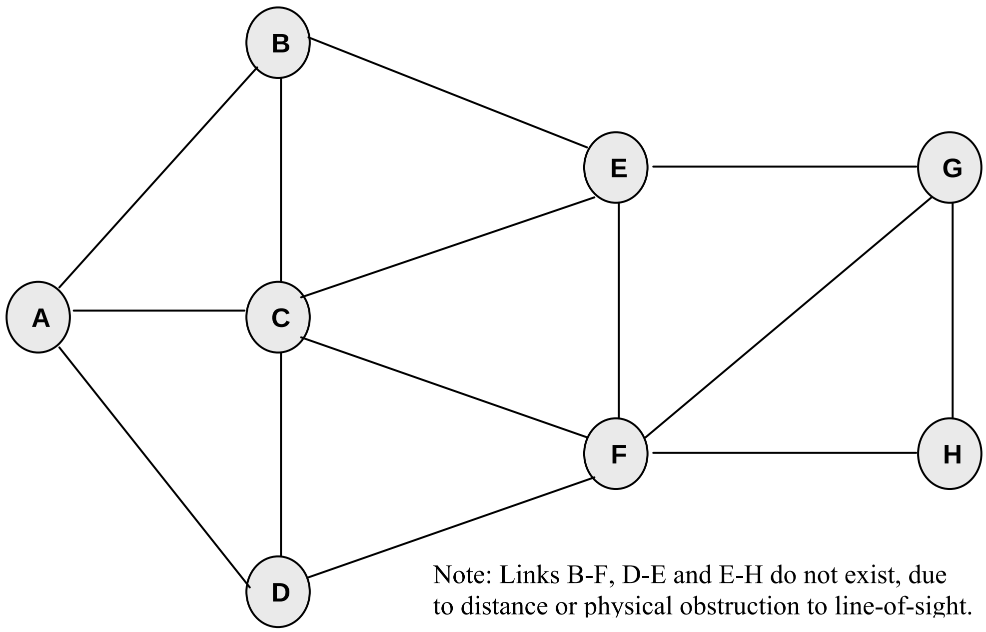


FIGURE I-1. Link diagram of a sample network.

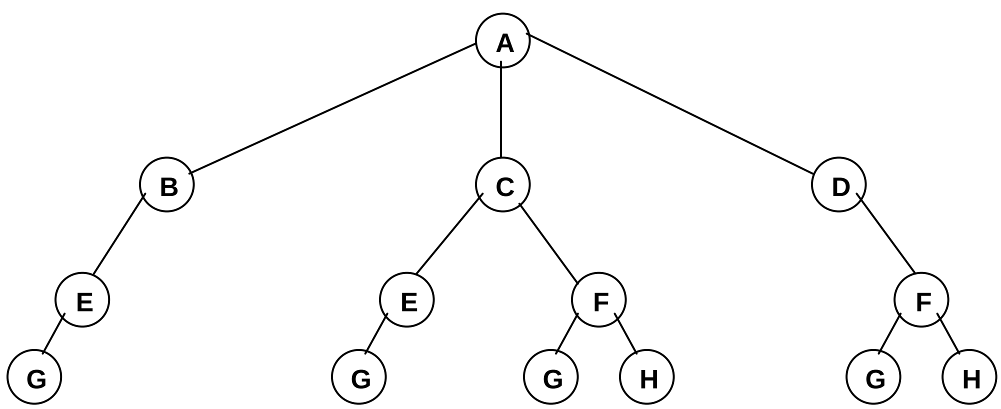


FIGURE I-2. Final routing tree for node A.

TABLE I-I. Sample node addresses.

Node	MSB							LSB	Address
A	0	0	0	1	1	1	1	x	15
B	0	0	0	0	1	0	0	x	4
C	0	0	0	0	1	0	1	x	5
D	0	0	0	0	1	1	0	x	6
E	0	0	0	0	1	1	1	x	7
F	0	0	0	1	0	0	0	x	8
G	0	0	0	1	0	0	1	x	9
H	0	0	0	1	0	1	0	x	10

I.5.1 Example 1.

Assume that node A has a packet bound for node G alone. Node A's Sparse Routing Tree provides the following potential paths to Node G: A-B-E-G, A-C-E-G, A-C-F-G and A-D-F-G. Assuming that all paths have the same quality and cost, any path may be selected by Node A. In this example, path A-B-E-G is selected.

The following values are assigned to the Intranet Header in example 1:

MESSAGE TYPE = 4 (IPv4 Packet)
TYPE_OF_SERVICE = 00000000
MESSAGE ID = 1
MAX_HOP_COUNT = 3 (Distance from node A to node G)
ORIGINATOR ADDRESS = 15 (node A)
STATUS BYTE 1 = 00001001 (ACK=No, DES=No, REL=Yes, DIS=1)
DESTINATION 1 = 4 (node B)
STATUS BYTE 2 = 00001010 (ACK=No, DES=No, REL=Yes, DIS=2)
DESTINATION 2 = 7 (node E)
STATUS BYTE 3 = 01000011 (ACK=No, DES=Yes, REL=No, DIS=3)
DESTINATION 3 = 9 (node G)
HEADER LENGTH = 12 octets

FIGURE I-3 shows the complete Intranet Header for example 1. Note that the LSB in all destination addresses is 0 except for the last destination address (node G).

7 MSB	6	5	4	3	2	1	0 LSB
MESSAGE TYPE				VERSION NUMBER			
0	1	0	0	0	0	0	0
INTRANET HEADER LENGTH							
0	0	0	0	1	1	0	0
TYPE OF SERVICE							
0	0	0	0	0	0	0	0
MESSAGE IDENTIFICATION NUMBER							
0	0	0	0	0	0	0	1
SPARE				MAX HOP COUNT			
0	0	0	0	0	0	1	1
ORIGINATOR ADDRESS							
0	0	0	1	1	1	1	0
DESTINATION/RELAY STATUS BYTE 1							
0	0	0	0	1	0	0	1
DESTINATION/RELAY ADDRESS 1							
0	0	0	0	1	0	0	0
DESTINATION/RELAY STATUS BYTE 2							
0	0	0	0	1	0	1	0
DESTINATION/RELAY ADDRESS 2							
0	0	0	0	1	1	1	0
DESTINATION/RELAY STATUS BYTE 3							
0	1	0	0	0	0	1	1
DESTINATION/RELAY ADDRESS 3							
0	0	0	1	0	0	1	1

FIGURE I-3. Example 1 Intranet header.

I.5.2 Example 2.
Assume that node A has a packet bound for nodes G and H. Node A's Sparse Routing Tree provides the following potential paths to nodes G and H: A-B-E-G, A-C-E-G, A-C-F-G, A-C-F-H, A-D-F-G and A-D-F-H. Of these potential paths, the most economical choices are those that use node F for relaying: A-C-F-G, A-D-F-G, A-C-F-H and A-D-F-H. Although paths A-B-E-G and A-C-E-G are viable paths to node G, they would unnecessarily increase processing at nodes B and E, and would increase the size of the Intranet Header in this example. In this example the selected paths are A-C-F-G and A-C-F-H.

The following values are assigned to the Intranet Header in example 2:

MESSAGE TYPE = 4 (IPv4 Packet)
TYPE_OF_SERVICE = 00000000
MESSAGE ID = 2
MAX_HOP_COUNT = 3 (Distance from node A to nodes G and H)
ORIGINATOR ADDRESS = 15 (node A)
STATUS BYTE 1 = 00001001 (ACK=No, DES=No, REL=Yes, DIS=1)

DESTINATION 1 = 4 (node C)
STATUS BYTE 2 = 00001010 (ACK=No, DES=No, REL=Yes, DIS=2)
DESTINATION 2 = 8 (node F)
STATUS BYTE 3 = 01000011 (ACK=No, DES=Yes, REL=No, DIS=3)
DESTINATION 3 = 9 (node G)
STATUS BYTE 4 = 01000011 (ACK=No, DES=Yes, REL=No, DIS=3)
DESTINATION 4 = 10 (node H)
HEADER LENGTH = 14 octets

FIGURE I-4 shows the complete Intranet Header for example 2. Note that the LSB in all destination addresses is 0 except for the last destination address (node H).

7 MSB	*6*	*5*	*4*	*3*	*2*	*1*	*0 LSB*
MESSAGE TYPE				VERSION NUMBER			
0	1	0	0	0	0	0	0
INTRANET HEADER LENGTH							
0	0	0	0	1	1	1	0
TYPE OF SERVICE							
0	0	0	0	0	0	0	0
MESSAGE IDENTIFICATION NUMBER							
0	0	0	0	0	0	1	0
SPARE				MAX HOP COUNT			
0	0	0	0	0	0	1	1
ORIGINATOR ADDRESS							
0	0	0	1	1	1	1	0
DESTINATION/RELAY STATUS BYTE 1							
0	0	0	0	1	0	0	1
DESTINATION/RELAY ADDRESS 1							
0	0	0	0	1	0	0	0
DESTINATION/RELAY STATUS BYTE 2							
0	0	0	0	1	0	1	0
DESTINATION/RELAY ADDRESS 2							
0	0	0	1	0	0	0	0
DESTINATION/RELAY STATUS BYTE 3							
0	1	0	0	0	0	1	1
DESTINATION/RELAY ADDRESS 3							
0	0	0	1	0	0	1	0
DESTINATION/RELAY STATUS BYTE 4							
0	1	0	0	0	0	1	1
DESTINATION/RELAY ADDRESS 4							
0	0	0	1	0	1	0	1

FIGURE I-4. Example 2 Intranet header.

I.5.3 Example 3.
In the third example, node A wishes to deliver a packet to nodes D, E, F, G and H. In this case node A again would select the most economical path to each destination, taking into consideration the impacts on network traffic and Intranet header size. TABLE I-II lists the potential and selected paths from node A to each of the intended destinations.

A similar process would be used to select economical paths to relay nodes, such as node C. The shortest path to the most distant nodes G and H are reviewed to determine whether the relay nodes C and F are also destinations. Note that node F is both a destination and a relay while node C is a relay node only.

TABLE I-II. Paths used in example 3.

Destination Node	Potential Paths	Selected Path
D	A-D	A-D
E	A-B-E A-C-E	A-C-E
F	A-C-F A-D-F	A-C-F
G	A-B-E-G A-C-E-G A-C-F-G A-D-F-G	A-C-F-G
H	A-C-F-H A-D-F-H	A-C-F-H

The following values are assigned to the Intranet Header in example 3:

MESSAGE TYPE = 4 (IPv4 Packet)
TYPE_OF_SERVICE = 00000000
MESSAGE ID = 3
MAX_HOP_COUNT = 3 (Distance from node A to nodes G and H)
ORIGINATOR ADDRESS = 15 (node A)
STATUS BYTE 1 = 01000001 (ACK=No, DES=Yes, REL=No, DIS=1)
DESTINATION 1 = 6 (node D)
STATUS BYTE 2 = 00001001 (ACK=No, DES=No, REL=Yes, DIS=1)
DESTINATION 2 = 5 (node C)
STATUS BYTE 3 = 01000010 (ACK=No, DES=Yes, REL=No, DIS=2)
DESTINATION 3 = 7 (node E)
STATUS BYTE 4 = 01001010 (ACK=No, DES=Yes, REL=Yes, DIS=2)

DESTINATION 4 = 8 (node F)
STATUS BYTE 5 = 01000011 (ACK=No, DES=Yes, REL=No, DIS=3)
DESTINATION 5 = 9 (node G)
STATUS BYTE 6 = 01000011 (ACK=No, DES=Yes, REL=No, DIS=3)
DESTINATION 6 = 10 (node H)
HEADER LENGTH = 18 octets

FIGURE I-5 shows the complete Intranet Header for example 3. Note that the LSB in all destination addresses is 0 except for the last destination address (node H).

I.5.4 Relay processing.

Although the separate examples 1, 2, 3 all have diverse paths, they would all require the same number data link information frames for delivery (one). The UI, I or DIA frame would be transmitted to each destination simultaneously. Addressed destinations would perform the required data link layer processing described in 5.3 and pass the information field of the frame to the Intranet layer for further processing.

The Intranet header is scanned for the node's data link layer address. When found, the previous octet - the Destination/Relay Status byte - is inspected. If the Relay bit is not set and the destination bit is set, the data portion following the Intranet header is passed to the next higher protocol layer for further processing. If the Relay bit is set, Relay processing is required. If both the Relay bit and the Destination bit are set, Relay processing is performed before the passing data portion of the frame to the next higher protocol layer for further processing. Relay processing involves the following steps:

a. Scan forward until the relayer node sees its own address.

b. Scan toward the end of the header looking for all nodes whose DES bit is set and whose distance is one hop greater than your own. Terminate the scan when a distance less than or equal to your own or the end of the header is found. Save the addresses.

c. While scanning forward until a hop distance less than or equal to your own is found, find all relay addresses that are one hop away from your address and save these addresses.

d. Remove all duplicate saved addresses and pass the remaining addresses to the data link layer to form a multi-addressed information frame containing the Intranet header and data.

7 MSB	*6*	*5*	*4*	*3*	*2*	*1*	*0 LSB*
MESSAGE TYPE				VERSION NUMBER			
0	1	0	0	0	0	0	0
INTRANET HEADER LENGTH							
0	0	0	1	0	0	1	0
TYPE OF SERVICE							
0	0	0	0	0	0	0	0
MESSAGE IDENTIFICATION NUMBER							
0	0	0	0	0	0	1	1
SPARE				MAX HOP COUNT			
0	0	0	0	0	0	1	1
ORIGINATOR ADDRESS							
0	0	0	1	1	1	1	0
DESTINATION/RELAY STATUS BYTE 1							
0	1	0	0	0	0	0	1
DESTINATION/RELAY ADDRESS 1							
0	0	0	0	1	1	0	0
DESTINATION/RELAY STATUS BYTE 2							
0	0	0	0	1	0	0	1
DESTINATION/RELAY ADDRESS 2							
0	0	0	0	1	0	1	0
DESTINATION/RELAY STATUS BYTE 3							
0	1	0	0	0	0	1	0
DESTINATION/RELAY ADDRESS 3							
0	0	0	0	1	1	1	0
DESTINATION/RELAY STATUS BYTE 4							
0	1	0	0	1	0	1	0
DESTINATION/RELAY ADDRESS 4							
0	0	0	1	0	0	0	0
DESTINATION/RELAY STATUS BYTE 5							
0	1	0	0	0	0	1	1
DESTINATION/RELAY ADDRESS 5							
0	0	0	1	0	0	1	0
DESTINATION/RELAY STATUS BYTE 6							
0	1	0	0	0	0	1	1
DESTINATION/RELAY ADDRESS 6							
0	0	0	1	0	1	0	1

FIGURE I-5. Example 3 intranet header created by node A (originator).

The following sections discuss the relay processing at each of the downstream relayers in Example 3. There are two options when filling out the Intranet Header Address Field at the relay nodes. The relay nodes may copy the Address Field and place it into the relay packet intact or they may delete the addresses which have no impact on forwarding or return of a network layer acknowledgment. If the implementer chooses to leave the address field intact, the address field in FIGURE I-2 is used at every relayer. If the implementer chooses to compress the address field to save transmitted bytes, the following paragraphs dictate the method for compression. There is no interoperability problem regardless of which of these two methods are implemented.

I.5.4.1 Relay processing at node C.
Node C is a relay node, but not a destination node. Node C is responsible for relaying the information to nodes E, F, G and H. Node C assigns the following values to the Intranet Header in example 3:

MESSAGE TYPE = 4 (IPv4 Packet)
TYPE_OF_SERVICE = 00000000
MESSAGE ID = 3
MAX_HOP_COUNT = 2 (Original MAX_HOP_COUNT - 1)
ORIGINATOR ADDRESS = 15 (node A)
STATUS BYTE 1 = 00001001 (ACK=No, DES=No, REL=Yes, DIS=1)
DESTINATION 1 = 5 (node C)
STATUS BYTE 2 = 01000010 (ACK=No, DES=Yes, REL=No, DIS=2)
DESTINATION 2 = 7 (node E)
STATUS BYTE 3 = 01001010 (ACK=No, DES=Yes, REL=Yes, DIS=2)
DESTINATION 3 = 8 (node F)
STATUS BYTE 4 = 01000011 (ACK=No, DES=Yes, REL=No, DIS=3)
DESTINATION 4 = 9 (node G)
STATUS BYTE 5 = 01000011 (ACK=No, DES=Yes, REL=No, DIS=3)
DESTINATION 5 = 10 (node H)
HEADER LENGTH = 16 octets

FIGURE I-6 shows the complete Intranet Header created by Node C.

I.5.4.2 Relay processing at node F.
Node F is both a destination and a relayer with relay responsibilities to nodes G and H. Node F assigns the following values to the Intranet Header in example 3:

MESSAGE TYPE = 4 (IPv4 Packet)
TYPE_OF_SERVICE = 00000000
MESSAGE ID = 3
MAX_HOP_COUNT = 1 (Received MAX_HOP_COUNT - 1)
ORIGINATOR ADDRESS = 15 (node A)
STATUS BYTE 1 = 00001001 (ACK=No, DES=No, REL=Yes, DIS=1)
DESTINATION 1 = 5 (node C)
STATUS BYTE 2 = 01001010 (ACK=No, DES=Yes, REL=Yes, DIS=2)
DESTINATION 2 = 8 (node F)
STATUS BYTE 3 = 01000011 (ACK=No, DES=Yes, REL=No, DIS=3)
DESTINATION 3 = 9 (node G)
STATUS BYTE 4 = 01000011 (ACK=No, DES=Yes, REL=No, DIS=3)
DESTINATION 4 = 10 (node H)

HEADER LENGTH = 14 octets

FIGURE I-7 shows the complete Intranet Header created by Node F.

7 MSB	*6*	*5*	*4*	*3*	*2*	*1*	*0 LSB*
MESSAGE TYPE				VERSION NUMBER			
0	1	0	0	0	0	0	0
INTRANET HEADER LENGTH							
0	0	0	1	0	0	0	0
TYPE OF SERVICE							
0	0	0	0	0	0	0	0
MESSAGE IDENTIFICATION NUMBER							
0	0	0	0	0	0	1	1
SPARE				MAX HOP COUNT			
0	0	0	0	0	0	1	0
ORIGINATOR ADDRESS							
0	0	0	1	1	1	1	0
DESTINATION/RELAY STATUS BYTE 1							
0	0	0	0	1	0	0	1
DESTINATION/RELAY ADDRESS 1							
0	0	0	0	1	0	1	0
DESTINATION/RELAY STATUS BYTE 2							
0	1	0	0	0	0	1	0
DESTINATION/RELAY ADDRESS 2							
0	0	0	0	1	1	1	0
DESTINATION/RELAY STATUS BYTE 3							
0	1	0	0	1	0	1	0
DESTINATION/RELAY ADDRESS 3							
0	0	0	1	0	0	0	0
DESTINATION/RELAY STATUS BYTE 4							
0	1	0	0	0	0	1	1
DESTINATION/RELAY ADDRESS 4							
0	0	0	1	0	0	1	0
DESTINATION/RELAY STATUS BYTE 5							
0	1	0	0	0	0	1	1
DESTINATION/RELAY ADDRESS 5							
0	0	0	1	0	1	0	1

FIGURE I-6. Example 3 Intranet header for node C (relay node).

7 MSB	*6*	*5*	*4*	*3*	*2*	*1*	*0 LSB*
MESSAGE TYPE				VERSION NUMBER			
0	1	0	0	0	0	0	0
INTRANET HEADER LENGTH							
0	0	0	0	1	0	1	0
TYPE OF SERVICE							
0	0	0	0	0	0	0	0
MESSAGE IDENTIFICATION NUMBER							
0	0	0	0	0	0	1	1
SPARE				MAX HOP COUNT			
0	0	0	0	0	0	0	1
ORIGINATOR ADDRESS							
0	0	0	1	1	1	1	0
DESTINATION/RELAY STATUS BYTE 1							
0	0	0	0	1	0	0	1
DESTINATION/RELAY ADDRESS 1							
0	0	0	0	1	0	1	0
DESTINATION/RELAY STATUS BYTE 2							
0	1	0	0	1	0	1	0
DESTINATION/RELAY ADDRESS 2							
0	0	0	1	0	0	0	0
DESTINATION/RELAY STATUS BYTE 3							
0	1	0	0	0	0	1	1
DESTINATION/RELAY ADDRESS 3							
0	0	0	1	0	0	1	0
DESTINATION/RELAY STATUS BYTE 4							
0	1	0	0	0	0	1	1
DESTINATION/RELAY ADDRESS 4							
0	0	0	1	0	1	0	1

FIGURE I-7. Example 3 Intranet header created by node F (relay and destination nodes).

APPENDIX J

ROBUST COMMUNICATIONS PROTOCOL

J.1 General.

J.1.1 Scope.
This appendix describes the interoperability and technical requirements for the Robust Communications Protocol (RCP) for DMTD and interfacing C^4I systems (DTEs). This appendix applies only to HAVEQUICK II compatible systems that require interoperability with radios that do not have data buffering or synchronization capability.

J.1.2 Application.
This appendix is a mandatory part of MIL-STD-188-220. The information contained herein is intended for compliance.

J.2 Applicable documents.
JIEO Specification 9120A.

J.3 Introduction.
This physical layer protocol provides the additional processing to aid the transfer of secure and non-secure digital data when concatenated with the link processing of the MIL-STD-188-220 protocol. The additional processing of this protocol allows for a higher level protocol with an error correcting capability equal to rate 1/2 Golay to transfer a burst of data containing up to 67,200 data symbols with better than 90% probability of success in a single transmission, this being over an active HAVEQUICK II compatible link with a random bit error rate of 0.1 or less. The second goal of this physical protocol is for the required performance to be achieved entirely in software using current systems with modest processing capability.

J.3.1 Physical protocol components.
Three individually selectable processes are used to meet the performance requirement. The first is the application of rate 1/3 convolutional coding to combat high random bit error rates. The second is a provision for data scrambling. Scrambling at the physical layer is implemented simply as the multiplication of the transmit data with a pseudorandom bit pattern. The third is a packetizing scheme that allows for the re-transmission of the data that was lost due to an HAVEQUICK II compatible frequency hop. The re-transmission is performed, and data recovered within the data burst and the data interruption is transparent to the higher-level protocol. This packetizing scheme has been dubbed the multi-dwell protocol because it was formulated to allow a message to be transmitted over multiple HAVEQUICK II compatible hop dwells.

J.3.2 Optional rate 1/3 convolutional coding.
The transmitting convolutional encoder generates three output bits for each input information bit. FIGURE J-1 shows an example of the encoding process for a constraint length (K) of 3. The encoder consists of a shift register equal in length to the constraint length. The data to encode is shifted from left to right one bit at a time. After each shift, three output bits are generated using the G1, G2, and G3 polynomials. The three encoded output bits are generated in the G1, G2, and G3 order. The G2 output shall be inverted to provide some data scrambling capability. The convolutional encoding shift register is initialized to a state of zero when a transmission is requested. The first output bits are generated when the shift register contains the first upper layer bit to transmit, followed by all zeros. Upon detection of the robust synchronization pattern, the Viterbi decoder is initialized to make use of the knowledge of the initial encoder shift register state.

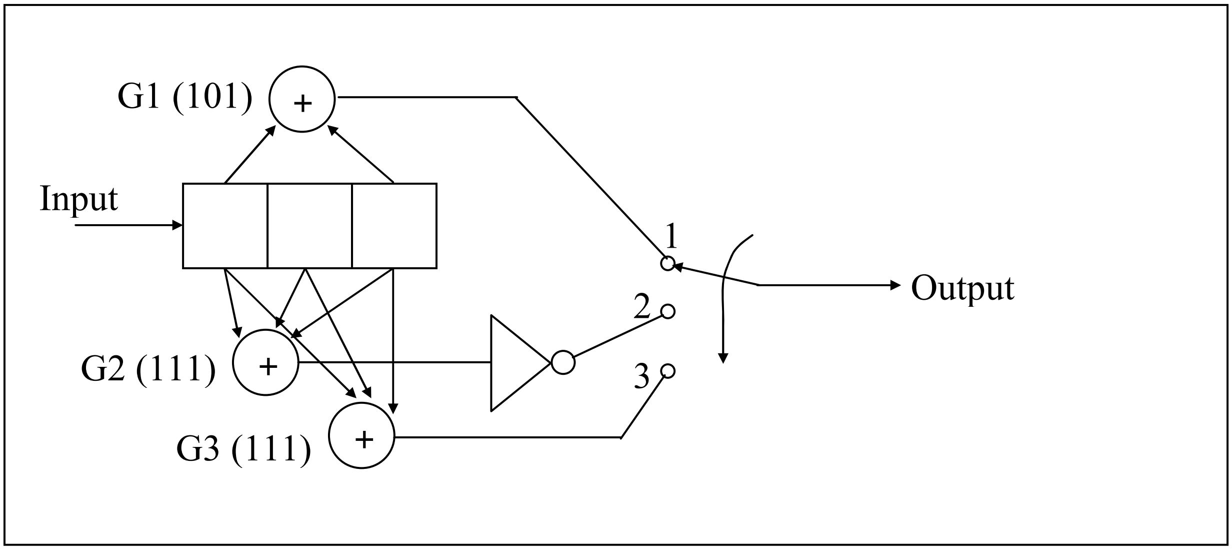


FIGURE J-1. Convolutional encoder with inverted G2 K=3.

TABLE J-I lists the generator polynomials used for the three specified constraint lengths. The MSBs of the octal representation of each polynomial are used for each polynomial.

TABLE J-I. Convolutional coding generator polynomials (octal).

Constraint Length	G1	G2	G3
3	5	7	7
5	52	66	76
7	554	624	764

FIGURE J-2 shows the relative error correcting capability of rate 1/3 convolutional coding in a random error environment using the Viterbi decoding algorithm with hard decisions. The performance was achieved using a trace back buffer length of 16, 32, and 64 for constraint lengths 3, 5, and 7 respectively. If the demodulator and decoder are components of the same subsystem, soft decision information from the demodulator can be used to further enhance the performance.

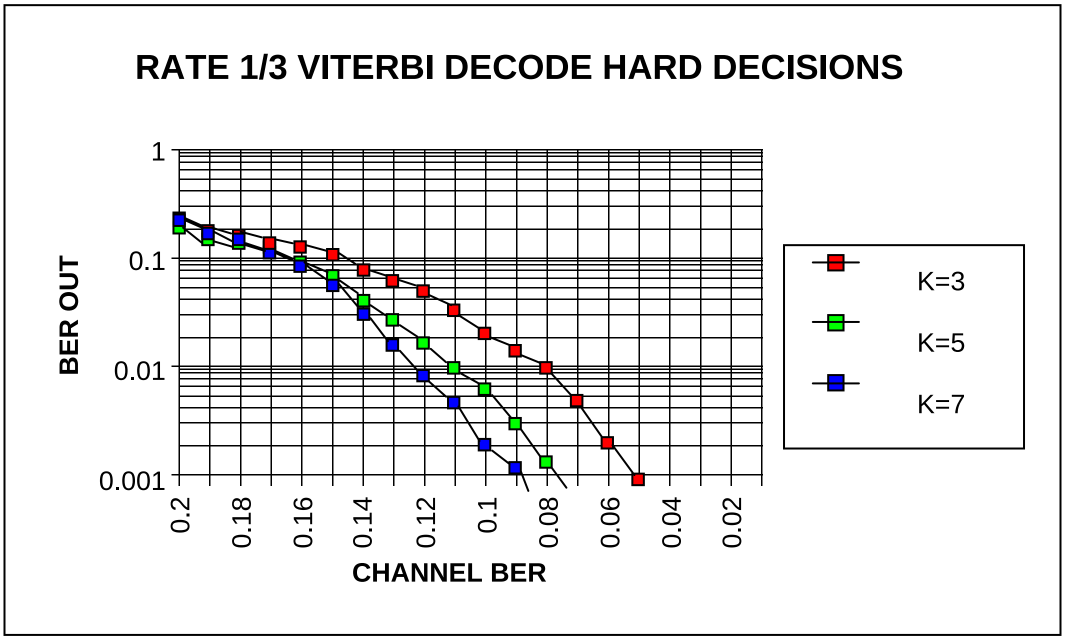


FIGURE J-2. Rate 1/3 convolutional coding performance for constraint lengths 3, 5, and 7.

J.3.3 <u>Optional data scrambling.</u>
Physical layer data scrambling shall use the scrambler and descrambler described in FIGURE J-3. Physical layer data scrambling shall use the pseudo-noise (PN) generator specified in CCITT V.33 Annex A. Although the generating polynomial used is as specified in CCITT V.33 Annex A, the process is different. The generating polynomial is $1 + X^{-18} + X^{-23}$. FIGURE J-3 shows the structure of the data scrambler and descrambler.

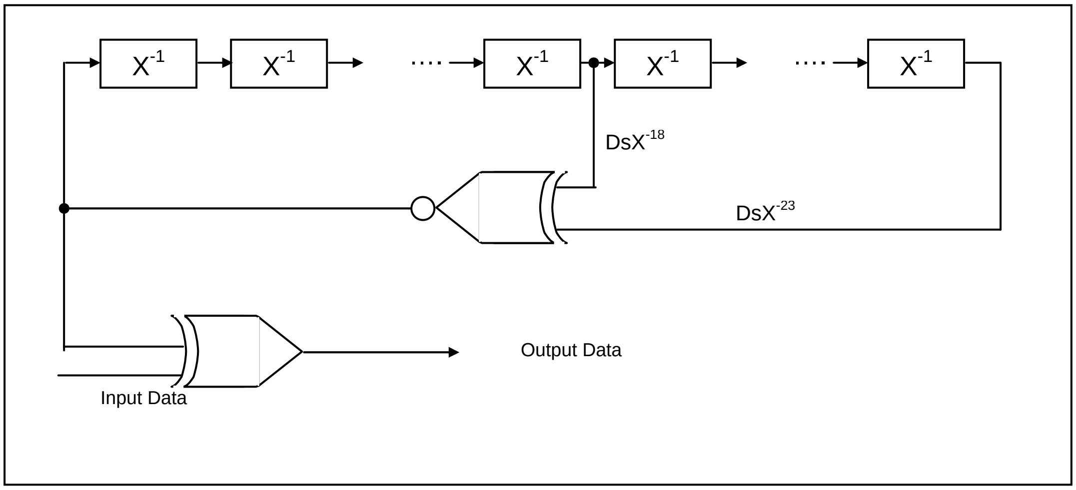


FIGURE J-3. Data scrambler structure.

The data sequence to be transmitted, D_{out} is formed as follows:

$$D_{out} = (D_{in}) \oplus \overline{((D_s X^{-18}) \oplus (D_s X^{-23}))}$$

|<---- pseudo noise (PN)---->|

Where D_{in} is the input data. The shift register D_s shall be initialized to zero before the first bit of data is scrambled on transmission. On data reception, the descrambler shift register D_s shall be initialized to zero before the first received data bit is descrambled.

Note: symbol ⊕ is XOR operand.

A ⊕ B is A **XOR** B.

$\overline{A \oplus B}$ is A **XNOR** B.

J.3.4 <u>Optional robust multi-dwell.</u>

J.3.4.1 <u>Multi-dwell packet format.</u>
When the HAVEQUICK II compatible radio is in active mode, multi-dwell packetizing shall be enabled. The multi-dwell packetizing described in this appendix assumes a physical level bit rate of 16 kbps. The format of each multi-dwell packet is shown in FIGURE J-4. Each packet consists of a start of packet (SOP) pattern and a segment counter followed by 6, 11 or 13 64-bit data segments.

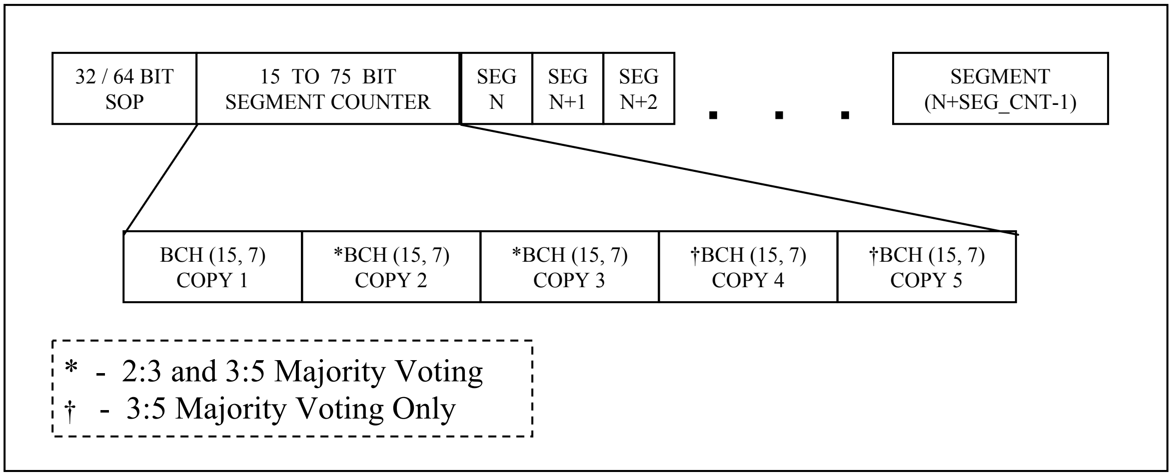


FIGURE J-4 Multi-dwell packet.

J.3.4.2 <u>Multi-dwell SOP field.</u>
The SOP pattern is a 32-bit (FIGURE J-5) or 64-bit (FIGURE J-6) pattern used for multi-dwell packet detection. The maximum number of bits in error should be set to match the bit error rate environment. For normal operation, it is recommended that the maximum number of bits in error be set to 13 for a 64-bit pattern, and to 3 for a 32-bit pattern. The length of the SOP pattern shall be determined by bits 2, 3 and 4 of the robust frame format.

MSB	**LSB**
1011101100110101011111100000100101100001010011110100011100100101	

FIGURE J-5. Multi-dwell 64-bit SOP pattern.

MSB	**LSB**
01110101110010010000100111000000	

FIGURE J-6. Multi-dwell 32-bit SOP pattern.

J.3.4.3 <u>Multi-dwell segment count field.</u>
The segment counter is a modulo 64 count of the first segment in the packet. The six required bits shall be encoded as 1, 3, or 5 BCH (15,7) codewords depending on bits 2, 3 and 4 of the robust frame format. The six-bit segment counter shall occupy the 6 LSBs of the seven-bit BCH data field. The MSB of the data field shall be used as an end-of-frame flag which, when set, indicates that data transmission is complete. A multi-dwell packet marked with an end-of-frame flag shall contain only the SOP pattern and the segment count field used to make the segment

number of the first fill data segment transmitted in the previous packet. If no fill data is included in the previous segment, the segment count field shall point to the last data segment plus one.

J.3.4.4 Multi-dwell data segments.
Each multi-dwell packet shall contain 6, 11 or 13 consecutive 64-bit data segments. Unless a channel interruption is detected during the transmission of the packet, each data segment shall contain the next 64 bits supplied by the data link layer for transmission. The last multi-dwell packet shall contain pad bits and segments as necessary to complete the packet. The transmitted pad data shall be an alternating one/zero sequence.

J.3.4.5 Multi-dwell hop detection.
The physical layer shall have the means of detecting or predicting communications link outages.

J.3.4.6 Multi-dwell transmit processing.
Data received from the data link layer for transmission shall be broken into 64 bit segments for transmission. The data shall be packetized as stated in J.3.4.1. Packets shall be transmitted consecutively with the segment count field containing the count, modulo 64, of the first segment in the packet until a communications link outage is detected, at which time, the remainder of the data segments in the currently transmitted packet shall be filled with an alternating one/zero pattern. The alternating one/zero pattern shall start soon enough to prevent a receiver from detecting a SOP header and segment count that would prematurely release segments that have been corrupted by a frequency hop. If the configurable hop recovery time (HRT), is greater than the time remaining to complete the transmission of the current packet, the alternating one/zero sequence shall be extended to the end of the HRT period. If a hop is detected during the multi-dwell SOP field, multi-dwell segment count field, or during the transmission of the first two segments, the entire multi-dwell packet shall be retransmitted. The first multi-dwell packet transmitted in a frame shall not contain the multi-dwell SOP field or multi-dwell segment count field. It is assumed that the segment count of the first packet is zero. The SOP and the segment count field shall not be transmitted during a possible frequency hop. The implementation shall develop an algorithm to establish when possible frequency hops may occur and adjust the timing of the data transmission to avoid transmitting a header during any possible hop. Refer to 3.3.4.6 (Code Generator) of JIEO Specification 9120A for guidance on developing a frequency hopping prediction algorithm.

J.3.4.6.1 Hop data recovery time period.
A configurable variable called the HRT shall be used to determine if the fill data transmitted following a hop shall be extended to ensure that the following multi-dwell synchronization field can be received. The HRT is defined as the time period from the beginning of the transmitting radio frequency (RF) synthesizer frequency hop to the time that the bit synchronizer connected to the receiving radio can reliably demodulate data. Because different hop detection/prediction methods flag the hop at different times relative to the beginning of the transmitting RF synthesizer frequency slew, the configured HRT shall be internally adjusted to insure that different DTEs in a network can all use the same configurable HRT.

J.3.4.6.2 Data transmitted after a hop.
The multi-dwell packet transmitted directly following a communications link outage shall retransmit data starting with the 64-bit segment preceding the segment that was being transmitted when the hop was detected plus sufficient segments to account for the transmitter pipeline delay if appropriate. If the radios are allowed to drift without being resynchronized by Time of Day (TOD) transfer or GPS reference it may also be necessary to repeat additional segments assuming that the transmitter is running slower than the receiver(s). Assuming a worst-case drift of 1 ppm in opposite directions, the transmitter may have to repeat an additional segment for each additional 30 minutes (3.6 msec) of drift.

J.3.4.6.3 Termination of transmission.
After the final packet of the frame is transmitted, without a hop detected during a data segment containing actual data (not fill data), data transmission shall be terminated. To prevent receive delays caused by the receiver not being able to determine that the last data segment has been received, a truncated multi-dwell packet shall be sent with the end-of-frame flag set. The segment count associated with the end-of-frame flag shall mark the first fill data segment transmitted. If no fill data is included in the previous segment, the segment count field shall point to the last segment data plus one. FIGURE J-7 depicts two examples of the last packet transmitted. In the first case, only three segments are included in the last frame of data (segments 100, 101, and 102) with the first segment being segment number 100. In this scenario, the segment header following the last frame to contain data will have the “last frame flag” bit set, and the segment counter will point to segment 103. In the second example, all the segments in the frame contain data (segment 100 through 105). The segment header following the last frame containing data will have the “last frame flag” bit set and the segment counter will point to segment 106. Note: In both examples, the TP timer shall be recalculated based upon reception of the last bit of the segment counter of the truncated multi-dwell packet.

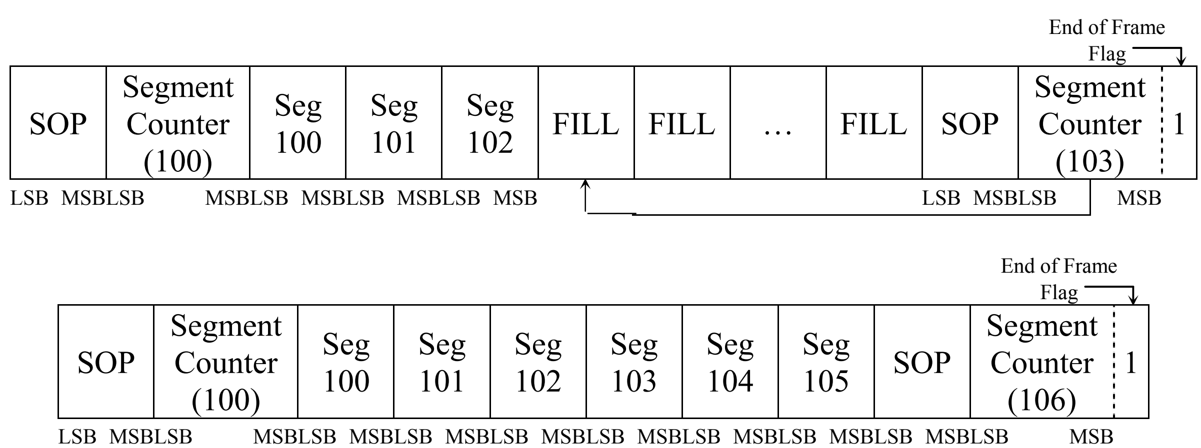


FIGURE J-7. Two transmission examples.

J.3.4.7 Multi-dwell receive processing.
If the multi-dwell flag was set in the robust synchronization field, the receiver shall buffer the multi-dwell data packet. The segment count for the first multi-dwell packet in a frame shall be assumed to be zero. After the last packet bit is received, the receiver shall open the SOP correlation window. When the SOP pattern is recognized, the segment count shall be decoded using the combination of majority and BCH decoding specified in the robust synchronization field. After each new segment count is decoded, the buffered data for data segments lower in count than the new segment count are passed on to the next higher layer as received bits. The segments of the newly received packet are then buffered and held until it is verified that the buffered segments will not be re-transmitted.

J.3.4.7.1 Receive end-of-frame detection.
The data remaining in the multi-dwell receive data buffer shall be provided to the higher-level protocol when an end-of-frame condition is detected. The end-of-frame condition shall be determined by the multi-dwell end-of-frame flag. If the end-of-frame flag is not detected before bit synchronization is lost then all buffered packets shall be released to the upper level protocol for receive processing.

J.3.4.7.2 Optional soft decision information.
When there is a very high link BER, a SOP pattern may not be recognized or the segment count may not be correctable. If fewer than three consecutive segment counts cannot be corrected the correct number of bits shall be supplied to the upper level protocol as to not cause a bit slip, and consequently, the loss of the remaining data in the frame. If additional forward error correction is used with multi-dwell, it is suggested that soft decision information is supplied indicating the low quality of the received data resulting from a missed SOP pattern or an unrecoverable segment count.

J.3.4.8 Multi-dwell majority logic overhead choice.
The choice of the amount of multi-dwell majority voting (MV) overhead is dependent on the expected link BER. TABLE J-II gives an estimate of the maximum random BER supported for a 90% probability of passing a single frame of length 1536 bits, 7680 bits, and 67,200 bits with no errors introduced due to multi-dwell processing.

TABLE J-II. Maximum supported BER.

Segment Count MV	1536	7680	67,200
1 out of 1	0.055	0.03	0.016
2 out of 3	0.14	0.11	0.07
3 out of 5	0.2	0.14	0.12

J.3.4.9 Multi-dwell overhead.
The multi-dwell protocol introduces an overhead that shall be considered in the network timing calculations. The overhead is a function of the radio hop rate, the multi-dwell segment count majority voting choice, and the message length. TABLE J-III gives the equation to calculate the actual worst-case realized data rate for each hop rate and majority logic combination. The numbers in TABLE J-III were run with a HRT of 15.625 msec, a maximum radio timing drift over a 1/2 hour period, an instantaneous data rate of 16000 bits/second. The actual efficiency will depend upon the exact implementation, therefore the numbers in TABLE J-III should be used as a guide only. The six-segment multi-dwell packet shall be used for protocol acknowledgments and other single TDC block messages. The calculated realized data rate shall be used for the bit rate of all data encapsulated by the multi-dwell protocol.

HOP RATE	TABLE-J-III. Multi-dwell overhead			
	MV 1:1, 11 segments	**MV 2:3, 13 segments**	**MV 3:5, 13 segments**	**MV 3:5, 6 segments**
0	$R/((0.3*10^{(-L*.00003)})+1.06)$	$R/((0.3*10^{(-L*.00003)})+1.16)$	$R/((0.2*10^{(-L*.00003)})+1.17)$	$R/((0.1*10^{(-L*.00003)})+1.36)$
1	$R/((0.6*10^{(-L*.00003)})+1.10)$	$R/((0.6*10^{(-L*.00003)})+1.21)$	$R/((.55*10^{(-L*.00003)})+1.23)$	$R/((0.3*10^{(-L*.00003)})+1.40)$
2	$R/((0.5*10^{(-L*.00003)})+1.15)$	$R/((0.5*10^{(-L*.00003)})+1.27)$	$R/((0.7*10^{(-L*.00003)})+1.30)$	$R/((0.4*10^{(-L*.00005)})+1.48)$
3	$R/((0.5*10^{(-L*.00003)})+1.20)$	$R/((0.4*10^{(-L*.00002)})+1.36)$	$R/((0.8*10^{(-L*.00003)})+1.29)$	$R/((0.2*10^{(-L*.00003)})+1.56)$
4	R/(1.45)	R/(1.51)	$R/((0.7*10^{(-L*.00002)})+1.46)$	$R/((.07*10^{(-L*.00002)})+1.85)$
ALL	R/(1.72)	R/(1.72)	R/(1.96)	R/(2.27)

R = the instantaneous data rate
L = the number of bits to be transmitted

J.3.4.9.1 Terminals lacking hop detection.
The ALL case in TABLE J-III is to show the efficiency of the multi-dwell protocol in systems where the hop cannot be detected due to hardware or software limitations. Since there is no hop timing information available, the DTE shall assume that the radio will hop at every possible time slot. In these systems, it is assumed that timing synchronization with the radio will be made by the detection of the falling edge of the radio delayed push to talk (DPTT) signal provided by the HAVEQUICK II compatible radio. However, the efficiency of systems that cannot detect and predict hops in HAVEQUICK II networks will severely limit the data throughput of those networks. Therefore, all DMTDs shall implement the capabilities to detect radio hops by monitoring the hop synch output signal from the HAVEQUICK II radio.

J.3.5 Robust communications protocol network timing.
The use of the robust communications protocol requires modification to some of the APPENDIX C Type 3 network timing equations. The bit rate, transmit delays, and receive processing delays are modified by the robust protocol. For purposes of robust network timing, two system bit rates

are defined. The first is the channel bit rate which is represented as n_c. The second is the data link bit rate which is represented as n_l. As an example, if rate 1/3 convolutional coding is applied at the physical layer and the channel bit rate is 16 kbps, the link bit rate would be 5.33 kbps. In this example, an external cryptographic device would transmit the MI field at n_c Hz and an internal cryptographic device would transmit the MI field at n_l Hz. The multi-dwell reduction of n_l is not deterministic but is bounded. The average multi-dwell n_l is a function of the multi-dwell packet format, the timing of the DTE transmit request in relation to the radio transmission security (TRANSEC) timing, and the number of bits to be transmitted. The following Type 3 network access control subfunctions are specified in APPENDIX C:

a. Network busy sensing

b. Response Hold Delay (RHD)

c. Timeout Period (TP)

d. Network Access Delay (NAD)

The following subparagraphs address required modifications to network timing equations associated with these subfunctions as a result of using the robust communications protocol.

J.3.5.1 Net busy sensing.
Because net busy sensing is performed at the physical level, there are no modifications to the net busy sensing timing or methods when using the robust communications protocol. However, users should be aware that equipment preamble times (EPRE) are much longer for COMSEC operation to account for the COMSEC delays when using HAVEQUICK II. The longer equipment preamble time will result in a significantly longer net busy detect time for COMSEC operation with HAVEQUICK II than for plain text operation with HAVEQUICK II.

J.3.5.2 Response hold delay.
The additional transmission time required for the Type 3 coupled acknowledgment due to the robust protocol and the TRANSEC delays are accounted for by inflating the response transmission time parameter (S) and the EPRE delay, contained in the RHD timing equation for RHD_0. Normally, a receiver is able to determine the length of a received message by decoding the robust frame format and message headers to determine the robust frame format and whether the message is using FEC or TDC and adjusting the transmit word count accordingly. For coupled responses, this information will be known ahead of time in order to reserve sufficient time for each response. Therefore, if it cannot be guaranteed that the entire acknowledgment can be transmitted on a single hop dwell all robust Type 3 coupled acknowledgments shall use the robust frame format 3 (MV 3:5, 6 segments). It should be noted that a multi-dwell format shall be used unless it is known that the current dwell is “long” because it cannot be assumed that network ELAG and HRT will allow a non multi-dwell acknowledgment on the shortest HAVEQUICK II dwell. All other characteristics of the response that will affect its length (e.g. FEC, TDC) are determined by the network configuration and shall be the same for all users. In

cases where the dwell length is not know, additional TRANSEC delays shall be accounted for by assuming the worst-case frequency hopping (Hop_All). In this case, each hop incurs a HRT delay plus a penalty for backing up and retransmitting two segments of data. From APPENDIX C, the RHD_0 is calculated as follows:

$$RHD_0 = EPRE + PHASING + S + ELAG + TURN + TOL$$

The actual value of S for acknowledgments is heavily dependent on the network HRT and the ability of the transmitting node to detect or predict hops. Worst-case S times for HRT values up to 25 msec for the six acknowledgment cases assuming the Hop_All case are given in TABLE J-IV. These approximate times, rounded to the nearest 5 msec, can be made much shorter in more optimum implementations.

TABLE J-IV. Multi-dwell acknowledgment times for Hop_All assumption.

ACK TYPE	S Value
80 bit no convolutional coding	100 msec
168 bit no convolutional coding	100 msec
384 bit no convolutional coding	160 msec
80 bit convolutional coding	225 msec
168 bit convolutional coding	225 msec
384 bit convolutional coding	350 msec

The maximum wait time before beginning any transmission is the maximum initial wait (one Hop_All interval) plus one hop recovery time for a final S time of:

$$S = S + (Hop\_All\ period) + HRT$$

J.3.5.2.1 Multi-dwell response.
Where multi-dwell is used to send the original message at a channel bit rate, n_c, of 16 Kbps, all responses (Type 3 acknowledgments) will be forced to use the robust frame format 3 (MV 3:5, 6 segments) as noted above unless the DTE knows that a single hop dwell will hold the entire acknowledgment. All nodes in a network shall use the configured EPRE value to determine if there will be a “long” dwell in which to transmit acknowledgments to determine which acknowledgment method to use for that network. A multi-dwell acknowledgment is always required when using an external crypto device.

J.3.5.2.2 Response transmission example.
FIGURE J-8 shows an example of the timing of an acknowledgment when an external cryptographic device is used with the HAVEQUICK II radio. The falling edge of the DPTT signal marks the beginning of a long hop dwell that is long enough to contain the crypto preamble time.

After the crypto has finished transmitting the MI field, the transmitting DTE begins to supply data for transmission. Typically, the COMSEC bit synchronization time is not very accurate and may be long enough to push the MI field to the end of the guaranteed "long" dwell time. For this reason, the DTE shall wait to start data transmission on the first hop dwell following the long guaranteed dwell. The end of the guaranteed hop dwell is marked by the first possible hop following the DPTT. The first bit of the robust start of message (SOM) pattern is transmitted after the configured HRT. During the transmission of the response, one or more hops may occur. When the response transmission is complete, the DTE de-asserts the transmit request signal. The radio will de-assert DPTT after a variable delay (ET_1) at a time synchronized with the hop sequence. After DPTT is de-asserted, the radio RF output remains active and a radio hop will not occur. This allows for the transmission of the crypto postamble. The radio RF output remains active for longer than is required for the transmission of the crypto postamble, which is shown as the ET_2 time period in FIGURE J-8. For HAVEQUICK II radios, ET_1, crypto postamble PLUS ET_2 equals the transmitter turnaround time, ($TTURN = ET_1 + ET_2$), as defined in APPENDIX C.

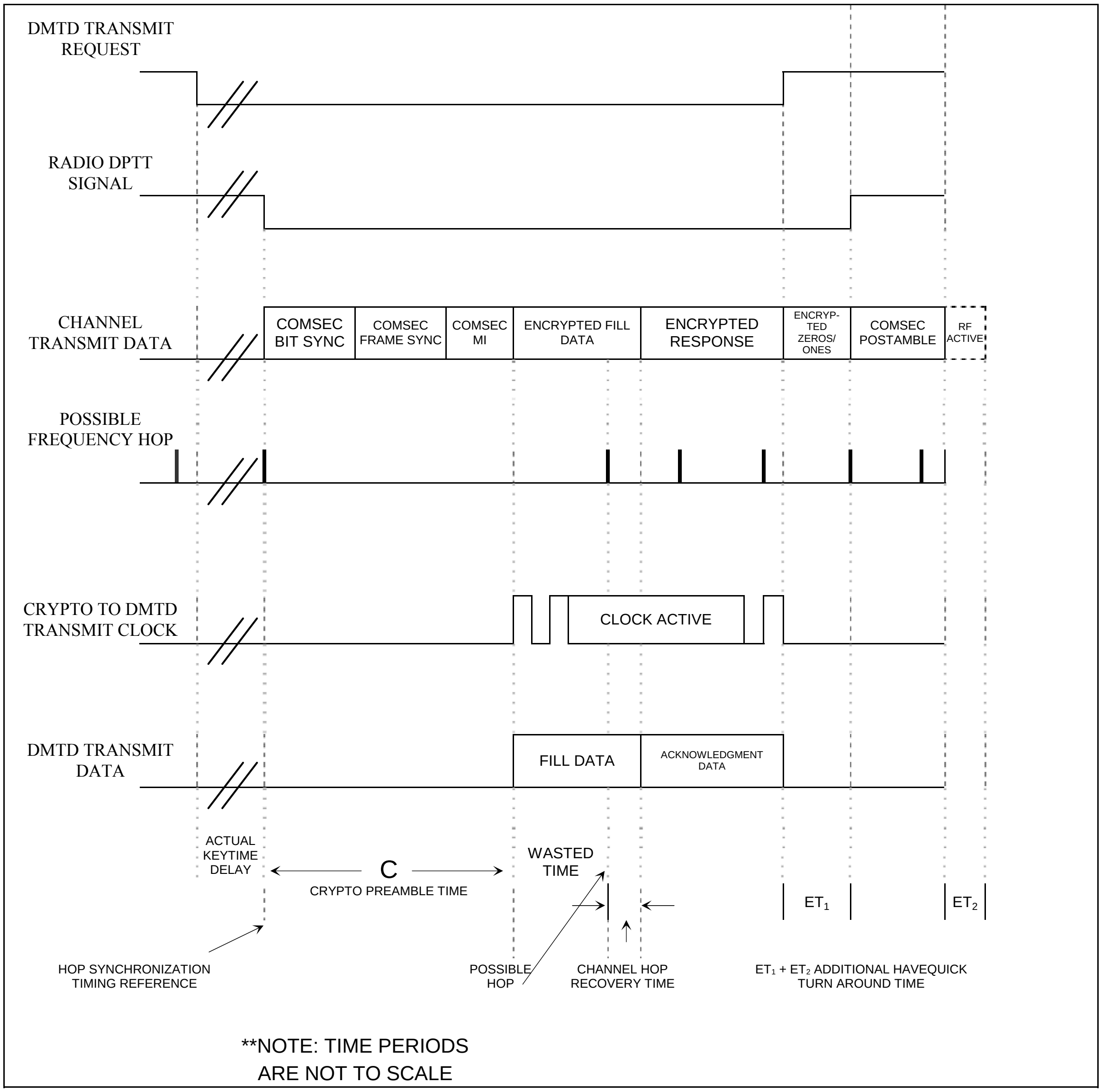


FIGURE J-8. HAVEQUICK II external crypto acknowledgment transmission.

J.3.5.2.3 Estimation of multi-dwell n_l.

FIGURE J-9 shows an example of the n_l data rate for a multi-dwell transmission with a channel data rate of 16 kbps. This is the worst case data rate reduction which would be experienced with rate 1/3 convolutional coding, a 64 bit SOP pattern length, and 3 out of 5 majority logic decoding of the segment count field for the specified HRT. The data rate shown FIGURE J-9 is the number of link bits to transmit divided by the number of channel bits transmitted times the n_c. Since rate 1/3 convolutional encoding is used in this example, the maximum link data rate achievable would be 5.33 kbps. For short messages, the radio hop timing at the beginning of the transmission has a significant impact on the transmission efficiency. This example uses 13 segments per packet which is the recommended segment per packet count for long transmissions using 3 out of 5 majority logic. This figure and the equations given in TABLE J-III are given as an aid for network throughput estimation and should not be used for network timing. The bit rate estimating equation used in FIGURE J-3 is:

$$\text{link rate} = n_c / (0.5*10^{(\text{-link bits} * .00003)} + 1.301)$$

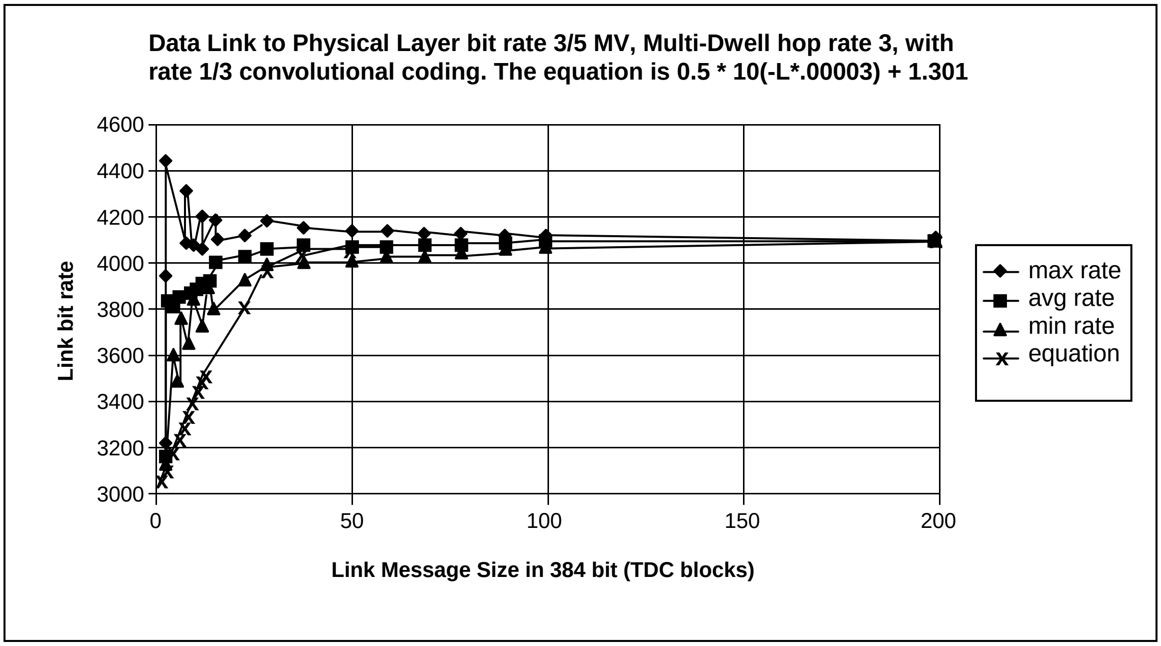


FIGURE J-9. Link data rate as a function of message size.

J.3.5.2.4 Receive processing delays.
In order to calculate the reference point for the RHD and TP timers, the receiving DTE shall know the time of arrival of the last bit of the transmission. In order to do this, the data link layer normally determines the last bit of the transmission after decoding the word count and tags the arrival of the last data bit from the physical layer. The physical layer receive delays are dependent on the DTE hardware and software implementation. The two delay components are processing delays and data pipeline delays. The processing delays are independent of the received data rate and the pipeline delays are dependent on the data rate. The data rate of all non-multi-dwell transmissions is known to be either n_c or $n_c/3$ dependent on the use of rate 1/3 convolutional coding. The received data rate of a multi-dwell transmission is not known. For this reason, when a multi-dwell transmission is received, the physical layer shall tag the time of arrival of the final multi-dwell bit. The physical layer can determine the time of arrival of the last bit by using the end-of-frame flag which is the MSB in the final multi-dwell segment count field. A logical signal from the physical layer to the data link layer indicating the message

completion time is required to insure that the transmitter and receiver(s) use the same reference point for the calculation of RHD and TP.

The trace back buffer length of the Viterbi decoder introduces a known pipeline delay in the received data that will be accounted for in the network ELAG. The length of the trace back buffer is an implementation choice which is dependent on the Viterbi decoder architecture. Pipeline delay is the time needed to flush the trace back buffer.

J.3.5.3 Timeout period (TP).
The timeout period is derived from the same equations as described in APPENDIX C. Modifications to the timeout period are the result of changes to RHD_0 and DTE receive processing delays, which have been addressed in J.3.5.2 and its subparagraphs.

J.3.5.4 Network access delay (NAD).
There are no modifications to the network timing equations associated network access delay. The network access delay is always an integer number times the Net_Busy_Detect_Time which, as previously discussed, has not been modified but could be significantly longer due to extended equipment preamble times, especially for COMSEC operation with HAVEQUICK II.

J.3.6 Application guidance for the HAVEQUICK II link.

J.3.6.1 Frequency hop synchronization.
The HAVEQUICK II TRANSEC timing and the DTE network timing are not synchronized. To avoid the loss of critical data, such as the cryptographic synchronization and/or the protocol SOM patterns, the DTE transmission timing shall be synchronized to the frequency hops through use of hop detection and prediction.

J.3.7 Summary.
The physical layer robust protocol introduces additional transmit and receive delays due to the robust header and the convolutional decoding pipeline delays. Multi-dwell packetizing introduces a data rate reduction which varies widely for short transmissions. The HAVEQUICK II radio introduces variable delays in the keytime delay and the equipment turn-around time. To maintain network timing using the Type 3 timing equations, the RHD shall be extended by inflating the S time for a fixed Type 3 acknowledgment transmit frame format for multi-dwell operation assuming the worst case hop rate (Hop_All). Since the message transmission time is variable, the time-out period (TP) sync point shall be figured from the final frame flag at the end of the transmission.

J.4 PDU construction.

The following examples shall be used to clarify robust PDU transmission order and processing order (i.e. scrambling, convolutional coding, and formation of packets). The robust protocol consists of three parts: (1) robust PDU header – robust frame synchronization and setting of the robust frame format, (2) the PL scrambled or unscrambled and/or convolutional coded user data and (3) SOPs and segment counters to form packets in accordance with the setting of the multi-dwell transmission format when the multi-dwell protocol is implemented. In this example, the MSB (2^n bit) of each octet of user data and the MSB of each field is represented with an italicized font. FIGURE J-10 shows the processing order with convolutional code disabled, no multi-dwell hope detection and no link outage. The main figure is shown as FIGURE J-10. For clarity purpose FIGURE J-10 is broken in two parts at the dotted line and shown as FIGURE J-11 and FIGURE J-12. The connection points are shown as A, B, C and D in FIGURE J-11 and FIGURE J-12 at the broken section in FIGURE J-10.

J.4.1 Robust PDU header.

The robust PDU header consists of two parts: (1) robust frame synchronization pattern (see FIGURE 7) and (2) setting of the robust frame format (RFF) (see TABLE I, TABLE II and TABLE III). The robust PDU header shall be inserted first when implementing Robust Communications Protocol. The robust frame format shall be formatted with multi-dwell majority vote 3 out of 5 BCH [15, 7] coding. The examples show the differences based on the multi-dwell flag settings to append the rest of the data.

J.4.2 User data.

The input to the robust protocol is a MIL-STD-188-220 DL PDU. The DL PDU is user data to the N-1 layer (i.e. robust protocol). PL scrambling and convolutional coding shall be applied to the user data if selected in the robust frame format. When the robust frame format selects both scrambling and convolutional coding, the user data is scrambled before the user data is convolutional coded. The LSB of each octet passed from the data shall be transmitted first. However, in the following examples, PL scrambling and convolutional coding are not selected, the user data is not a real DL PDU which reduces coupling between changes in the MIL-STD-188-220 frame and this example. The example user data is an array of octets counting down 49 – 0.

J.4.3 Multi-dwell flag set.

The multi-dwell protocol (MDP) is the main component of the Robust Communication Protocol (RCP). The multi-dwell flag shall be set in the robust frame format (RFF) if MDP is implemented. Either PL scrambled or unscrambled, and/or convolutional coded user data shall be divided into 64-bit segments. Based on the Multi-dwell Transmission Format (MDTF) setting, these segments shall be packed into 6, 11, or 13 segment groups. Then, a packet shall be formed by appending the SOP and the segment counter to the end of the group. BCH [15,7] shall be applied to the segment counter prior to appending. The number of BCH [15, 7] copies, 32-bit or 64-bit SOP pattern, and the number of segments per packet are determined by the MDTF setting. An example of the robust transmission with MDTF=3 (64-bit SOP, MV 3:5, 6 segments), no PL scrambling, no convolutional coding and without a hop occurring is shown in TABLE J-V.

TABLE J-V. Robust protocol example with multi-dwell flag set

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^7 LSB 2^0	MSB 2^7 LSB 2^0		
Robust Frame Syn	64		*0*0011100 01111010 10110110 01000000 11111101 10110111 00110011 10010010		10010010 00110011 10110111 11111101 01000000 10110110 01111010 *0*0011100	0x92 0x33 0xB7 0xFD 0x40 0xB6 0x7A 0x1C	0 1 2 3 4 5 6 7
1 of 5							
Multi-dwell Flag	1	1	*1*	xxxxxxx*1*			
Scrambling	1	0 (no scramble)	*0*	xxxxxx*0*x			
Multi-dwell Tx Format	3	3	*011*	xxx*011*xx			
Convolution Coding Constraint length	2	3 (disabled)	*11*	x*11*xxxxx			
BCH(15,7)	8		*1*0110110	0xxxxxxx x*1*011011	0*1*101101	0x6D	8
2 of 5							
Multi-dwell Flag	1	1	*1*	*1*xxxxxxx	*1*1011011	0xDB	9
Scrambling	1	0	*0*	xxxxxxx*0*			
Multi-dwell Tx Format	3	3	*011*	xxxx*011*x			
Convolution Coding Constraint length	2	3	*11*	xx*11*xxxx			
BCH(15,7)	8		*1*0110110	10xxxxxx xx*1*01101	10*110110*	0xB6	10
3 of 5							
Multi-dwell Flag	1	1	*1*	x*1*xxxxxx			

TABLE J-V. Robust protocol example with multi-dwell flag set-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^7 LSB 2^0	MSB 2^7 LSB 2^0		
Scrambling	1	0	*0*	0xxxxxxx	0*1*101101	0x6D	11
Multi-dwell Tx Format	3	3	*011*	xxxxx*011*			
Convolution Coding Constraint length	2	3	*11*	xxx*11*xxx			
BCH(15,7)	8		*1*0110110	110xxxxx xxx*1*0110	110*11*011	0xDB	12
4 of 5							
Multi-dwell Flag	1	1	*1*	xx*1*xxxxx			
Scrambling	1	0	*0*	x*0*xxxxxx			
Multi-dwell Tx Format	3	3	*011*	1xxxxxxx xxxxxx*01*	1*011*0110	0xB6	13
Convolution Coding Constraint length	2	3	*11*	xxxx*11*xx			
BCH(15,7)	8		*1*0110110	0110xxxx xxxx*1*011	0110*1*101	0x6D	14
5 of 5							
Multi-dwell Flag	1	1	*1*	xxx*1*xxxx			
Scrambling	1	0	*0*	xx*0*xxxxx			
Multi-dwell Tx Format	3	3	*011*	11xxxxxx xxxxxxx*0*	11*011*011	0xDB	15
Convolution Coding Constraint length	2	3	*11*	xxxxx*11*x			
BCH(15,7)	8		*1*0110110	10110xxx xxxxx*101*	10110*110*	0xB6	16
User data octet 1 (seg 0)	8	49	*0*0110001	10001xxx xxxxx*001*	10001101	0x8D	17
User data octet 2 (seg 0)	8	48	*0*0110000	10000xxx xxxxx*001*	10000*001*	0x81	18
User data octet 3 (seg 0)	8	47	*0*0101111	01111xxx xxxxx*001*	01111001	0x79	19
User data octet 4 (seg 0)	8	46	*0*0101110	01110xxx xxxxx*001*	01110*001*	0x71	20

TABLE J-V. Robust protocol example with multi-dwell flag set-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^7 LSB 2^0	MSB 2^7 LSB 2^0		
User data octet 5 (seg 0)	8	45	*0*0101101	01101xxx xxxxx*0*01	01101*0*01	0x69	21
User data octet 6 (seg 0)	8	44	*0*0101100	01100xxx xxxxx*0*01	01100*0*01	0x61	22
User data octet 7 (seg 0)	8	43	*0*0101011	01011xxx xxxxx*0*01	01011*0*01	0x59	23
User data octet 8 (seg 0)	8	42	*0*0101010	01010xxx xxxxx*0*01	01010*0*01	0x51	24
User data octet 9 (seg 1)	8	41	*0*0101001	01001xxx xxxxx*0*01	01001*0*01	0x49	25
User data octet 10 (seg 1)	8	40	*0*0101000	01000xxx xxxxx*0*01	01000*0*01	0x41	26
User data octet 11 (seg 1)	8	39	*0*0100111	00111xxx xxxxx*0*01	00111*0*01	0x39	27
User data octet 12 (seg 1)	8	38	*0*0100110	00110xxx xxxxx*0*01	00110*0*01	0x31	28
User data octet 13 (seg 1)	8	37	*0*0100101	00101xxx xxxxx*0*01	00101*0*01	0x29	29
User data octet 14 (seg 1)	8	36	*0*0100100	00100xxx xxxxx*0*01	00100*0*01	0x21	30
User data octet 15 (seg 1)	8	35	*0*0100011	00011xxx xxxxx*0*01	00011*0*01	0x19	31
User data octet 16 (seg 1)	8	34	*0*0100010	00010xxx xxxxx*0*01	00010*0*01	0x11	32
User data octet 17 (seg 2)	8	33	*0*0100001	00001xxx xxxxx*0*01	00001*0*01	0x09	33
User data octet 18 (seg 2)	8	32	*0*0100000	00000xxx xxxxx*0*01	00000*0*01	0x01	34
User data octet 19 (seg 2)	8	31	*0*0011111	11111xxx xxxxx*0*00	11111*0*00	0xF9	35
User data octet 20 (seg 2)	8	30	*0*0011110	11110xxx xxxxx*0*00	11110*0*00	0xF0	36
User data octet 21 (seg 2)	8	29	*0*0011101	11101xxx xxxxx*0*00	11101*0*00	0xE8	37
User data octet 22 (seg 2)	8	28	*0*0011100	11100xxx xxxxx*0*00	11100*0*00	0xE0	38

TABLE J-V. Robust protocol example with multi-dwell flag set-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^7 LSB 2^0	MSB 2^7 LSB 2^0		
User data octet 23 (seg 2)	8	27	*0*0011011	11011xxx xxxxx*000*	11011*000*	0xD8	39
User data octet 24 (seg 2)	8	26	*0*0011010	11010xxx xxxxx*000*	11010*000*	0xD0	40
User data octet 25 (seg 3)	8	25	*0*0011001	11001xxx xxxxx*000*	11001*000*	0xC8	41
User data octet 26 (seg 3)	8	24	*0*0011000	11000xxx xxxxx*000*	11000*000*	0xC0	42
User data octet 27 (seg 3)	8	23	*0*0010111	10111xxx xxxxx*000*	10111*000*	0xB8	43
User data octet 28 (seg 3)	8	22	*0*0010110	10110xxx xxxxx*000*	10110*000*	0xB0	44
User data octet 29 (seg 3)	8	21	*0*0010101	10101xxx xxxxx*000*	10101*000*	0xA8	45
User data octet 30 (seg 3)	8	20	*0*0010100	10100xxx xxxxx*000*	10100*000*	0xA0	46
User data octet 31 (seg 3)	8	19	*0*0010011	10011xxx xxxxx*000*	10011*000*	0x98	47
User data octet 32 (seg 3)	8	18	*0*0010010	10010xxx xxxxx*000*	10010*000*	0x90	48
User data octet 33 (seg 4)	8	17	*0*0010001	xxx10001 xxxxx*000*	10001*000*	0x88	49
User data octet 34 (seg 4)	8	16	*0*0010000	10000xxx xxxxx*000*	10000*000*	0x80	50
User data octet 35 (seg 4)	8	15	*0*0001111	01111xxx xxxxx*000*	01111*000*	0x78	51
User data octet 36 (seg 4)	8	14	*0*0001110	xxx01110 xxxxx*000*	01110*000*	0x70	52
User data octet 37 (seg 4)	8	13	*0*0001101	01101xxx xxxxx*000*	01101*000*	0x68	53
User data octet 38 (seg 4)	8	12	*0*0001100	01100xxx xxxxx*000*	01100*000*	0x60	54
User data octet 39 (seg 4)	8	11	*0*0001011	01011xxx xxxxx*000*	01011*000*	0x58	55
User data octet 40 (seg 4)	8	10	*0*0001010	01010xxx xxxxx*000*	01010*000*	0x50	56

TABLE J-V. Robust protocol example with multi-dwell flag set-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^7 LSB 2^0	MSB 2^7 LSB 2^0		
User data octet 41 (seg 5)	8	9	00001001	01001xxx xxxxx000	01001000	0x48	57
User data octet 42 (seg 5)	8	8	00001000	01000xxx xxxxx000	01000000	0x40	58
User data octet 43 (seg 5)	8	7	00000111	00111xxx xxxxx000	00111000	0x38	59
User data octet 44 (seg 5)	8	6	00000110	00110xxx xxxxx000	00110000	0x30	60
User data octet 45 (seg 5)	8	5	00000101	00101xxx xxxxx000	00101000	0x28	61
User data octet 46 (seg 5)	8	4	00000100	00100xxx xxxxx000	00100000	0x20	62
User data octet 47 (seg 5)	8	3	00000011	00011xxx xxxxx000	00011000	0x18	63
User data octet 48 (seg 5)	8	2	00000010	00010xxx xxxxx000	00010000	0x10	64
SOP	64		10111011 00110101 01111110 00001001 01100001 01001111 01000111 00100101	00101xxx 00111001 01111010 00001010 01001011 11110000 10101011 11011001 xxxxx101	00101000 00111001 01111010 00001010 01001011 11110000 10101011 11011001	0x28 0x39 0x7A 0x0A 0x4B 0xF0 0xAB 0xD9	65 66 67 68 69 70 71 72
Segment Counter BCH 1 of 5							
Segment Counter	6	6	000110	00110xxx xxxxxxx0	00110101	0x35	73
Segment Counter Final Seg Flag	1	0	0	xxxxxx0x			
Segment Counter BCH	8		01110010	110010xx xxxxxx01	11001000	0xC8	74
Segment Counter BCH 2 of 5							
Segment Counter	6	6	000110	000110xx	00011001	0x19	75

TABLE J-V. Robust protocol example with multi-dwell flag set-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^7 LSB 2^0	MSB 2^7 LSB 2^0		
Segment Counter Final Seg Flag	1	0	*0*	xxxxxxx*0*			
Segment Counter BCH	8		*0*1110010	1110010x xxxxxxx*0*	1110010*0*	0xE4	76
Segment Counter BCH 3 of 5							
Segment Counter	6	6	*0*00110	x*0*00110x			
Segment Counter Final Seg Flag	1	0	*0*	*0*xxxxxxx	*0*000110*0*	0x0C	77
Segment Counter BCH	8		*0*1110010	*0*1110010	*0*1110010	0x72	78
Segment Counter BCH 4 of 5							
Segment Counter	6	6	*0*00110	xx*0*00110			
Segment Counter Final Seg Flag	1	0	*0*	x*0*xxxxxx			
Segment Counter BCH	8		*0*1110010	0xxxxxxx x*0*111001	0*0*000110	0x06	79
Segment Counter BCH 5 of 5							
Segment Counter	6	6	*0*00110	0xxxxxxx xxx*0*0011	0*0*111001	0x39	80
Segment Counter Final Seg Flag	1	0	*0*	xx*0*xxxxx			
Segment Counter BCH	8		*0*1110010	10xxxxxx xx*0*11100	10*0*00011	0x83	81
User data octet 49 (seg 6)	8	1	*0*0000001	01xxxxxx xx*0*00000	01*0*11100	0x5C	82
User data octet 50 (seg 6)	8	0	*0*0000000	00xxxxxx xx*0*00000	00*0*00000	0x00	83
Fill (seg 6)	8		*0*1010101	01xxxxxx xx*0*10101	01*0*00000	0x40	84
Fill (seg 6)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	85
Fill (seg 6)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	86

TABLE J-V. Robust protocol example with multi-dwell flag set-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^7 LSB 2^0	MSB 2^7 LSB 2^0		
Fill (seg 6)	8		01010101	01xxxxxx xx010101	01010101	0x55	87
Fill (seg 6)	8		01010101	01xxxxxx xx010101	01010101	0x55	88
Fill (seg 6)	8		01010101	01xxxxxx xx010101	01010101	0x55	89
Fill (seg 7)	8		01010101	01xxxxxx xx010101	01010101	0x55	90
Fill (seg 7)	8		01010101	01xxxxxx xx010101	01010101	0x55	91
Fill (seg 7)	8		01010101	01xxxxxx xx010101	01010101	0x55	92
Fill (seg 7)	8		01010101	01xxxxxx xx010101	01010101	0x55	93
Fill (seg 7)	8		01010101	01xxxxxx xx010101	01010101	0x55	94
Fill (seg 7)	8		01010101	01xxxxxx xx010101	01010101	0x55	95
Fill (seg 7)	8		01010101	01xxxxxx xx010101	01010101	0x55	96
Fill (seg 7)	8		01010101	01xxxxxx xx010101	01010101	0x55	97
Fill (seg 8)	8		01010101	01xxxxxx xx010101	01010101	0x55	98
Fill (seg 8)	8		01010101	01xxxxxx xx010101	01010101	0x55	99
Fill (seg 8)	8		01010101	01xxxxxx xx010101	01010101	0x55	100
Fill (seg 8)	8		01010101	01xxxxxx xx010101	01010101	0x55	101
Fill (seg 8)	8		01010101	01xxxxxx xx010101	01010101	0x55	102
Fill (seg 8)	8		01010101	01xxxxxx xx010101	01010101	0x55	103
Fill (seg 8)	8		01010101	01xxxxxx xx010101	01010101	0x55	104

TABLE J-V. Robust protocol example with multi-dwell flag set-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^7 LSB 2^0	MSB 2^7 LSB 2^0		
Fill (seg 8)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	105
Fill (seg 9)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	106
Fill (seg 9)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	107
Fill (seg 9)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	108
Fill (seg 9)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	109
Fill (seg 9)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	110
Fill (seg 9)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	111
Fill (seg 9)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	112
Fill (seg 9)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	113
Fill (seg 10)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	114
Fill (seg 10)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	115
Fill (seg 10)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	116
Fill (seg 10)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	117
Fill (seg 10)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	118
Fill (seg 10)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	119
Fill (seg 10)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	120
Fill (seg 10)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	121
Fill (seg 11)	8		01010101	01xxxxxx xx*0*10101	01*0*10101	0x55	122

TABLE J-V. Robust protocol example with multi-dwell flag set-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^7 LSB 2^0	MSB 2^7 LSB 2^0		
Fill (seg 11)	8		01010101	01xxxxxx xx010101	01010101	0x55	123
Fill (seg 11)	8		01010101	01xxxxxx xx010101	01010101	0x55	124
Fill (seg 11)	8		01010101	01xxxxxx xx010101	01010101	0x55	125
Fill (seg 11)	8		01010101	01xxxxxx xx010101	01010101	0x55	126
Fill (seg 11)	8		01010101	01xxxxxx xx010101	01010101	0x55	127
Fill (seg 11)	8		01010101	01xxxxxx xx010101	01010101	0x55	128
Fill (seg 11)	8		01010101	01xxxxxx xx010101	01010101	0x55	129
SOP	64		10111011 00110101 01111110 00001001 01100001 01001111 01000111 00100101	01xxxxxx 11001001 11010001 01010011 01011000 10000010 01011111 11001101 xx101110	01010101 11001001 11010001 01010011 01011000 10000010 01011111 11001101	0x55 0xC9 0xD1 0x53 0x58 0x82 0x5F 0xCD	130 131 132 133 134 135 136 137
Segment Counter BCH 1 of 5							
Segment Counter	6	7	000111	11xxxxxx xxxx0001	11101110	0xEE	138
Segment Counter Final Seg Flag	1	1	1	xxx1xxxx			
Segment Counter BCH	8		11101110	110xxxxx xxx11101	11010001	0xD1	139
Segment Counter BCH 2 of 5							
Segment Counter	6	7	000111	111xxxxx xxxxx000	11111101	0xFD	140

TABLE J-V. Robust protocol example with multi-dwell flag set-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^7 LSB 2^0	MSB 2^7 LSB 2^0		
Segment Counter Final Seg Flag	1	1	*1*	xxxx*1*xxx			
Segment Counter BCH	8		*1*1101110	1110xxxx xxxx*1*110	*1*110*1*000	0xE8	141
Segment Counter BCH 3 of 5							
Segment Counter	6	7	*0*00111	0111xxxx xxxxxx*0*0	0111*1*110	0x7E	142
Segment Counter Final Seg Flag	1	1	*1*	xxxxx*1*xx			
Segment Counter BCH	8		*1*1101110	01110xxx xxxxx*1*11	01110*1*00	0x74	143
Segment Counter BCH 4 of 5							
Segment Counter	6	7	*0*00111	00111xxx xxxxxxx*0*	00111*1*11	0x3F	144
Segment Counter Final Seg Flag	1	1	*1*	xxxxxx*1*x			
Segment Counter BCH	8		*1*1101110	101110xx xxxxxx*1*1	101110*1*0	0xBA	145
Segment Counter BCH 5 of 5							
Segment Counter	6	7	*0*00111	*0*00111xx	*0*00111*1*1	0x1F	146
Segment Counter Final Seg Flag	1	1	*1*	xxxxxxx*1*			
Segment Counter BCH	8		*1*1101110	1101110x xxxxxxx*1*	1101110*1* xxxxxxx*1*	0xDD	147 148

J.4.4 Multi-dwell flag not set.
When the multi-dwell flag is zero the data shall not be put into packets. Only the robust frame synchronization field and robust frame format shall be inserted and PL scrambling, and/or convolutional coding can be applied to the user data. An example of the robust transmission without MDP, no PL scrambling, no convolutional coding is shown in TABLE J-VI.

TABLE J-VI. Robust protocol example with multi-dwell flag not set.

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^7 LSB 2^0	MSB 2^7 LSB 2^0		
Robust Frame Syn	64		*0*0011100		10010010	0x92	0
			01111010		00110011	0x33	1
			10110110		10110111	0xB7	2
			01000000		11111101	0xFD	3
			11111101		01000000	0x40	4
			10110111		10110110	0xB6	5
			00110011		01111010	0x7A	6
			10010010		*0*0011100	0x1C	7
1 of 5							
Multi-dwell Flag	1	0	*0*	xxxxxxx*0*			
Scrambling	1	1 (scramble)	*1*	xxxxxx*1*x			
Multi-dwell Tx Format	3	0 (N/A)	*000*	xxx*000*xx			
Convolution Coding Constraint length	2	3 (disabled)	*11*	x*11*xxxxx			

TABLE J-VI. Robust protocol example with multi-dwell flag not set-Continued

Field Name	**Length (bits)**	**Value (Dec)**	**Value (Binary)**	**Field Fragments**	**Octet Value (Binary)**	**Octet Value (Hex)**	**Octet Number**
			MSB LSB **2^n 2^0**	**MSB LSB** **2^7 2^0**	**MSB LSB** **2^7 2^0**		
BCH(15,7)	8		01101011	1xxxxxxx x0110101	11100010	0xE2	8
2 of 5							
Multi-dwell Flag	1	0	0	0xxxxxxx	00110101	0x35	9
Scrambling	1	1	1	xxxxxxx1			
Multi-dwell Tx Format	3	0	000	xxxx000x			
Convolution Coding Constraint length	2	3	11	xx11xxxx			
BCH(15,7)	8		01101011	11xxxxxx xx011010	11110001	0xF1	10
3 of 5							
Multi-dwell Flag	1	0	0	x0xxxxxx			
Scrambling	1	1	1	1xxxxxxx	10011010	0x9A	11
Multi-dwell Tx Format	3	0	000	xxxxx000			
Convolution Coding Constraint length	2	3	11	xxx11xxx			
BCH(15,7)	8		01101011	011xxxxx xxx01101	01111000	0x78	12
4 of 5							
Multi-dwell Flag	1	0	0	xx0xxxxx			
Scrambling	1	1	1	x1xxxxxxx			
Multi-dwell Tx Format	3	0	000	0xxxxxxx xxxxxx00	01001101	0x4D	13
Convolution Coding Constraint length	2	3	11	xxxx11xx			
BCH(15,7)	8		01101011	1011xxxx xxxx0110	10111100	0xBC	14
5 of 5							
Multi-dwell Flag	1	0	0	xxx0xxxx			
Scrambling	1	1	1	xx1xxxxx			

TABLE J-VI. Robust protocol example with multi-dwell flag not set-Continued

Field Name	Length (bits)	Value (Dec)	Value (Binary)	Field Fragments	Octet Value (Binary)	Octet Value (Hex)	Octet Number
			MSB 2^n LSB 2^0	MSB 2^7 LSB 2^0	MSB 2^7 LSB 2^0		
Multi-dwell Tx Format	3	0	*000*	00xxxxxx xxxxxxx*0*	00*100*110	0x26	15
Convolution Coding Constraint length	2	3	*11*	xxxxx*11*x			
BCH(15,7)	8		*01101011*	01011xxx xxxxx*011*	01011*110*	0x5E	16
User data octet 1	8	49	*00110001* *	10001xxx xxxxx*001*	10001*011*	0x8B	17
….							
User data octet 50	8	0	*00000000* *	00000xxx xxxxx*000*			66 67

*Note: User data not scrambled for clarity

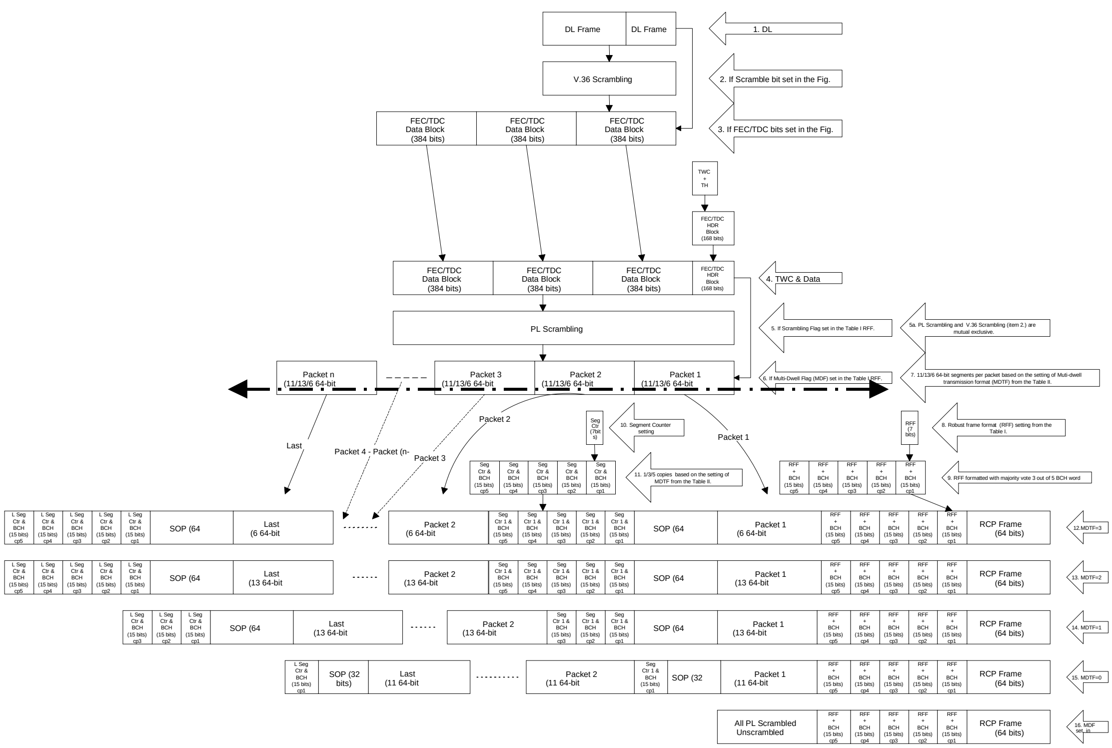


FIGURE J-10. Robust PDU Construction

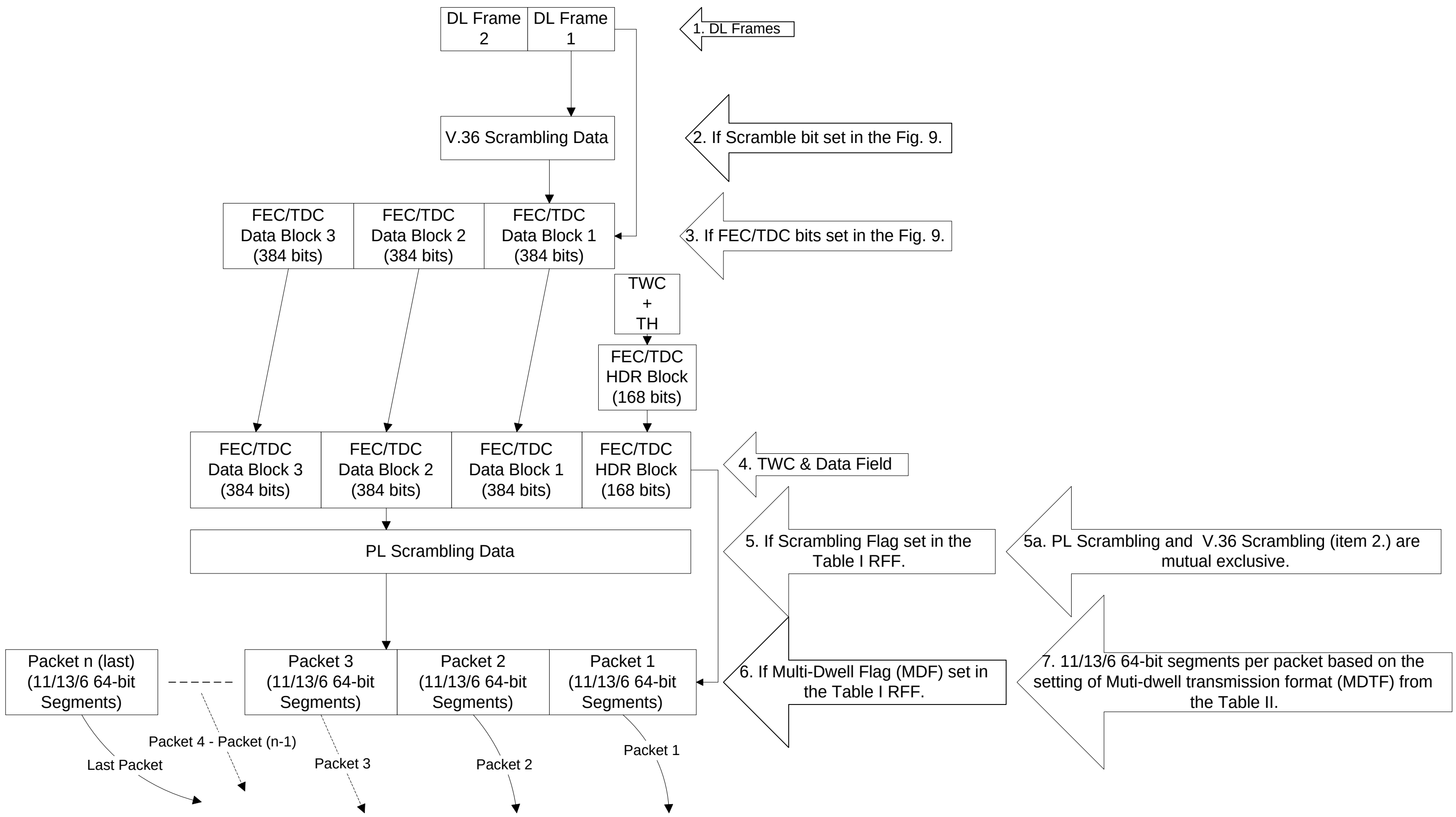


FIGURE J-11. Robust PDU Construction (Top Part).

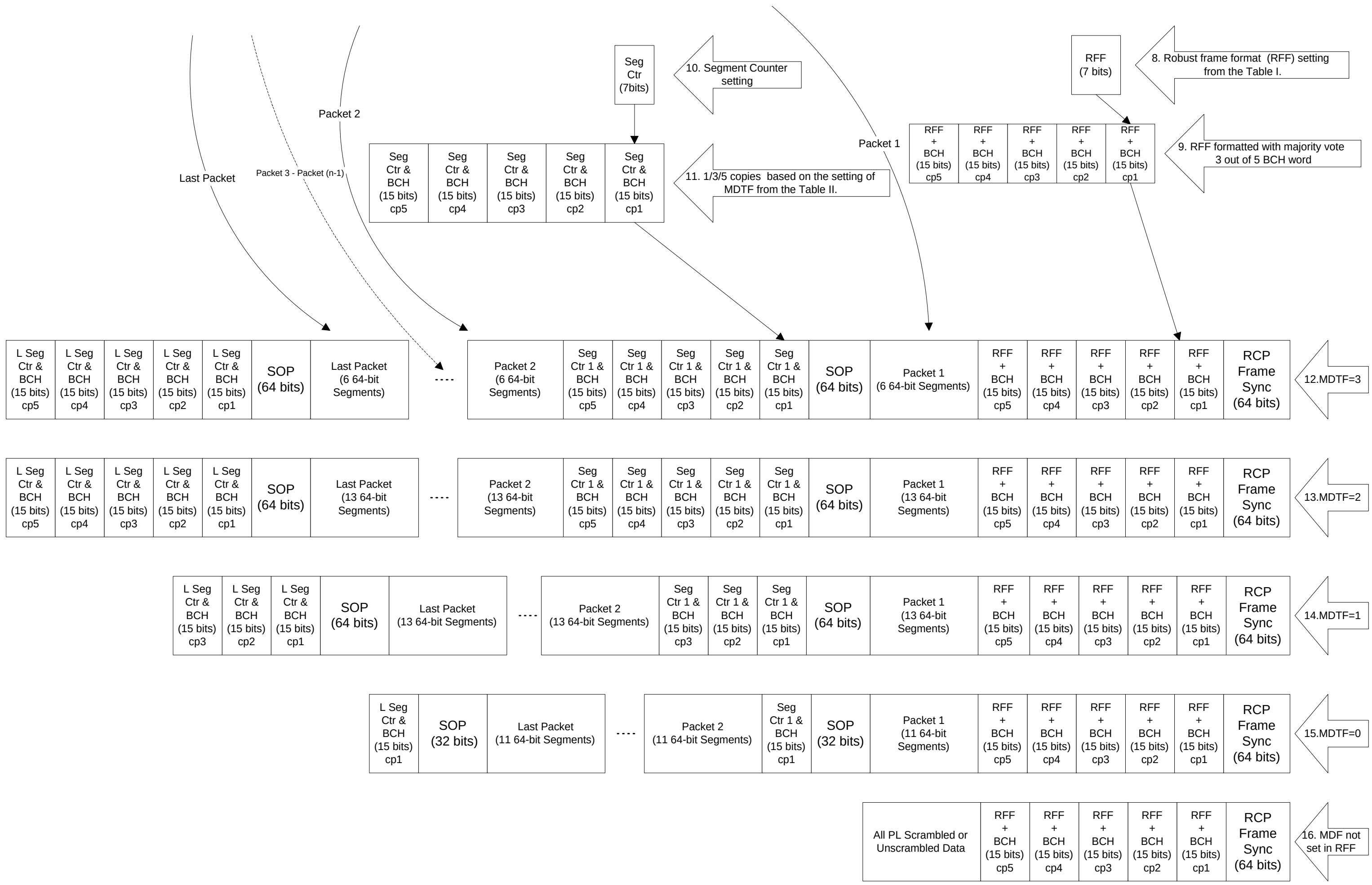


FIGURE J-12. Robust PDU Construction (Bottom Part).

APPENDIX K

BOSE - CHAUDHURI - HOCQUENGHEM (15,7) CODING ALGORITHM

K.1 General.

K.1.1 Scope.

This appendix describes a linear block cyclic code capable of correcting any combination of two or fewer errors in a block of 15 bits.

K.1.2 Application.

This appendix is a conditionally mandatory part of MIL-STD-188-220. It is mandatory for implementing the Robust Communications Protocol described in APPENDIX J.

K.2 Applicable documents.

This section is not applicable to this appendix.

K.3 BCH (15,7) code.

The BCH (15,7) code is a linear, block, cyclic, BCH code capable of correcting any combination of two or fewer errors in a block of 15 bits. The generator polynomial for this code is

$$g(x) = 1 + X^4 + X^6 + X^7 + X^8$$

where g(x) is a factor of $X^{15} + 1$

K.3.1 Hardware encoding.

BCH (15, 7) encoding can be performed with an 8 stage feedback shift register with feedback connections selected according to the coefficients of g(x). A shift register corresponding to the coefficients of g(x) and containing the shifted information digits is shown in FIGURE K-1. Suppose that a 7-bit message is to be encoded:

Information vector $\mathbf{m} = (m_0\ \ m_1\ \ m_2\ \ m_3\ \ m_4\ \ m_5\ \ m_6)$

Information polynomial $m(x) = m_0 + m_1 x + m_2 x^2 + m_3 x^3 + m_4 x^4 + m_5 x^5 + m_6 x^6$

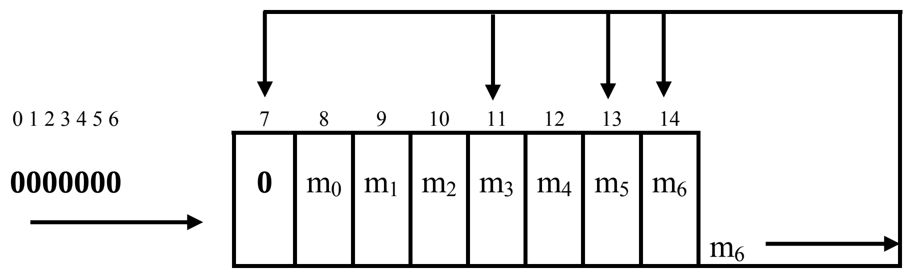
m_6 is the first digit to be shifted into the register. The horizontal right arrow illustrates its shifting direction to the right. And the vertical down arrows illustrate their positions of the feedback connections. The m_6 near the horizontal right arrow on the right illustrates the shifted out digit and feedback digit. The eight (8) parity check digits:

$$r(x) = r_0 + r_1x + r_2x^2 + r_3x^3 + r_4x^4 + r_5x^5 + r_6x^6 + r_7x^7$$

With the seven (7) information digits, x^8 m(x) makes a complete code word:

$$v(x) = r(x) + x^8 m(x)$$

Therefore, the m_6 bit is used as LSB and the first bit to be transmitted.



Notes:

1. The label 0 to 14 are intentionally set from the left in order to match the order of the polynomial.

FIGURE K-1. Shift register encoder for the BCH (15,7) code.

FIGURE K-2 illustrates its operation by showing the encoding of the information vector (1000010) to form the code vector (10100101 | 1000010), where the parity check sequence is shown before the partition and the information sequence after. The information sequence, bits 8 to 14, with eight zeros, bits 0 to 7, after it (place holders for the parity bits to be calculated) is shifted into the register initially (it is really a 15-bit shift register but only the last eight positions, bits 7 to 14, correspond to the coefficients of g(x) and contain feedback connections). The operation of the shift register consists of seven rounds of shift, feedback, and sum operations. The parity portion of the code vector, bits 7 to 14, can then be read out of the shift register as shown.

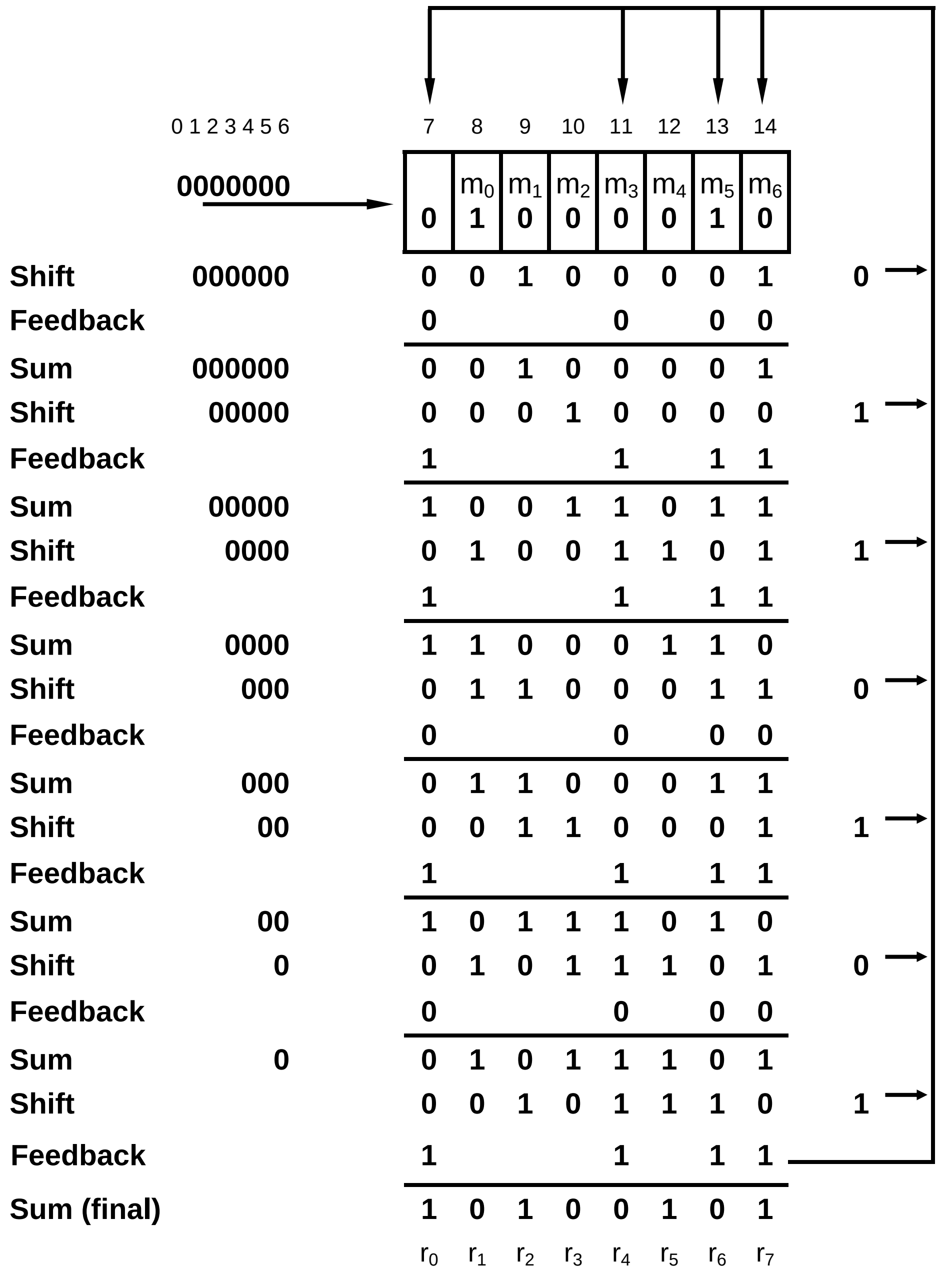


FIGURE K-2. Encoding example.

Thus, the code polynomial is:

$$v(x) = r_0 + r_1x + r_2x^2 + r_3x^3 + r_4x^4 + r_5x^5 + r_6x^6 + r_7x^7$$

$$+ x^8 (m_0 + m_1 x + m_2 x^2 + m_3 x^3 + m_4 x^4 + m_5 x^5 + m_6 x^6)$$

$$= 1 + x^2 + x^5 + x^7 + x^8 + x^{13}$$

And the complete code word is:

$$(r_0 \ r_1 \ r_2 \ r_3 \ r_4 \ r_5 \ r_6 \ r_7 \ m_0 \ m_1 \ m_2 \ m_3 \ m_4 \ m_5 \ m_6)$$

i.e. (101001011000010)

the first bit transmitted

Again, FIGURE K- illustrates its operation by showing the BCH (15,7) encoding of the robust frame format subfield. The setting of robust frame format for the example is with multi-dwell majority vote 3 out of 5 BCH (15,7) encoding (6 64-bit segments per packet) and no scrambling or convolutional encoding. The robust frame format information vector is (1101101) to form the robust frame format code vector (10110110 | 1101101), where the parity check sequence is shown before the partition and the information sequence after.

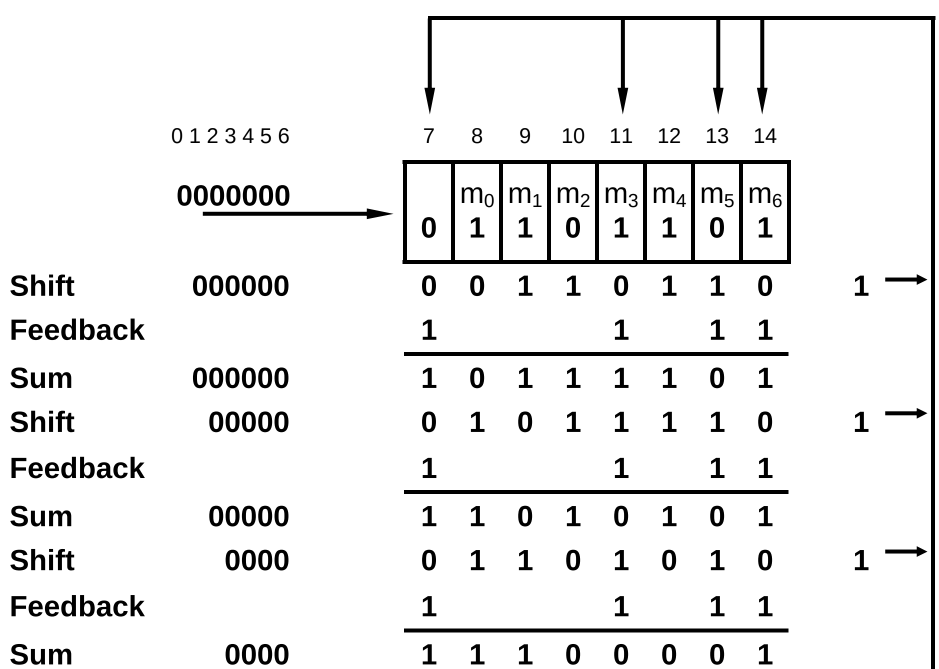


FIGURE K-3. Robust frame format encoding example.

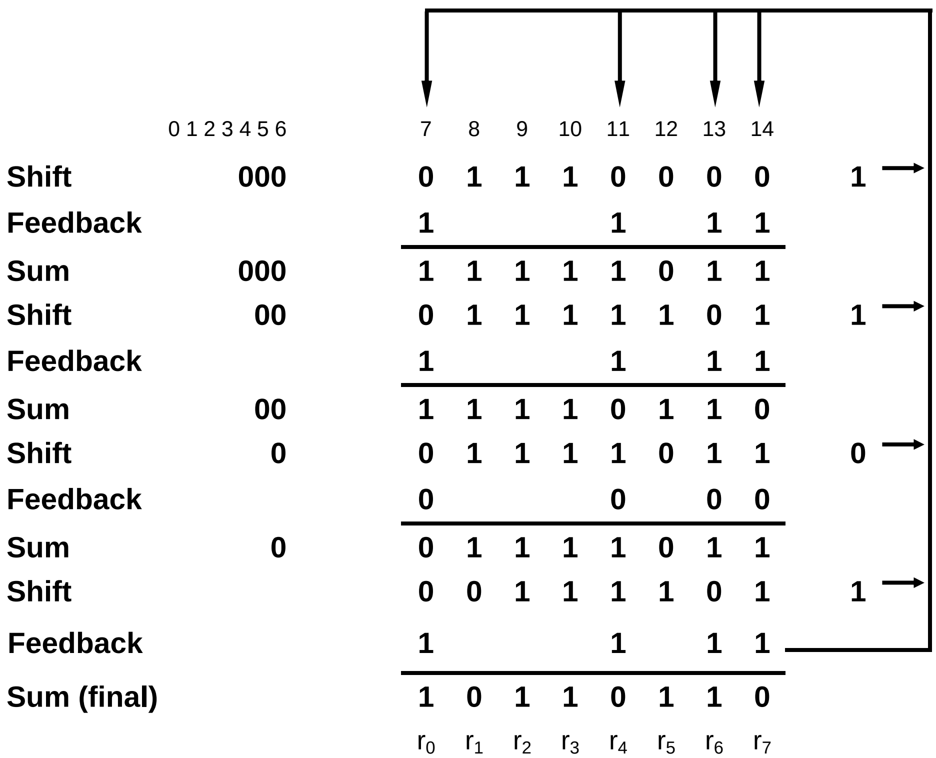


FIGURE K-3. Robust frame format encoding example-continued

Thus, the code polynomial is:

$$v(x) = r_0 + r_1x + r_2x^2 + r_3x^3 + r_4x^4 + r_5x^5 + r_6x^6 + r_7x^7$$

$$+ x^8 (m_0 + m_1 x + m_2 x^2 + m_3 x^3 + m_4 x^4 + m_5 x^5 + m_6 x^6)$$

$$= 1 + x^2 + x^3 + x^5 + x^6 + x^8 + x^9 + x^{11} + x^{12} + x^{14}$$

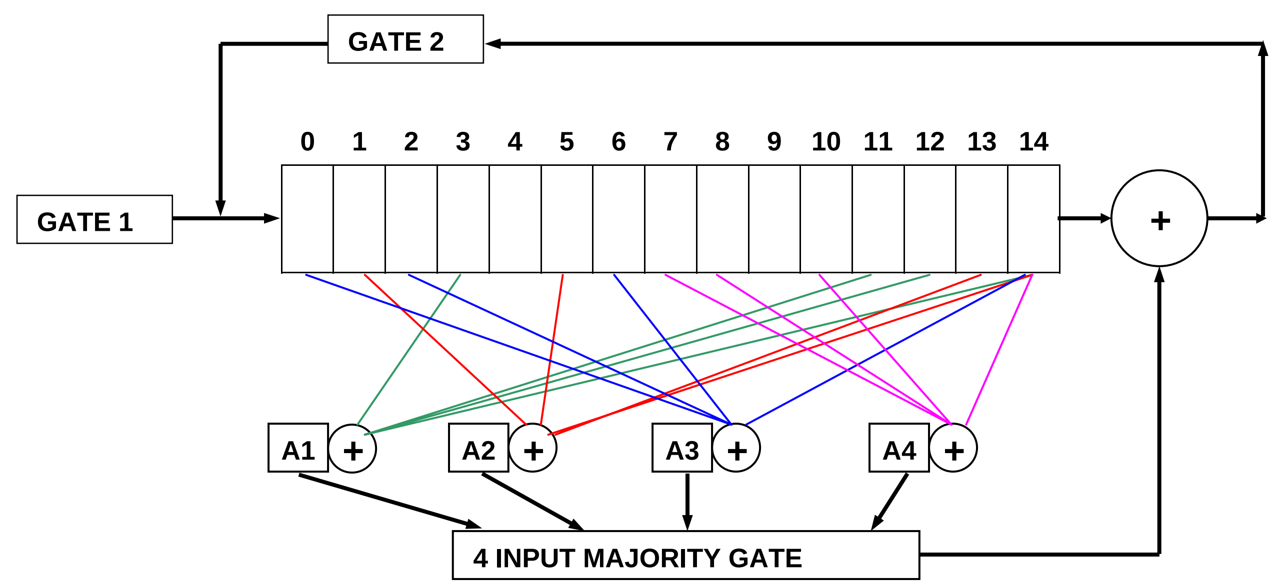
And the complete code word is:

$(r_0\ \ r_1\ \ r_2\ \ r_3\ \ r_4\ \ r_5\ \ r_6\ \ r_7\ \ m_0\ \ m_1\ \ m_2\ \ m_3\ \ m_4\ \ m_5\ \ m_6)$

i.e. (101101101101101)

the first bit transmitted

K.3.2 Hardware/Software decoding.
Because of its special structure (it is completely orthogonalizable in one step), the BCH (15,7) code can be decoded very efficiently with a majority logic scheme which can be directly implemented in software or hardware. It is most easily described in terms of the shift register implementation shown in FIGURE K-4. With gate 2 open and gate 1 closed, the received block is read into the shift register. The output of the four modulo 2 summers is sampled by the majority gate and processed as follows: if a clear majority of the inputs are ones (three or more) then the output is one, otherwise (if two or fewer inputs are ones) the output is zero. This output is used to correct the last bit of the shift register. The corrected bit is output to the receiver and feedback through gate 2 as the register is right shifted. The process is now repeated thirteen times until the last bit is corrected.



A1	3	11	12	14
A2	1	5	13	14
A3	0	2	6	14
A4	7	8	10	14

FIGURE K-4. BCH (15,7) majority logic decoding.

The parity check matrix H of the BCH (15,7) code as shown in FIGURE K-2 can also be obtained in systematic form from the generator matrix as shown in FIGURE K-. The BCH (15,7) majority logic decoding is derived from the matrix H, FIGURE K-5.

H =

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	0	0	0	0	0	0	1	1	0	1	0	0	0
0	1	0	0	0	0	0	0	0	1	1	0	1	0	0
0	0	1	0	0	0	0	0	0	0	1	1	0	1	0
0	0	0	1	0	0	0	0	0	0	0	1	1	0	1
0	0	0	0	1	0	0	0	1	1	0	1	1	1	0
0	0	0	0	0	1	0	0	0	1	1	0	1	1	1
0	0	0	0	0	0	1	0	1	1	1	0	0	1	1
0	0	0	0	0	0	0	1	1	0	1	0	0	0	1

FIGURE K-5. BCH (15,7) parity check matrix.

K.3.3 Software encoding.
The BCH (15,7) code is most efficiently encoded in systematic form from the generator matrix shown in FIGURE K-6.

G =

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	0	0	1	0	1	1	1	0	0	0	0	0	0
1	1	0	0	1	1	1	0	0	1	0	0	0	0	0
0	1	1	0	0	1	1	1	0	0	1	0	0	0	0
1	0	1	1	1	0	0	0	0	0	0	1	0	0	0
0	1	0	1	1	1	0	0	0	0	0	0	1	0	0
0	0	1	0	1	1	1	0	0	0	0	0	0	1	0
0	0	0	1	0	1	1	1	0	0	0	0	0	0	1

Parity (columns 0–7) Identity (columns 8–14)

FIGURE K-6. BCH (15,7) generator matrix.

The BCH(15,7) encoding of the robust frame format subfield as specified in the example of FIGURE K-2 is shown below.

G =

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
g1	1	0	0	0	1	0	1	1	1	0	0	0	0	0	0
g2	1	1	0	0	1	1	1	0	0	1	0	0	0	0	0
g3	0	1	1	0	0	1	1	1	0	0	1	0	0	0	0
g4	1	0	1	1	1	0	0	0	0	0	0	1	0	0	0
g5	0	1	0	1	1	1	0	0	0	0	0	0	1	0	0
g6	0	0	1	0	1	1	1	0	0	0	0	0	0	1	0
g7	0	0	0	1	0	1	1	1	0	0	0	0	0	0	1

The BCH(15,7) code vector:

v = **m (dot product) G**

$$= (m_0\ m_1\ m_2\ m_3\ m_4\ m_5\ m_6)\ \textbf{(dot product)}\ \begin{bmatrix} g_1 \\ g_2 \\ g_3 \\ g_4 \\ g_5 \\ g_6 \\ g_7 \end{bmatrix}$$

Thus, the robust frame format code vector for robust frame format subfield m (1101101) is:

v =
1 **(dot product)** **(**1 0 0 0 1 0 1 1 1 0 0 0 0 0 0**)**
\+ 1 **(dot product)** **(**1 1 0 0 1 1 1 0 0 1 0 0 0 0 0**)**
\+ 0 **(dot product)** **(**0 1 1 0 0 1 1 1 0 0 1 0 0 0 0**)**
\+ 1 **(dot product)** **(**1 0 1 1 1 0 0 0 0 0 0 1 0 0 0**)**
\+ 1 **(dot product)** **(**0 1 0 1 1 1 0 0 0 0 0 0 1 0 0**)**
\+ 0 **(dot product)** **(**0 0 1 0 1 1 1 0 0 0 0 0 0 1 0**)**
\+ 1 **(dot product)** **(**0 0 0 1 0 1 1 1 0 0 0 0 0 0 1**)**

i.e. **v** = **(**1 0 1 1 0 1 1 0 1 1 0 1 1 0 1**)**

Then, the complete robust frame format BCH(15,7) code word is:

(101101101101101)
the first bit transmitted

This is the same code vector obtained in the robust frame format encoding example, FIGURE K-2.

APPENDIX L

TRANSMISSION CHANNEL INTERFACES

L.1 General.

L.1.1 Scope.
This appendix describes transmission channel interfaces for DMTD and interfacing C^4I systems.

L.1.2 Application.
This appendix is a mandatory part of MIL-STD-188-220. The information contained herein is intended for compliance.

L.2 Applicable documents.

a.	MIL-STD-188-110	Equipment Technical Design Standards for Common Long Haul/Tactical Data Modems
b.	MIL-STD-188-114A	Electrical Characteristics of Digital Interface Circuits
c.	MIL-STD-188-200	System Design and Engineering Standards for Tactical Communications
d.	CCITT V.10	Electrical Characteristics for Unbalanced Double-Current Interchange Circuits for General Use with Integrated Circuit Equipment in the Field of Data Communications
e.	CCITT X.21	Interface Between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) for Synchronous Operation on Public Data Networks

L.3 Definitions.
Refer to Section 3 of the main document.

L.4 Detailed requirements.

L.4.1 Transmission channel interfaces.
The transmission channel interfaces specified below define the transmission envelope characteristics (signal waveform, transmission rates, and operating mode) authorized at the standard interface between a DMTD and the transmission channel. The transmission channel may consist of wireline, satellite, or radio links.

L.4.1.1 Non-Return-to-Zero (NRZ) interface.
A NRZ signal waveform shall be used for this interface. This interface is used primarily with digital transmission equipment.

L.4.1.1.1 Waveform.
The NRZ unbalanced and balanced waveforms shall conform to 5.1.1.7 and 5.2.1.7, respectively, of MIL-STD-188-114A.

L.4.1.1.2 Transmission rates.
The output transmission rates of the NRZ interface shall be the following bit rates: 75, 150, 300, 600, 1200, 2400, 4800, 9600, and 16000 bits per second (bps).

L.4.1.1.3 Operating mode.
The NRZ interface shall support half-duplex transmission.

L.4.1.2 Frequency-Shift Keying (FSK) interface for voice frequency channels.
This interface may be used. It is primarily associated with analog single-channel [3-kilohertz (KHz)] radio equipment. The FSK data modem characteristics shall conform to 5.2.2 of MIL-STD-188-110. Waveform.

The FSK modulation waveform shall conform to 5.2.2.1 of MIL-STD-188-110. The characteristic frequencies, in hertz (Hz), for transmission rates of 600 bps or less, and 1200 bps, shall be as shown in TABLE L-I.

TABLE L-I. Characteristic frequencies of FSK interface for voice frequency channels.

PARAMETER	CHARACTERISTIC FREQUENCY (Hz)	
	600 bps or less	1200 bps
Mark Frequency	1300	1300
Space Frequency	1700	2100

L.4.1.2.1 Transmission rates.
Output transmission rates of the FSK interface shall be the following bit rates: 75, 150, 300, 600, and 1200 bps.

L.4.1.2.2 Operating mode.
The FSK interface shall support half-duplex transmission.

L.4.1.3 Frequency-Shift Keying (FSK) interface for single-channel radio.
This interface, used within DoD, may also be used for North Atlantic Treaty Organization (NATO) single-channel radio applications. The FSK interface data modem characteristics shall conform to 5.1 of MIL-STD-188-110.

L.4.1.3.1 Waveform.
The FSK modulation waveform shall conform to 5.1.1 and 5.1.2 of MIL-STD-188-110. The characteristic frequencies shall be as specified in TABLE L-II.

TABLE L-II. Characteristic frequencies of FSK interface for single-channel radio.

PARAMETER	CHARACTERISTIC FREQUENCY (Hz)
Mark Frequency	1575
Space Frequency	2425

L.4.1.3.2 Transmission rates.
Output transmission rates of the single-channel FSK interface shall be the following bit rates: 75, 150, 300, 600, and 1200 bps.

L.4.1.3.3 Operating mode.
The single-channel FSK interface shall support half-duplex transmission.

L.4.1.4 Conditioned Diphase (CDP) interface.
This interface may be used. It is primarily associated with wideband wireline equipment.

L.4.1.4.1 Waveform.
The CDP modulation waveform shall conform to 5.4.1.4 of MIL-STD-188-200. The unbalanced and balanced signal waveform shall conform to 5.1.1.7 and 5.2.1.7, respectively, of MIL-STD-188-114A.

L.4.1.4.2 Transmission rates.
The output transmission rate of the CDP interface shall be 16 and 32 kilobits per second (kbps).

L.4.1.4.3 Operating mode.
The CDP interface shall support half-duplex transmission.

L.4.1.5 Differential Phase-Shift Keying (DPSK) interface for voice frequency channels.
This interface may be used. It is primarily associated with analog (nominal 4-KHz voice frequency) wireline and radio equipment. DPSK modulation data modem (2400 bps) and phase-shift keying (PSK) modulation data modem (1200 bps) characteristics shall conform to the applicable requirements of MIL-STD-188-110.

L.4.1.5.1 Waveform.
The DPSK modulation waveform shall conform to APPENDIX A of MIL-STD-188-110. The PSK modulation waveform shall conform to 5.3 of MIL-STD-188-110.

L.4.1.5.2 Transmission rates.
The output transmission rate of the DPSK and PSK interfaces shall be 2400 and 1200 bps, respectively.

L.4.1.5.3 Operating mode.
The DPSK and PSK interfaces shall support half-duplex transmission.

L.4.1.6 Packet mode interface.
This interface may be used. If present, this interface shall use a modified CCITT X.21 half-duplex synchronous interface, with a CCITT V.10 electrical circuit, for transferring data across the interface between data terminal equipment (DTE) (i.e. the DMTD or C^4I system) and data circuit-terminating equipment (DCE).

L.4.1.6.1 Waveform.
The electrical characteristics of the packet mode interface shall be identical to CCITT V.10 for interfaces to voice band modems.

L.4.1.6.2 Transmission rates.
The DTE device shall be required to accept signal timing from the DCE (radio) at 16 kbps. The DTE shall be required to synchronize to the DCE signal timing and accept data at the supplied signaling timing rate. In the packet mode, the radio provides signal timing to support 16 kbps data transfers between the radio and the DTE.

L.4.1.6.3 Operating mode.
The packet mode interface shall support half-duplex transmission.

L.4.1.7 Amplitude Shift Keying (ASK) interface.
This interface is used primarily with analog voice grade radios to transmit digital data.

L.4.1.7.1 Waveform.
The ASK waveform is a band limited NRZ waveform with average white Gaussian noise added to it. The ASK signal shall be a bipolar signal nominally centered around ground. However due to the radio automatic gain control performance, the ASK signal may have a direct current (DC) component. The ASK signal-to-noise ratio (S/N) shall be in the range of 0 to 12 decibels (dB). The ASK signal shall be demodulated using an optimal bit synchronizer with a bit error rate (BER) performance of 1.5 dB from theoretical.

L.4.1.7.2 Transmission rates.
The output transmission rates of the ASK interface shall be the following bit rates: 2400, 4800, 9600 and 16000 bps.

L.4.1.7.3 Operating mode.
The ASK interfaces shall support half-duplex transmission.

CONCLUDING MATERIAL

a. Preparing activity:

US Army Communications Electronics Life Cycle Management Command (USA CE LCMC): CR1

b. Custodians:

Army:	CR1
Navy:	OM
Air Force:	02
DISA:	DC1

c. Review activities:

OSD:	IR, SE
Army:	AC, CR, MI, PT
Navy:	CG, EC, MC, NC
Air Force:	11, 13, 93, 99
DCMA:	CM
DISA:	DC5
DOT:	OST
NIMA:	MP
DIA:	DI
NSA:	NS
NORAD & USSPACECOM:	US

d. Project number:

TCSS-0088

e. NOTE:

The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at http://assist.daps.dla.mil.