

ARINC

AVIATION VHF PACKET COMMUNICATIONS (AVPAC) FUNCTIONAL DESCRIPTION

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Supplement 1 will not be made available separately due to the extensive changes to previous version of the standard. It is included in its entirety in Specification 631-1.

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1.0 INTRODUCTION

1.1 Purpose of this Document

The intent of this document is to provide general and specific design guidance for the development and installation of the protocols needed to exchange bit-oriented data across an air-ground VHF data link in an Open System Interconnection (OSI) environment. The protocols defined herein are consistent with the concepts of the Aeronautical Telecommunications Network (ATN).

This document describes the functions to be performed by the airborne components of the Aviation VHF Packet Communications (AVPAC) data link to successfully transfer messages from VHF ground stations to avionics systems on aircraft and vice versa where the data are encoded in a code and byte independent format. These functions are referred to as Aviation VHF Packet Communications (AVPAC) protocols. The compatibility with OSI is provided by defining a set of services and protocols in accordance with the OSI model.

COMMENTARY

AVPAC, as used in this document, refers to the digital communication protocols to be exercised by the VHF transceiver and supporting avionics to exchange messages with any appropriately equipped ground system. The AVPAC definitions were introduced to enhance the effectiveness of air-ground operational control communications.

1.2 Background

Communications across the air-ground VHF link were initiated using the Aircraft Communications Addressing and Reporting System (ACARS). The ACARS air-ground system description was initially included in ARINC Characteristic 597. It was later transferred to Project Paper 618.

The VHF air-ground data communication functions described herein are compatible with the OSI Model. They were developed as the first step toward a fully OSI compliant protocol "stack".

1.3 Relationship of this Document to ARINC Characteristics

This Specification may be referenced by any appropriate equipment Characteristic: 750, 748, 724B, 724 or 597. To obtain AVPAC communications capability, the AVPAC functions defined herein should be installed in an existing 597, 724 or 724B ACARS Management Unit (MU), 748 Communications Management Unit (CMU) or 750 VHF Data Radio to produce a unit capable of exchanging information in a bit-oriented environment. Section 2 of Project Paper 618 includes a description of the air-ground communication environment.

The description of the Internetworking protocol, which accomplishes the routing function, is defined in Project Paper 637.

Transport, Session, Presentation and Application Layer definitions will be described in Project Paper 638.

1.3.1 Characteristic 748

New aircraft will be designed with communications architectures designed to operate within the ATN. The Communications Management Unit (CMU) described in ARINC Characteristic 748 may house the protocols described in Sections 4 through 6 of this Specification.

1.3.2 Characteristic 724B

ARINC Characteristic 724B describes ARINC 600-packaged equipment intended to perform communications routing functions for ACARS air-ground message transfers. The 724B ACARS Line Replaceable Units (LRUs) will interface with the broadest range of ARINC "700-series" - avionics equipment.

The MU described in ARINC Characteristic 724B provides for input/output ARINC 429 data bus interfaces between the MU and two ARINC 702 Flight Management Computers (FMC) and multiple other on-board LRUs.

1.3.3 Characteristic 724

ARINC Characteristic 724 describes ARINC 600-packaged equipment intended to perform ACARS message routing. The MUs built to ARINC Characteristic 724 have a limited set of digital data bus interfaces and interacts with a dedicated Control/Display Unit (CDU).

1.3.4 Characteristic 597

ARINC Characteristic 597, "Aircraft Communications Addressing and Report System (ACARS)", describes ARINC 404A-packaged airborne ACARS equipment. Many MUs, built to ARINC Characteristic 597, were produced with relatively small memory capacity. These MUs would not be appropriate candidates to perform the more memory-intensive communication system functions called for by the AVPAC definitions.

1.3.5 Characteristic 750

ARINC Characteristic 750 describes the digital data radio to be used for VHF air-ground communications. This characteristic is being developed at present by AEEC to overcome the limitations of existing radios and provide high speed data transfer capability.

1.4 Relationship to OSI Protocols

The AVPAC functions are the Physical Layer and Data Link Layer protocols and conform to High-Level Data Link Control (HDLC) as specified by ISO 3309(E) version 3 10/84, ISO 4335(E) version 3 8/87, ISO 7809(E) version 1 2/84 and ISO 8885(E) second edition 6/91 except as noted in Sections 4 and 5 of this Specification.

1.5 Conventions Used in This Document

This section describes the incoming events, outgoing events, and the state transition table included in the attachments used to more explicitly describe the protocol.

c-1

c-1

c-1

1.0 INTRODUCTION (cont'd)

1.5 Conventions Used in This Document (cont'd)

The tables for the physical layer are contained in Attachment 2, for the MAC sublayer in Attachment 3, and for the DLS sublayer in Attachment 4.

The state tables define the mapping between protocol events and the service that the user can expect. These state transition tables show the state of the data link connection, the events that occur in the protocol, the actions taken and the resultant state.

1.5.1 State Tables

Incoming events are represented in the state tables by abbreviated names as defined in Table 1 of an Attachment. Similarly Tables 2 and 3 contain the abbreviated names for States and Outgoing Events respectively.

The intersection of an event and a state which is invalid may be left blank. The action to be taken in this case is one of the following:

- a) for an event related to a received frame Incoming Event follow the frame reject procedure for the treatment of protocol errors. This action is only available to the DLS and packet layers.
- b) for a service primitive or any other event (e.g., invalid timer firing) take no action, except to optionally report invalid condition to the higher layer entity.

At each intersection of state and event which is not blank, the state tables specify an action which will include an action constituted by a list of any number of Outgoing Events (none, one or more) given by their abbreviated name defined in Table 3 of the appropriate Attachment. This action is followed by the abbreviated name of the resultant state (from Table 2).

2.0 INTEROPERABILITY

2.1 Subnetwork Interoperability

AVPAC is one of a number of airplane-to-ground subnetworks which may be used to provide communications across the ATN between the airplane-based application processes and their ground-based peer processes. It is essential that each of these subnetworks be interoperable with the other subnetworks such that the network router (Internetworking Protocol) may choose to establish a path across any available subnet when communication is required.

One of the prime reasons for development of AVPAC is to provide a VHF data link that is interoperable with other airplane/ground subnetworks. These other subnetworks might include satellite communication, Mode S data link, parked aircraft link, or HF data radio. Interoperability provides the capability for an application process to send or receive data messages over any of the available subnetworks. The application process is not required to select a particular subnetwork or even know which subnetwork is being used for a particular message.

2.2 AVPAC/ACARS RF Coexistence

It is desirable that ACARS and AVPAC MUs using MSK modulation not be precluded from operating (coexisting) on the same frequency. The introduction of AVPAC-capable MUs is intended to minimize any negative impact on the existing units operating under the original ACARS system.

COMMENTARY

Accommodations are needed on the part of ground service providers to preclude negative impact on CARS and AVPAC units and to allow system faults to be detected and isolated.

The AVPAC communications exchanges may co-exist with communications exchanges of systems using the original ACARS character-oriented message protocol for as long as the latter is operational. If this occurs in the interim both ACARS and AVPAC equipment should satisfy the requirements imposed by their own environments without interference with, or degradation of, the other.

3.0 SYSTEM OVERVIEW

3.1 General Description

This chapter provides the background information needed to enable the functional aspects of the airborne equipment to be appreciated, and may be regarded as a preface to the material of Sections 4 through 6.

3.2 System Architecture

The architecture, message protocols and message formats defined herein for AVPAC are based on the concepts of the International Organization for Standardization Open System Interconnect (OSI) model for telecommunications and data processing services. The OSI model was developed specifically to facilitate data transfer between different end systems without one having precise knowledge of the other's transmission characteristics or the characteristics of all the links which connect them.

The OSI model represents an environment through which messages can be transported as a stream of digital bits. This environment is depicted in Attachment 1 as an accumulation of data processing networks, either public or private, which can be accessed by any user connected to the ATN and employing a compatible application process. All networks and intermediate nodes in the environment must be compatible with the OSI environment.

Examples of the application process by which a user may enter the environment are: a person operating a manual keyboard terminal, an aircraft performance sensor with digital output, the sensing of a magnetic strip on an ID card, a digitally encoded time check or any other information transaction which is in digital form.

The term "Open", in Open Systems Interconnect, is used to convey the concept of one end-system, or user, communicating with another end-system, perhaps having a different design, provided both are compatible with the system architecture of the OSI model.

The OSI model has a structure comprised of a series of seven layers. For each layer functional responsibilities are assigned. The boundaries between these layers are called interfaces. Some layers have been sub-divided, producing additional interfaces.

The value of the model is that it provides a uniform nomenclature and an orderly manner in which the responsibility for various network activities can be distributed. The manner in which these activities are executed is known as the protocol. Protocols are used to regulate the interaction across these interfaces. A protocol is defined for each layer (sublayer). AVPAC protocols are defined by: (1) standards, such as those developed by ISO, and included in this Specification by reference or (2) defined in this Specification.

The service interface definition describes the way in which each layer, as a functional unit, interacts with the adjacent (upper and lower) layers within a system. The protocol determines how each layer is to communicate with its peer layers. For each layer of the source, a complementary peer layer will normally be present at the other end of the communication path. Complementary

peer layers may also appear at points along the communication path.

Actually, data are not exchanged directly between peer layers (see Attachment 1), but rather sent down through the lower layers to the physical medium, across the physical medium and then up through the layers at the receiving end. Each layer contributes a portion of the header, which is treated as data by the next lower layer. At the receiving terminal, the appropriate portion of the header, containing the protocol control information, is read and understood by the peer layer, then discarded.

Layer interface protocols are identified in a series of fields in the header inserted at each layer. These headers contain the information necessary for the appropriate receiving layer to process the message. The format and contents of the header fields are described in the associated sections of this Specification pertaining to a particular layer.

3.2.1 Architectural Guidelines

AVPAC represents a significant architectural extension of the original ACARS air-ground data link. The following set of Architectural Design Guidelines were developed to assure complete compatibility with existing airborne terminals while providing maximum user utility. These eleven guidelines should be used as a basis for AVPAC capable MU design to achieve avionics compatibility with both the aircraft environment and the ground network.

1. Various levels of aircraft equipment must be able to co-exist for extended periods. At any one time in the future, aircraft containing ACARS equipment of various developmental levels may occupy the same airspace. Aircraft equipment replacement should be dictated by business factors, not to avoid incompatibilities with newer AVPAC system definitions.
2. All levels of avionics equipment designed to operate within the AVPAC environment should be able to utilize a designated radio frequency within a particular airspace referred to as the appropriate Common Signalling Channel (CSC). The architecture should not limit the number, the type or the administration of VHF frequencies.
3. Frequency management should be a cooperative effort between ground network and the aircraft. The ground service provider has primary responsibility for aircraft tracking. Ground service providers dynamically assign operational frequencies within a particular airspace to resolve factors beyond the control of the aircraft. If needed, negotiations with the aircraft for frequency use should be initiated by the ground service provider and resolved to a mutual satisfaction. The resulting "system" should be able to freely adjust frequencies to account for volumes, area of responsibility and political jurisdiction.
4. Maximizing message throughput is an important consideration in AVPAC design.

3.0 SYSTEM OVERVIEW (cont'd)

5. AVPAC should be able to participate in, and contribute to the establishment and maintenance of a reliable communications path between the aircraft and the ground network. A Mark 3 MU should exercise methods of radio station tracking so as to minimize misdirected transmissions as the aircraft transitions, from the reception area of one ground station to another. Similarly, the AVPAC MU should be capable of transitioning from one ground network to another. It should be able to maintain continuity for a message, originating either on the ground or in the air, without manual intervention or prompting.
6. AVPAC should not preclude aircraft-to-aircraft message exchange capability. This feature is not accommodated in this specification.
7. AVPAC should be "data transparent"; i.e., totally insensitive to the textual content of messages it carries. Changes in message content and format should have no effect on the implementation or effectiveness of AVPAC communications.
8. Many computer networks and systems in place today are constrained by prior generations of software and hardware. AVPAC should not be affected by those constraints. AVPAC implementations should be independent of data rate.
9. AVPAC should be able to tolerate less than optimum operating conditions. Degradation should be gradual when operating within adverse operational scenarios, including failure modes. Neither a ground station nor an aircraft should be able to abuse a channel.
10. The architecture should be able to accommodate concurrent message exchanges with multiple ground systems. This will allow use of the communications system, not only by multiple airline sources, but also by such entities as air traffic control, weather agencies and others, without the necessity for interlinking within the ground networks.
11. Installation of a digital radio, using state-of-the-art features, would improve communications reliability and reduce costs.

3.2.2 Layers of the OSI Model

Each communication in the ATN environment represents a series of functions which must be arranged in a logical order to be clearly understood. The OSI model uses the technique of layering to achieve a logical balance between a complicated system structure and complicated protocol. Seven layers are used in the OSI model to provide the functions needed to make the transition from the user's application process to the transmission medium; e.g., the VHF radio. These seven layers, depicted in Figure 3-1, are briefly described as follows:

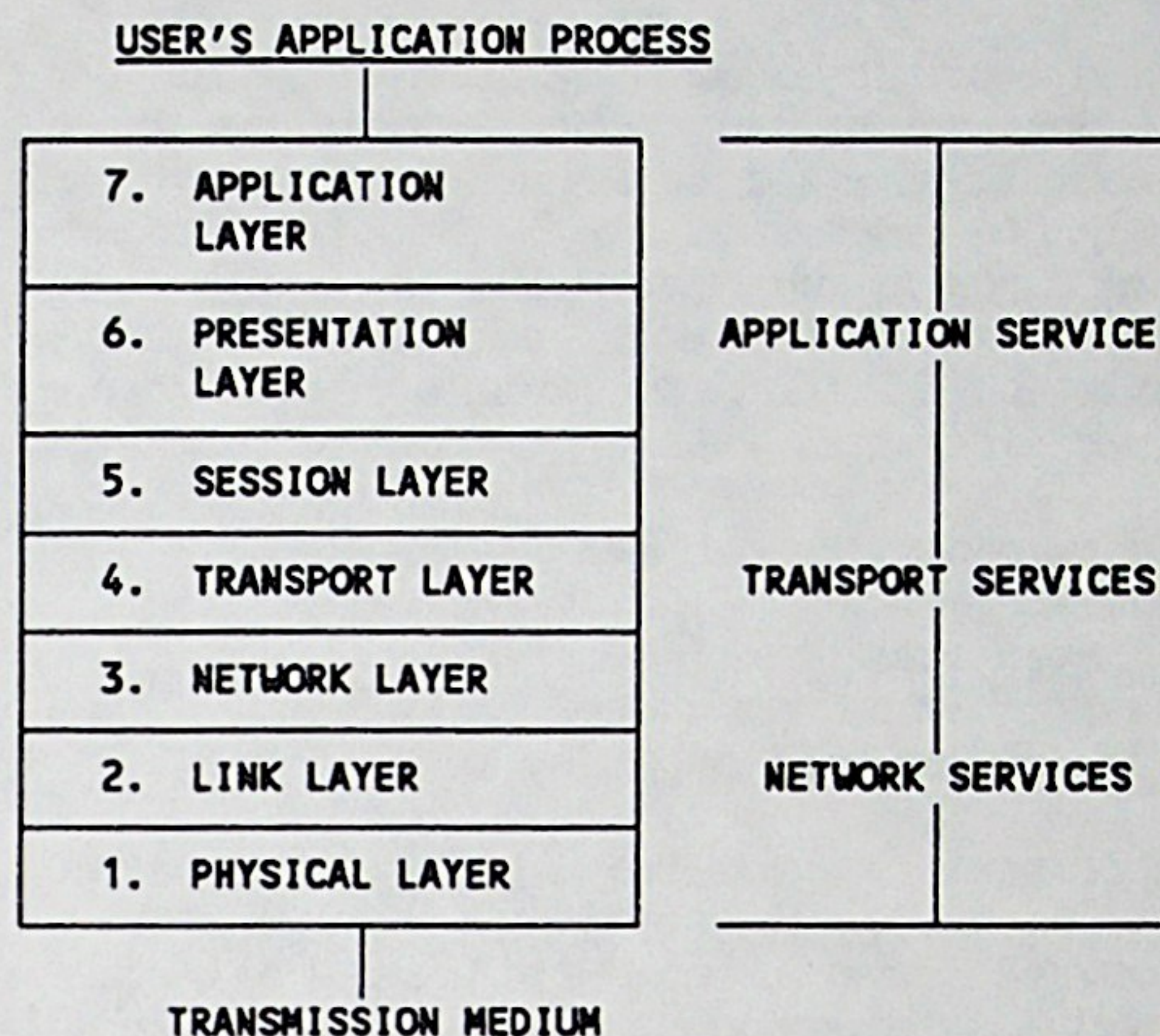


Figure 3-1
Layers of the OSI Model

3.2.2.1 Layer 1, The Physical Layer

The Physical Layer provides services to activate, maintain and deactivate connections for bit transmission in the Data Link Layers. The following service elements are the responsibility of Layer 1.

- Activation of the transmission channel
- Establishment of bit synchronization
- Physical data transmission by an appropriate radio system
- Channel status signalling
- Fault condition notification
- Local network definitions
- Service quality parameters

3.2.2.2 Layer 2, The Link Layer

The Link Layer is responsible for transferring information from one network entity to another and for annunciating any errors encountered during transmission.

The Link Layer draws on the service provided by the Physical Layer. This function is transparent to the type of radio media used. The service responsibility of the Link Layer includes the following:

- Frame assembly and disassembly
- Establish frame synchronization
- Rejection of non-standard frame types
- Detection and control of frame errors
- RF channel selection
- Address recognition
- Initiate receiver muting
- Generate the frame check sequence

The Link Layer provides the basic bit transmission service over the RF channel. Data at the Link Layer are transmitted as a bit stream in a series of frames exchanged between the aircraft transceiver and the ground-based radio elements.

3.0 SYSTEM OVERVIEW (cont'd)**3.2.2.3 Layer 3, The Network Layer**

It is the responsibility of the Network Layer to ensure that data packets are properly routed between the source airborne end system and the designated recipient ground end system (or vice versa). The Network Layer expects the Link Layer to supply data from correctly received frames; however, it does not assume reliable transmission. Specific responsibilities of the Network Layer include the following:

- Data packet assembly and disassembly
- Routing
- Error resolution
- Equipment error resolution
- Priority handling

At the Network Layer, messages (data) are broken into packets of a size appropriate for the transmission media. The message is then transmitted as a series of packets. Each packet is transmitted in one frame (Layer 2). Each frame carries only one packet. A complete message may consist of one or more packets.

The Network Layer has been divided into three Sublayers. These are the Subnetwork Sublayer, the Subnetwork Convergence Function Sublayer and the Internetwork Sublayer.

3.2.2.4 Layer 4, Transport Layer

The Transport Layer controls the transportation of data from a source end-system to a destination end-system. It provides "network independent" data delivery between these processing end-systems. It is the highest order of function involved in moving data between systems. It relieves higher layers from any concern with the pure transportation of information between them. Service responsibilities of the Transport Layer include:

- Multiplexing
- Sequence control
- Error detection and recovery
- Segmentation
- Flow control

3.2.2.5 Layer 5, Session Layer

This layer provides the means for a pair of end-system functions to be properly initialized, sequenced, terminated and if necessary, restarted, taking care of the relationship or "session" between the distributed processes. This layer allows end-system functions competing for transport access to regulate their dialogue and conduct an orderly exchange of messages. Service responsibilities of Layer 5 include:

- Establish the type of interaction, alternate or simultaneous
- Sequencing and acknowledgement of information
- Establishment of reset and restart points

3.2.2.6 Layer 6, Presentation Layer

This layer formats and structures data for the benefit of an application. It provides for syntax transformation and

selection (i.e., code and character set conversion, modification of layout of data) between dissimilar applications. Responsibilities of Layer 6 include:

- Syntax selection
- Data translation and formatting

3.2.2.7 Layer 7, Application Layer

This layer provides a means for an application process to access the OSI environment. In addition to information transfer and together with OSI management, this layer provides:

- Identification and authentication of communication partner
- Determination of quality of service, cost and resources
- Agreement on error recovery and data integrity procedures

3.2.3 AVPAC Functional Organization

The three upper layers (application services) provide direct support of the application process while the lower three layers (network services) support the transmission of information between the end systems. The Transport Layer is the essential link between these services providing end-to-end integrity of the communication.

AVPAC is constituted of the protocols of layers 1, 2, and the first sublayer of layer 3. See Appendix B for a diagram showing the interaction of these layers.

The OSI model is organized to permit a user's application process to communicate with its counterpart in another end-system. The actual communication path, however, descends through the layers from the sender's process and ascends through the layers to the recipient's process. As the data block descends through the layers a header containing protocol control information is attached to the data. The header is a set of instructions intended to be "read" by the peer layer in the recipient's process. No layer is aware of the header used by the other layers. As a received frame ascends through the layers, the headers are read by the peer layer and then removed as the message segment is passed on.

3.3 Radio Frequency Management

In AVPAC, a tiered structure of operating frequencies and zones is used such that communications are optimized for individual enroute and terminal area requirements.

AVPAC necessarily operates on multiple frequencies. If applicable, a common frequency referred to as the Common Signaling Channel or CSC may be used. The designation of a CSC would provide a ready means for an aircraft user to first enter the system (log on). It could also serve as a common or base channel to be used in emergency or light traffic areas, and a fallback (default) channel whenever communication is lost for any reason.

If a CSC is designated, the avionics equipment must be capable of operating on the CSC. In fact, it should be able to tune to any discrete frequency within the assigned

3.0 SYSTEM OVERVIEW (cont'd)

c-1 | frequency range. Tuning may be commanded by the
aircrew, automatically performed by AVPAC or
commanded by the ground network.

3.4 Message Composition

The bit-oriented protocol used in AVPAC permits user definition of all bits in the data field. The only segments of the message for which the bit pattern is preassigned are those required for identification, control (link maintenance) and message quality.

4.0 INTERFACES AND PROTOCOLS FOR LAYER 1 - THE PHYSICAL LAYER**4.1 Introduction**

The airborne terminal of Aviation VHF Packet Communication (AVPAC) system accesses the VHF air-ground network with a VHF radio transceiver operating in a two-way alternate mode. ATN systems often refer to AVPAC as a subnetwork.

AVPAC is not dependent on any particular modulation technique for data transfer. Refer to ARINC Specification 618 and ARINC Characteristic 750 for defined AVPAC modulation techniques.

4.2 Physical Layer Service Definition

The lowest level layer in the OSI 7-layer protocol model is Layer 1, known as the Physical Layer. The Physical Layer is concerned only with the unstructured bit stream over the physical medium (VHF radio). It is the most basic protocol level in the OSI model dealing only with the physical interface between devices and the rules by which bits are passed from one to another.

COMMENTARY

Certain application processes which will use AVPAC may require continuous data link capacity. Therefore, it is recommended that the radio be dedicated for data only operation, although voice capability will be supported for non-routine operation.

This section specifies the services offered by the AVPAC Physical Layer.

Within the context of this document a service user is an entity at a layer which makes use of the services provided by the layer below. The Physical Layer (Layer 1) service user is the Data Link Layer (Layer 2); the Physical Layer service user makes use of the Physical Layer services. Similarly the Physical Layer service provider provides service to a service user at the Data Link Layer. These services are provided at Service Access Points (SAP) through the use of service primitives. See Section 4.2.2 for a definition of physical layer service primitives utilized within AVPAC.

Data Link Layer user data is passed to the Physical Layer from the Data Link Layer on primitives. Data link user data received by the Physical Layer entity from a remote Physical Layer entity via the VHF media is passed up to the Data Link Layer on a primitive. Any indications required for diagnostic or error conditions are passed between these layers on service primitives.

4.2.1 Functions

The functions provided by the Physical Layer include the following:

- a) Transceiver control
- b) Reception of data on the VHF radio
- c) Transmission of data on the VHF radio
- d) Operational performance notification

4.2.1.1 Transceiver Control

An important requirement of the Physical Layer is the control of the radio equipment ultimately responsible for the transmission and reception of the data. Control of this equipment involves mode switching [transmit/receive] and frequency tuning. Frequency selection will be performed upon requests passed on from the Data Link Layer. Transmitter keying will be performed on demand from the Data Link Layer to transmit a frame.

AVPAC will not support voice/data mode as defined in ACARS. Instead, AVPAC will execute a DISC upon receipt of an indication to switch from data to voice and the link connection has to be re-established once the radio is returned to data mode.

4.2.1.2 Data Reception

Signals received by the VHF transceiver will be conveyed to the demodulator to initiate the data processing cycle. It is the responsibility of the Physical Layer to decode these signals so they may be accurately read by the next higher layer.

4.2.1.3 Data Transmission

When data is to be transmitted, the modulator will transform the information to a form satisfactory for transmission on the VHF channel. It is the responsibility of the Physical Layer to encode the data so that the information can be successfully transferred to a receiving demodulator.

4.2.1.4 Notification Services

The operational parameters of the modem will be monitored at the Physical Layer.

Signal quality indication will be performed on the demodulator evaluation process, using parameters as defined in ARINC Characteristic 750.

4.2.2 Service Primitives

Service primitives are short status and control information that must be available to the receiving entity to properly process incoming information. All primitive parameters are mandatory (M) for the correct operation of the protocol state machine. No specific primitive implementation is implied. See Table A2-1, Service Primitives List, of Attachment 2.

Primitives passed from the Physical Service User (Ph User) to the Physical Service Provider (Ph Provider) are Request primitives. Primitives passed from the Ph Provider to the Ph User are Indication or Confirm primitives. New primitives may be defined in the future if additional Physical Layer parameters are negotiated using XID frames at the Data Link Layer. See Attachment 2, Table A2-1.

4.0 INTERFACES AND PROTOCOLS FOR LAYER 1 - THE PHYSICAL LAYER (cont'd)

4.2.2.1 Physical Layer Data Request

Ph_DATA.request is the service request primitive for the data transmission service. This primitive is generated by the Ph_User and passed to the Ph_Provider to request user data transmission. The receipt of this primitive by the Ph_Provider causes the Ph_Provider to transmit one bit of user data. This primitive is usually in the form of clock and data.

Parameters: PhS User data (M)

4.2.2.2 Physical Layer Data Indication

Ph_DATA.indication is the service indication primitive for the data transfer service. This primitive is generated by the Ph_Provider and passed to the Ph_User to transfer one bit of received user data. This primitive is usually in the form of clock and data.

Parameters: PhS User data (M)

4.2.2.3 Physical Layer Frequency Request

Ph_FREQUENCY.request is the service request primitive for the frequency request service. This primitive is generated by the Ph_User and passed to the Ph_Provider. The receipt of this primitive by the Ph_Provider causes the local Ph_Provider to select the VHF frequency requested by the Ph_User.

Parameters: Desired frequency (M)

4.2.2.4 Physical Layer Prekey Request

Ph_PREKEY.request is the service request primitive for the pre-key request service. This primitive is generated by the Ph_User and passed to the Ph_Provider. This primitive is used only for the AM MSK data rate / modulation scheme defined in Attachment 5. The receipt of this primitive by the Ph_Provider causes the local Ph_Provider to update its pre-key sequence length.

Parameters: AM MSK Pre-key length (M)

4.2.2.5 Physical Layer Channel Sense Indication

Ph_CHANNELSENSE.indication is the service indication primitive for the channel sensing service. This primitive is generated by the Ph_Provider and passed to the Ph_User whenever the state of the channel sense changes. See ARINC Characteristic 750 for a description of the channel sensing algorithms.

Parameters: PhS Channel Sense (M)

4.2.2.6 Physical Layer Data Rate Request

Ph_DATARATE.request is the service request primitive for the data rate service. This primitive is generated by the Ph_User and passed to the Ph_Provider. The receipt of this primitive by the Ph_Provider causes the local Ph_Provider to set the physical link data rate and modulation for the requested speed. The table in

Attachment 5 defines the available data rates and modulation schemes.

Parameters: PhS Data rate parameter (M)

4.2.2.7 Physical Layer Signal Quality Indication

Ph_SQP.indication is the service indication primitive for the signal quality service. This primitive is generated by the Ph_Provider and passed to the Link Management Entity to indicate the current signal quality. Note that this primitive is usually generated once per received transmission and applies to the entire transmission.

Parameters: PhS Signal quality parameter (M)

4.3 Protocol State Machine

The physical layer Event and State Transition tables are located in Attachment 2.

5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER**5.1 Introduction**

This section contains both service and protocol sections. The service sections explain both the general functions of the sublayer as used and the interactions of this sublayer with the layer or sublayer above using service primitives. The protocol sections of this chapter specify both the Protocol Data Unit (PDU) formats and the elements of procedure for the AVPAC link only.

5.1.1 Model

The Link Layer provides for the reliable transfer of information across the physical media. The Link Layer is divided into three sublayers: (1) a Media Access Control (MAC) sublayer which specifies the use of a Carrier Sense Multiple Access (CSMA) algorithm to obtain access to the media, (2) a Data Link Service sublayer which provides several services over the MAC sublayer similar to HDLC, and (3) a Link Management Entity that manages the connections and performs handoffs. The specific options, classes, and modes of this layer, as defined in this Specification, will be referred to as Aviation VHF Link Control (AVLC).

Data are organized into Data Link Protocol Data Units (DLPDUs), also called frames, with synchronization, sequencing, and error control necessary for effective transmission through the physical layer.

The AVLC provides the following 2 services from the AVLC service provider to the AVLC service user:

- (1) a connection-oriented acknowledged point-to-point service,
- (2) a connection-less unacknowledged broadcast service.

This connection-oriented point-to-point service is designed to provide reliable transfer of information over the VHF broadcast media in a manner which hides the broadcast nature of the media.

5.1.2 General Operation

The DLS is modeled after the service definition of ISO 8886.

The DLS sublayer specified is intended to be conformant to High-Level Data Link Control (HDLC) as specified by ISO 3309(E) version 3 10/84, ISO 4335(E) version 3 8/87, ISO 7809(E) version 1 2/84 and ISO 8885(E) second edition 6/91. The service definition in this document is intended to conform to the OSI Data Link Service Definition (ISO 8886.3). If there are any differences between this guidance document and the cited specifications, this document should have precedence. HDLC is an umbrella standard with many options. It is the intention of this document to fully specify the HDLC options that pertain to AVLC. This variant of HDLC conforms to, but is not fully specified by options 1, 2, 4, 7, 12 of HDLC Consolidation of classes of procedures (ISO 7809).

COMMENTARY

Multiple AVLC Data Link connections can exist from a single aircraft to the ground at the same time. How this is to be used operationally is beyond the scope of this document.

The DLS layer within AVLC is a bit-oriented two way alternate (TWA) communications protocol which conforms to the Asynchronous Balanced Mode (ABM) of HDLC. This document defines a new class of HDLC operation. Specialized XID frame formats are specified for negotiation of AVPAC operational parameters. A subset of HDLC frames and elements of procedure are defined as legal for AVLC. This subset is optimized to make appropriate use of the MAC sublayer service given the random delay and contention possible due to the nature of the MAC sublayer as well as minimize unnecessary traffic. The HDLC subset is also intended to simplify the protocol state machine in general.

5.2 AVLC Media Access Control Sublayer**5.2.1 MAC Service Specification**

This section specifies the services provided by the MAC sublayer to the DLS sublayer. The services are described in an abstract way and do not imply any particular implementation.

5.2.2 Overview of Service

The primary service is provided by the use of two primitives, MA_RTS.request and MA_CTS.indication.

5.2.2.1 Media Access Request To Send

MA_RTS.request service primitive has no parameters. This primitive is a simple logical request by the DLS entity for permission to activate the physical transmission channel. This request is good for one transmission.

5.2.2.2 Media Access Clear To Send

MA_CTS.indication has no parameters. This primitive is a simple logical indication to the DLS entity that it has permission to activate the physical transmission channel for one transmission.

5.2.2.3 MA_TIMER1.request

This service primitive initiates the local MAC timer, TM1. This timer is used by the MAC layer to wait for a slot time. This primitive is an outgoing event to the state transition table. See Section 5.2.3 for a description of the MAC algorithm and Table A4-4 for a description of the timer operation.

5.2.2.4 MA_TIMER1.indication

This is defined as a primitive from the local MAC environment which occurs when the TM1 timer expires. This is used as an incoming event in MAC state Table A3-4.

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5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER (cont'd)

5.2.2.5 MA_TIMER2.request

This service primitive initiates the MAC timer, TM2. This timer is used to determine if access to the media is denied because of continuous transmissions (i.e., a stuck carrier). This primitive is an outgoing event to the state transition table. See Table A4-4 for a description of the timer operation.

5.2.2.6 MA_TIMER2.indication

This is defined as a primitive from the DLS environment which occurs when the TM2 timer expires. This is used as a pass through primitive from the MAC layer to the DLS primitive DL_EVENT to the LME state transition table.

5.2.2.7 MAC Layer Access Parameter Request

This primitive is the service request primitive to set the value of p in the unslotted p-persistent CSMA algorithm. This primitive is generated by the MA_User and passed to the MA_Provider.

Parameter: value of p (M)

5.2.3 Media Access Control Functions

The function of this sublayer involves the use of the channel access algorithm required to permit multiple aircraft and ground stations to operate on the same frequency. For AVPAC, a non-adaptive p-persistent Carrier Sense Multiple Access (CSMA) algorithm is adopted which can be implemented as a discrete process (Bernoulli process with probability of success p and delay before the next attempt of Δt). The value of p should be as shown the table below.

Value of p

Station Type	Min	Max	Increment	Default	Notes
Aircraft	1/256	1	1/256	13/256	
Ground	1/256	1	1/256	128/256	

The value of Δt , which is equal to the length of the receiver portion of the pre-key segment of the training sequence, is dependent on the class of equipment found on the channel. After completing a transmission, the MAC layer should not attempt to reacquire the channel for a length of time equal to Δt .

In order to guarantee a finite wait time, the upper bound of the delay for a single attempt to access the channel should be limited to the 99.9% point of the tail of the probability density function. After repeating the Bernoulli process $-\log(1000) / \log(1-p)$ times, the MAC algorithm should automatically generate a MA_CTS.ind.

COMMENTARY

The values of p and the sample period are subject to further research and prototyping, and may be defined

dependent on the data rate. The maximum value has been derived so that the tail of the probability (0.1% of all transmissions) should occur in a definite time interval. The value of p is currently defined as a managed object.

5.2.3.1 Transmitter Activation

The transmitter should be activated when there is a message waiting to be transmitted and the channel sense algorithm enables transmission. Frame transmission is done not only to send user messages but also to establish the data link connection and for other maintenance, management and diagnostic functions. These functions are provided by the MAC service user.

5.2.3.2 Channel Sensing

Before the MAC layer can generate a MA_CTS.indication, it must first determine that the RF channel is not occupied. How this is accomplished is outside the scope of this specification, and should be specified along with the modulation schemes. The MAC layer should wait for a length of TM1 for the channel to become idle.

If another station begins to transmit, while the MAC layer is waiting to transmit, then the MAC layer should clear the TM1 timer and reattempt to acquire the channel from scratch when it goes idle.

5.2.3.3 Channel Occupancy

An AVPAC station may hold the channel for a maximum time required to transmit k-1 maximum-size data frames at the current data rate. The holding time is computed by the following equation:

$$\text{Holding Time} = \text{Training Sequence Time} + \frac{[8 + (k-1) * (N1 + 8)]}{\text{Effective Data Rate}}$$

where the EffectiveDataRate is the actual instantaneous data throughput realized after overheads imposed by bit stuffing and any forward error correction encoding. TrainingSequenceTime is determined by the modulation scheme and k and N1 are link layer parameters. This specification does not independently fix the maximum channel holding time.

5.2.3.4 MAC Protocol State Machine

The MAC Event and State Transition Tables are located in Attachment 3.

5.3 AVLC Data Link Service Definition

This section specifies the services offered by the AVPAC Data Link layer to the layer above. Within the context of this document a service user is an entity at a layer which makes use of the services provided by the layer below. The Data Link layer service user exists at the Network layer and makes use of the Data Link layer services. Similarly a service provider is an entity which provides service to the layer above. So the Data Link service

5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER**5.3 AVLK Data Link Service Definition (cont'd)**

provider provides service to a service user at the Network layer. These services are provided at service access points (SAPs) through the use of service primitives. A service primitive is an abstract, implementation-independent description of an interaction between service user and service provider. A service primitive may contain parameters. These parameters, if they exist in the service primitive definition, describe information that is either defined as mandatory (M) or optional (O) for the primitive. Any physical realization details of these primitives are outside the scope of this document.

5.3.1 Functions

In this section the specific functions of the AVLK data link service sublayer are listed in a descriptive fashion with limited reference to DL_Users, DL_Providers or service primitives used for these functions. A formal definition of the AVLK data link layer primitives can be found in ISO 8886.

5.3.1.1 Link Activation and Release

The acquisition of the data path and movement of bits over the path is the responsibility of underlying MAC sublayer. Link activation involves the exchange of supervisory sequences to establish readiness to transmit, receive, and if necessary, the identification of the communicating parties. Note that link negotiation can be initiated by either an aircraft or a ground station. When there is a failure in the underlying physical media the link may go through an abnormal release procedure. The link may then be re-established by the data link entities. In general, it is the responsibility of the data link layer entity to re-establish the link, if possible, or notify the layer above, if this is not possible. In general, a link layer connection will be kept open if only for the purposes of flight following. Normal release can occur only after confirmation that all data sent have been received and the connection is cleared. Normal release can be initiated by either the avionics or the ground transceiver to hand-off the connection to a different link.

5.3.1.2 Frame Sequencing

It is the responsibility of the data link service sublayer protocol to number and verify sequences of frames. This system of sequence control permits the detection of missing frames. However, not all frames contain sequence numbers and are subject to sequence control.

5.3.1.3 Error Detection and Correction

Error in transmission can occur on the VHF channel due to collisions or spurious errors. These errors are detected at the DLS by computing the frame check sequence (FCS) per ISO 3309. If the computed FCS does not match the transmitted FCS, the frame is discarded and the error optionally logged.

5.3.1.4 Address Identification

Identification of a particular sender or receiver is necessary when there are many possible senders or

receivers in a multipoint system like AVPAC. Fields are established in the link layer header for both a source and destination address. The process of identification of addresses not only permits recognition, but allows each communicating station to determine the operating capability across the broadcast media.

5.3.1.5 Data Transfer

Data is transferred in the information field of AVPAC Info and XID frames per ISO 7809. There is no segmenting at the link layer, consequently, the link layer must be capable of handling the largest packet size.

5.3.2 Connection-Mode Service Primitives

This section specifies the services offered by the AVPAC data link layer to the DL_User, by the DL_Provider at the user/service boundary. These services allow a DL_User to establish a communications channel with a remote DL_User using service primitives. This section defines parameter data and valid sequences as appropriate for these service primitives using the notation of the OSI Data Link Service Definition (ISO 8886).

5.3.2.1 Connection Establishment Phase

The DL_User is responsible for initiating data link connection. It is the responsibility of the DL_Provider to attempt to establish a new data link connection if a current data link connection can no longer be provided.

DL_CONNECT service is requested by an initiating DL_User to an accepting DL_User. This service is a confirmed service which means that it results in explicit confirmation from the accepting DL_User to the initiating DL_User. The service primitives associated with data link connection are:

DL_CONNECT.request
DL_CONNECT.indication
DL_CONNECT.response
DL_CONNECT.confirm

The DL_CONNECT.request primitive is passed from the initiating DL_User to the DL_Provider to request that a logical link connection be established between a local Data Link Service Access Point (DLSAP) and a remote DLSAP.

The DL_CONNECT.indication is passed from the DL_Provider to the accepting DL_User to indicate an attempt by the initiating DL_User to establish a connection to a local DLSAP.

The DL_CONNECT.response primitive is passed to the DL_Provider from the accepting DL_User to convey the response to a previous associated DL_CONNECT.indication primitive.

The DL_CONNECT.confirm primitive is passed from the DL_Provider to the initiating DL_User to convey the results of the previous associated DL_CONNECT.request.

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5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER (cont'd)

5.3.2.2 Data Transfer Phase

Higher layer information is, in general, sent during data transfer phase, using the DL_DATA.request primitive. This higher layer information is passed to the layer below as the DLS User-data parameter of the primitive. This service is an unconfirmed service which is subject to flow control by higher layers. The primitives associated with data transfer are:

DL_DATA.request
DL_DATA.indication

The DL_DATA.request primitive is passed to the DL_Provider to request that a DLS User-data parameter be sent.

At the remote system, the DL_DATA.indication primitive is passed from the DL_Provider, indicating the arrival of a DLS User-data parameter.

Also within data transfer phase is a reset service which is associated with normal reset as well as link hand-off (frequency or ground station change). This is a confirmed service. The primitives associated with reset are:

DL_RESET.request
DL_RESET.indication
DL_RESET.response
DL_RESET.confirm

The DL_RESET.request primitive is passed from the initiating DL_User to the DL_Provider to request that a logical link connection be reset. Optional parameters for XID negotiation and other possible Quality of Signal (QOS) parameters may be passed with this primitive.

The DL_RESET.indication is passed from the DL_Provider to the accepting DL_User to indicate an attempt by the initiating DL_User to reset a connection. Optional parameters for XID negotiation and other possible QOS parameters may be passed with this primitive.

The DL_RESET.response primitive is passed to the DL_Provider from the accepting DL_User to convey the response to a previous associated DL_RESET.indication primitive. Optional parameters for XID negotiation and other possible QOS parameters may be passed with this primitive.

The DL_RESET.confirm primitive is passed from the DL_Provider to the initiating DL_User to convey the results of the previous associated DL_RESET.request. Optional parameters for XID negotiation and other possible QOS parameters may be passed with this primitive.

5.3.2.3 Disconnection Phase

Either DL_User (ground or avionics) can initiate a disconnect. Disconnection is not subject to the response of a higher layer, but is treated as an automatic sequence once either end of the connection initiates it. This is a

confirmed service. The primitives associated with connection termination are:

DL_DISCONNECT.request
DL_DISCONNECT.indication
DL_DISCONNECT.response
DL_DISCONNECT.confirm

The DL_DISCONNECT.request is passed to the DL_Provider to initiate the disconnect sequence.

The DL_DISCONNECT.indication is passed from the DL_Provider, indicating the termination of a connection by the remote entity.

The DL_DISCONNECT.response primitive is passed to the DL_Provider from the accepting DL_User to confirm receipt of the previous associated DL_DISCONNECT.indication primitive.

The DL_DISCONNECT.confirm primitive is passed from the DL_Provider to the initiating DL_User to confirm receipt of the associated DL_DISCONNECT.indication by the remote DL_User.

5.3.2.4 Service Primitive Specification

A detailed description of the standard data link service primitives can be found ISO 8886.

5.3.3 Connectionless-Mode Service Primitives

The connectionless-mode service is only intended to be used for unacknowledged broadcast service.

COMMENTARY

Note that DL_DATA are connection-mode data primitives, and DL_UNITDATA are connectionless-mode data primitives.

5.3.3.1 Data Transfer Phase

Higher layer information is sent using the DL_UNITDATA.request primitive. This higher layer information is passed to the layer below as the DLS User-data parameter of this primitive. This service is an unconfirmed service. The primitives associated with data transfer are:

DL_UNITDATA.request
DL_UNITDATA.indication

The DL_UNITDATA.request primitive is passed to the DL_Provider to request that a DLS User-data parameter be sent.

The DL_UNITDATA.indication is passed to the peer DL_Provider, indicating the arrival of a DLS User-data parameter.

5.3.4 Management Primitives

5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER (cont'd)**5.3.4.1 Data Link Event**

DL_EVENT.indication is the service indication primitive that the Data Link layer sends to the Link Management Entity (LME) when one of several events occur. These are reception of any frame from a peer entity (only ground stations for aircraft, and vice-versa), N2 retransmit count exceeded, or the TM2 timer expired. The primitive is generated by the DL Provider and passed to the LME. The purpose is to allow the LME to keep track of the quality of reception of any frames transmitted from peer entities in the PECT and to possibly initiate the Site Recovery Function. The contents of the frame are required only if the frame is a GSIF or XID.

Parameters: Link Layer Source Station Address (M)
Contents of Frame (O)
N2 Exceeded indication (O)
TM2 timer expired indication (O)

5.3.4.2 Data Link Connection Handoff Request

DL_HANDOFF.request is the service request primitive for the transfer of connection-oriented link state information. It is generated by LME and passed to the DL Provider when the LME requests transfer of a connection. This is a confirmed service.

Parameters: New Peer Entity Station address (M)
Other XID parameters to be negotiated (M)

5.3.4.3 Data Link Connection Handoff Indication

DL_HANDOFF.indication is the service indication primitive that indicates the DL Provider has received a handoff request from the remote entity.

Parameters: Receive State Variable (M)

5.3.4.4 Data Link Connection Handoff Response

DL_HANDOFF.response is the service response primitive generated by the LME and passed to the DL Provider indicating completion of the handoff on the responding side.

Parameters: Receive State Variable of peer entity (M)

5.3.4.5 Data Link Connection Handoff Confirmation

DL_HANDOFF.confirm is the service confirmation primitive informing the LME that the handoff is complete. It is generated by the DL Provider and passed to the LME.

Parameters: Success/failure (M)

5.3.5 Access Points

Source and Destination Addresses completely and uniquely identify Data Link Service Access Points.

5.4 AVLC Data Link Service Protocol Specification

This protocol specification section consists of two parts, a data link protocol data unit (DLPDU) or Frame Format

Section 5.4.1 and an Elements of Procedure Section 5.4.2. The Frame Format section specifies the structure and coding of the frames used for transfer of data and control information.

The Elements of Procedure section specifies any differences in phases of connection operation, data link system parameters and the procedures for the transfer of data and control information from one data link entity to a peer data link entity between ISO 4335 and AVLC. These procedures are supplemented by the protocol state machine tables. In the event of differences or ambiguities, the state tables should have precedence.

For the purposes of this document a "data link entity" is a protocol state machine capable of setting up and managing a single data link connection.

5.4.1 Frame Format

AVLC DLPDUs should conform to HDLC frame structure as specified by ISO 3309, except as noted below. Note that it will be possible for a transmitter to include more than one frame in a single physical layer transmission as long as the total transmission does not exceed maximum channel occupancy time. For example, a ground station may transmit, in a single instance, two short uplink messages to the same or different aircraft without releasing and subsequently reacquiring the radio channel, leading to more efficient use of the available bandwidth.

5.4.1.1 Specific Field Structures**5.4.1.1.1 Address Structure**

The address field consists of eight octets. The low order (first transmitted) bit of each octet is reserved for address extension. When set to binary zero it indicates that the rest of the following octet is an extension of the address field. The presence of binary one in the first transmitted bit of the address octet signals that the octet is the final octet of the address field.

The AVLC frame will contain a Destination and a Source address field. The Destination address field can contain either a Station address or a Broadcast address both of which are four octets in length. A Source address can only contain a Station address. Station Addresses are assigned to all transceivers (aircraft, ground stations and others) that use the AVPAC communications system.

Twenty-seven bits are allowed for address information, excluding the air-ground (A/G) or command response bit which is not, strictly speaking, address information. This 27 bit field is broken up into 3 or 4 sub-fields, depending upon the field values.

The Address Type field is a 3 bit field which specifies, among other things, whether the address is: (1) an aircraft addressed using the ICAO 24 bit aircraft address or (2) if the address designates a fixed ground based "base station". See Table A7-1.

5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER (cont'd)

The first bit of the Base Station Address partitions the address space into ICAO administered addresses and non-ICAO administered addresses. See Table A7-2.

If the Address Type field indicates that this address is a Base Station Address, the Transceiver Address field contains a Service Provider sub-field and a Ground Station sub-field. The size of the two sub-fields is different for different classes of addresses. See Tables A7-3 and A7-4.

COMMENTARY

It is desirable that ground station addresses are assigned uniquely across frequencies in order to reduce problems caused by "spurious radiation".

There are two bits in the Address fields which are set by the transmitting station to reflect status information. Bit 2 in octet 5 (the Source Address field) is the C/R bit (C/R = 0 command, C/R = 1 response). Bit 2 in octet 1 (the Destination Address field) is the A/G bit (A/G = 0 transmitting station is in the air, A/G = 1 transmitting station is on the ground). The default value for this air/ground bit is 0 for aircraft that do not provide this information at the link level and it should always be 1 for ground-based transmitters. See Figure A7-1 in Attachment 7.

See Appendix A for a sample encoding of a link layer header.

5.4.1.1.1 Broadcast Address

The broadcast destination addresses are defined as follows:

Broadcast to all aircraft	
type field	001
24-bit aircraft ID	all ones

Broadcast to all ground stations	
type field	010
remaining 24 bits	all ones

Broadcast to all ground stations for a specific service provider	
type field	010
service provider sub-field	ID of service provider
ground station sub-field	all ones

Broadcast to all stations:	
type field	111
remaining 24 bits	all ones

COMMENTARY

This broadcast address can only be used as a destination address for Unacknowledged Information (UI) frames, or XID frames broadcasting ground station information; since only connection oriented service is currently defined. These should never be used as a source address.

5.4.1.1.2 Point-to-Point Address

Normal addresses contain Source and Destination Station addresses. Per option 7 of HDLC, the last octet of this address will have the first bit set to one to indicate that this is the last octet in the extended address.

5.4.1.2 Types of Data Link Protocol Data Units (DLPDUs)

The basic repertoire of commands and responses for AVLC should be as follows:

Commands Responses

I	I
RR	RR
XID	XID
TEST	TEST
REJ	FRMR
UI	
DISC	

Since a UA is not used, the P/F bit must be set to 0 for UI and DISC frames. The frame types should be encoded per ISO 4335.

5.4.1.2.1 Exchange Identity (XID)

The information field of the XID frame is specified by ISO/IEC 8885 1991(E) and ISO/IEC 8885:1991/Amd.3:1991(E). In addition to the standard parameters specified by use of the General Purpose Format Identifier, AVPAC defines private parameters to allow each entity to inform its peer of parameters specific to the AVPAC environment. The ground system also has the capability to set various subnetwork parameters to be used by an aircraft. In order to ensure consistent operation of the network, an aircraft should only use parameters that it received from the service provider that it is communicating with.

The receipt of a link establishment XID will cause the reset of the link state variables if a link corresponding to the source and destination addresses already exists.

The XID user data field is used in AVPAC to reduce the number of transmissions during connection setup,

5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER (cont'd)**5.4.1.2.1 Exchange Identity (XID) (cont'd)**

consequently this data should not be passed to the DL User until a link layer connection is established. The following table summarizes the parameters and when they can be used. There are two hexadecimal values in each valid table entry, the first is the group identifier and the second is the parameter identifier.

COMMENTARY

The group identifiers listed in this document are backwards from what is listed in ISO 8885 because this document lists the high bit on the left, and ISO lists the low bit on the left.

Table 1. Use of Parameters in XID Frames

XID Parameter	GSIF		Ground->Air Connection		Air->Ground Connection	
	GI	PI	GI	PI	GI	PI
Procedure classes	80	02	80	02*	80	02*
HDLC options	80	03	80	03*	80	03*
N1 - uplink	80	05				
N1 - downlink	80	06				
k - uplink	80	07				
k - downlink	80	08				
T1 timer	80	09				
N2	80	0A				
T2 timer	80	0B				
XID sequencing			F0	03	F0	03
Handoff, LCR			F0	01	F0	01
Handoff mask	F0	C3				
T4 (downlink)	F0	41				
T4 (uplink)	F0	C2				
SQP			F0	02	F0	02
Previous Gnd Sta Modulation					F0	80
Support					F0	81*
Alternate Gnd Sta					F0	82
Replacem Gnd Sta			F0	43		
Autotune Freq			F0	40		
Frequency List	F0	C0				
Airport						
Identifier	F0	C1			F0	83
value of MAC p	F0	42				

Table entries marked with a '*' can only be used during link establishment attempts.

5.4.1.2.1.1 Public Parameters

The Format Identifier (82_H) is used (per ISO 4335.2:1990, Annex C) to identify the public parameter list identified in ISO 8885, which defines the negotiations for many of the parameters used in AVPAC. The following clarifications should be noted: all binary encoding will be implemented as unsigned 16-bit integers with most significant byte first, the reply delay before acknowledgement timer will be the minimum delay for generation of a reply, and the retransmission timer will be encoded as follows:

Parameter ID 0000 1001 T1 timer
 Parameter Len 0000 0100
 Parameter Value ffff ffff (MSB) fixed delay value
 ffff ffff (LSB)
 rrrr rrrr (MSB) upper limit of random timer value
 rrrr rrrr (LSB)

5.4.1.2.1.2 Private Parameters

The private parameter group is used to define those parameters which are unique to the AVPAC operating environment. The parameter identifiers have been chosen to allow simple identification of the purpose of the parameter:

bit 8 bit 7 purpose

0 0 general purpose information private parameter
 0 1 ground initiated modification private parameter
 1 0 aircraft initiated information private parameter
 1 1 ground initiated information private parameter

COMMENTARY

Other parameter groups may be defined in the future as required for additional functions such as Forward Error Correction (FEC), code division multiple access (CDMA), time slotting or any other physical, media access or logical link parameters that are deemed appropriate for the use of new frequencies or more robust performance in the VHF environment.

5.4.1.2.1.2.1 General Purpose Information Private Parameters

Parameter ID 0000 0000 Parameter Set Identification
 Parameter Len nnnn nnnn
 Parameter Value 0101 0110 character 'V'
 vvvv vvvv first digit
 vvvv vvvv last digit

This parameter is required to be used whenever any of the following private parameters are to be sent. It should be the first private parameter sent. Following the IA5 character 'V' is an IA5 string of digits indicating the 631 supplement supported. For example, the parameter set identification string for software supporting supplement 1 should be 'V1'.

Parameter ID 0000 0001 Handoff, LCR
 Parameter Len 0000 0001
 Parameter Value nnnn 00rh

This parameter should consist of a single octet bit field. Bit position 1 (h) is defined as the HO (handoff) bit. (0=a link initialization is occurring, 1=a handoff is occurring.) Bit position 2 (r) indicates LCR (Link Connection Refused) bit. (0=link connection accepted, 1=link connection refused.) Bit positions 8, 7, and 6 (nnn) indicate the sender's value of N(r). Bit position 5 is the reset bit (0=do not reset link state variables, 1=reset link state variables). Bit 5=1 indicates that an abnormal failure has occurred and the link state variables should be reset (any packet layer resolution will occur via the user data field). When bit 5-1 in an XID_CMD it also

5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER (cont'd)

indicates that no transmissions are allowed during the handoff. Other bit positions are reserved and should be set to 0. This parameter is only sent for link set up, handoffs, and reset.

Parameter ID 0000 0010 SQP
Parameter Len 0000 0001
Parameter Value 0000 qqqq

The parameter should consist of a 4-bit integer indicating the sender's reception quality value of the receiver's last transmission.

Parameter ID 0000 0011 XID Sequencing
Parameter Len 0000 0001
Parameter Value rrr0 0sss

This parameter is used to sequence XIDs to simplify the processing logic. This parameter contains two fields, an XID sequence number and an XID retransmission number. A station increments the sequence number for every new XID (setting the retransmission field to zero on the first transmission), and increments the retransmission field after every retransmission. In an XID_RSP, the sequence number is set to the value of the XID_CMD sequence number generating the response (the retransmission field is ignored).

5.4.1.2.1.2.2 Ground Initiated Modification Private Parameters

Parameter ID 0100 0000 Autotune Frequency
Parameter Len 0000 0010
Parameter Value nnnn gggg
9999 9999

This parameter is the frequency (gggg gggg gggg) and modulation (nnnn) on which reply to this command. This parameter is sent by a ground station to cause an aircraft to retune to a new frequency.

Parameter ID 0100 0001 T4
Parameter Len 0000 0010
Parameter Value nnnn nnnn (MSB)
nnnn nnnn (LSB)

This parameter is the value of the T4 timer that the aircraft will use in minutes, encoded as an unsigned 16-bit integer.

Parameter ID 0100 0010 value of MAC p
Parameter Len 0000 0001
Parameter Value nnnn nnnn value

This parameter is the value of the parameter p in the p-persistent CSMA algorithm that aircraft will use, this 8-bit integer is encoded as 00_H (= 1/256) and FF_H (=1).

Parameter ID 0100 0011 Replacement Ground Stations
Parameter Len nnnn nnnn
Parameter Value gggg gggg (MSB)
gggg gggg
gggg gggg (LSB)

This parameter should consist of an ordered list of 24-bit station addresses, to be used by the aircraft LME during

ground-initiated or ground-requested handoffs as possible replacement ground stations.

5.4.1.2.1.2.3 Aircraft Initiated Information Private Parameters

Parameter ID 1000 0000 Previous Ground Station
Parameter Len 0000 0011
Parameter Value gggg gggg (MSB)
gggg gggg
gggg gggg (LSB)

This parameter is the address of the previous ground station during a handoff.

Parameter ID 1000 0001 Modulation Support
Parameter Len 0000 0001
Parameter Value 0000 nnnn

This parameter indicates support for high speed modulation schemes. This parameter may be sent on link set up. Encoding is per Table A5-1.

Parameter ID 1000 0010 Alternate Ground Stations
Parameter Len nnnn nnnn
Parameter Value gggg gggg (MSB)
gggg gggg
gggg gggg (LSB)

This parameter should consist of an ordered list of 24-bit station addresses, to be used by the ground system LME during handoffs as possible alternate ground stations if the preferred ground station is not acceptable to the ground system.

Parameter ID 1000 0011 Airport Identifier
Parameter Len 0000 0100
Parameter Value aaaa aaaa (1st byte)
aaaa aaaa
aaaa aaaa
aaaa aaaa (4th byte)

This parameter should consist of the four letter airport identifier of the airport that the aircraft is approaching, encoded as four eight-bit ISO IAS characters.

5.4.1.2.1.2.4 Ground Initiated Information Private Parameters

Parameter ID 1100 0000 Frequency List
Parameter Len nnnn nnnn
Parameter Value rrrr ffff (MSB)
ffff ffff (LSB)

This parameter indicates the list of frequencies and modulation schemes supported by the originating ground station. The parameter should consist of an ordered list of 16-bit integers. The high order 4 bits of each 16-bit integer should be a Data Rate parameter encoded as defined in Table A5-1. The remaining 12 bits should be the frequency encoded as integer (Frequency in Mhz * 100) - 10000 (e.g., for a frequency of 131.725 Mhz, the encoded value will be 3172.) These values are repeated for the length of the parameter value field.)

5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER (cont'd)**5.4.1.2.1.2.4 Ground Initiated Information Private Parameters (cont'd)**

Parameter ID	1100 0001	Airport Identifier
Parameter Len	nnnn nnnn	
Parameter Value	aaaa aaaa	(1st byte)
	aaaa aaaa	
	aaaa aaaa	
	aaaa aaaa	(4th byte)

This parameter should consist of a list of four letter airport identifiers of airports with which the ground station can support on-ground traffic. Each four letter identifier is encoded as four eight-bit ISO IA5 characters.

Parameter ID	1100 0010	T4
Parameter Len	0000 0010	
Parameter Value	nnnn nnnn	(MSB)
	nnnn nnnn	(LSB)

This parameter is the value of the T4 timer that the ground system is using in minutes, encoded as an unsigned 16-bit integer.

Parameter ID	1100 0011	Handoff Mask
Parameter Len	0000 0011	
Parameter Value	9999 9999	(MSB)
	9999 9999	
	9999 9999	(LSB)

c-1 This parameter is a ground station address mask which is used to determine if a handoff is supported between the current and a candidate ground station. The inter-router handoff is supported if (current_ground_station & handoff_mask == candidate_ground_station & handoff_mask) is true. See section 5.5.2.3.

5.4.1.2.2 Disconnect Command (DISC)

The Disconnect Command (DISC) command is used to cause the disconnection of an existing link. This command can be issued at any time during data transfer phase. Its use may result in the loss of unacknowledged data. Unlike normal 4335 operations, the P/F bit must be set to 0 for all DISC command PDUs (thus no response PDU is expected).

5.4.1.2.3 Unnumbered Information (UI)

Unnumbered Information frames are included solely to support of connectionless data transfer required for the use of broadcast addressing. The use of UI frames is not recommended at this time. Unlike normal 4335 operations, the P/F bit must be set to 0 for all UI command PDUs (thus no response PDU is expected).

5.4.1.2.4 REJECT (REJ)

The REJ frame is used by a station to request retransmission of all information frames starting with sequence number N(r). I frames numbered up through N(r)-1 should be considered as acknowledged. In any one direction, only one "sent REJ" condition should be established at any given time per AVLC connection. The "sent REJ" condition should be cleared upon the receipt of an I frame with an N(s) equal to the N(r) of the REJ

frame. Although ISO 4335 allows (but does not require) a station to retransmit a REJ frame if the T1 timer expires, in AVLC a REJ command can only be transmitted by receipt of an unacceptable frame.

5.4.2 Elements of Procedure**5.4.2.1 Phases of Operation****5.4.2.1.1 Link Initialization Phase**

Link initialization is done through an exchange of XID unnumbered frames. Link level addressing information and parameters that specify the proposed properties of the link are passed in the initiating XID frame which will have the poll bit set to one indicating that a response is required. The responding XID will also have its final bit set to one to indicate that it is a response.

The responding XID frame will confirm the respondent's address and the link parameters to be used. Once XID parameters have been exchanged, data transfer phase can begin.

It is the responsibility of the aircraft to establish the link. The way this is done is by listening to any uplink messages or GSIF frames, and based on the signal characteristics, choosing the appropriate ground station and then setting up a link connection with the ground station. Once this is done, any message destined to that particular aircraft will be routed properly by the service provider.

COMMENTARY

This application of XID frames is considered non-standard in ISO, but was used due to the specific needs of the AVPAC environment.

Link initialization procedures use the XID command frame, not the SABM frame.

SABM should not be used and, if received, should be treated as an error. The establishment and determination of the link is provided only by the exchange of XID frames.

5.4.2.1.2 Data Transfer Phase

The Data Transfer Phase consists primarily of the exchange of Information frames, interspersed with the necessary exchange of Receive Ready (RR) frames to continue to assure that the link is up and provide flow control.

Receive Ready frames will be used for acknowledgement if there is no data to be sent and the T2 timer (see Section 5.4.2.2.2) expires following the receipt of an Information frame.

If a link layer queue is not empty, sequences of I frames (no greater than the window size) can be sent with the poll bit set to zero. If an I frame is received with the poll bit set, an RR or other valid acknowledgement (an I frame with the proper N(R)) is sent immediately; otherwise, an acknowledgement is sent after T2 seconds.

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5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER (cont'd)

5.4.2.1.3 Ground Station Hand-off

See Section 5.5.2.2 for ground station handoff procedures.

5.4.2.1.4 Disconnection Phase

Below are listed the two ways in which disconnection can occur and the corresponding frame exchanges associated with these disconnection scenarios. Only the planned disconnection will cause a DL_DISC.ind to be issued to the DL_User; in an unexpected disconnection the LME will intercept the DL_DISC.ind and attempt to handoff to a new ground station, and only on failure of a handoff will the DL_DISC.ind be issued to the DL_User.

5.4.2.1.4.1 Unexpected Disconnection

Unexpected loss of the underlying physical service is detected due to the lack of a response or acknowledgement to some frame. After N2-1 retransmissions the data link entity can optionally either inform the DL_User of loss of connection or attempt to establish a new connection with different characteristics (different frequency, physical characteristics or location). Further communication will be established with the exchange of XID frames.

5.4.2.1.4.2 Planned Disconnection

Planned disconnection is accomplished through the Disconnect Command (DISC) (see Section 5.4.1.2.2). A DISC frame is issued by the data link entity wishing to disconnect the link.

5.4.2.2 List of Data Link Service System Parameters

Listed below are the system parameters needed by the Data Link Service sublayer. These parameters are negotiated by the use of XID frames (Section 5.4.1.2.1).

The timers in this list may in the future be defined as primitives to the local environment and added to the DLS service definition.

Data Link Service System Parameters for 2400 bps

	Name	Min.	Max.	Default	Increment
T1	Delay before retransmission (fixed part)	1 sec	15 sec	10 sec	1 msec
T1	Delay before retransmission (random part)	1 sec	20 sec	15 sec	1 msec
T2	Min delay before ACK	0 sec	10 sec	2 sec	1 msec
T3	Link Initialization Time (fixed part)	6 sec	20 sec	15 sec	1 msec

T4	Max delay between transmissions	10 mins	65535 min	20 mins	1 min
T5	Max time since transmission	Random bet 100-120 sec			
N1	Max Info Frame Size	256 bits	16472 bits	2136 bits	1 bit
N2	Max number of transmissions	1	15	6	1
k	Window size	1	7	7	1

5.4.2.2.1 Timer T1 - Delay Before Retransmission

The value of both parts of T1 in the avionics can be set by an XID from the ground station. The value of the timer is constructed by summing a fixed part (which is a managed object) and a random part (uniform distribution range of 0 to a managed object) which is calculated for every transmission attempt. This timer is actually initiated at the end of the transmission. If the timer expires, the frame or frames are retransmitted. See Table A4-4 for a description of the timer operation.

5.4.2.2.2 Timer T2 - Minimum Delay Before Acknowledgement

The parameter T2, at either the ground or avionics, represents the amount of time a station should wait before transmitting an acknowledgement.

The period of T2 is a delay, of shorter duration than the T1 value of the peer entity, which is provided to permit the acknowledging station to schedule the response as an event in normal data processing and to allow sufficient time for an acknowledgement, while maximizing the likelihood of reverse-bound traffic eliminating the need for an explicit acknowledgement. The T2 timer in the avionics can be set by an XID from the ground station.

The value of this timer is very critical to network performance when ISO 8208 is used as the next layer protocol. The optimum value is a function of network load, therefore this value is a managed object.

5.4.2.2.3 Timer T3 - Link Initialization Time

The parameter T3, at either the ground or the avionics, represents the amount of time a data link entity waits for the peer entity to respond during link initialization, before retransmitting the "XID Command".

The period of T3 delay, of longer duration than the T1 value of the peer entity, which is provided to permit the responding entity to co-ordinate the response during the initialization. T3 is not separately negotiated, but is simply the value of T1 timer plus five seconds. That is,

5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER (cont'd)**5.4.2.2.3 Timer T3- Link Initialization Time (cont'd)**

the same random T1 value, but a fixed value 5 seconds longer than the fixed T1 value.

5.4.2.2.4 Timer T4 - Maximum Delay Between Transmissions

This timer is used to verify the continued existence of the link. If a station does not receive a frame (P=1) before this timer expires, it will send a command RR to ensure a response from the peer entity. The value for the T4 timer should be shorter for an aircraft than a ground station. After attempting to receive a response after N2 attempts, the station should assume the link is disconnected. The timer is a managed object.

5.4.2.2.5 Timer T5 - Maximum Time Since Transmission

This timer is used only by the ground transceiver unit to initiate the transmission of a Ground Station Information Frame (GSIF) XID frame when the timer expires. The value for this timer is uniformly distributed between 100-120 seconds with resolution of one second. This timer is reset whenever a ground station sends a frame of any kind.

5.4.2.2.6 Timer T6 - Connection Time-out

This section acts as a place holder for the specification of this timer which should not be required by the AVPAC context.

5.4.2.2.7 Maximum Size in an Information Frame - N1

The parameter N1, at either the ground station or avionics, indicates the maximum number of bits in an Info frame (excluding flags and zero bits inserted for transparency) that a station will accept. This is equal to the maximum packet size plus link layer address, control field and FCS.

5.4.2.2.8 Maximum Number of Transmissions - N2

When the T1 timer, expires, the avionics will automatically attempt to retransmit the frame. This process is repeated for a number of times defined as N2.

The value of the ground N2 parameter may be different from the value of the avionics N2 parameter. Both systems should be advised of both values during the XID exchange.

Following the last retransmission attempt, defined by N2, the avionics will not attempt to retransmit the same frame to the same ground station on the same frequency without external intervention. (See the link management entity in Section 5.5.)

5.4.2.2.9 Window Size - k

The parameter k defines the maximum number of outstanding sequentially numbered I frames that may be

transmitted before an acknowledgement is required. The value of the ground k parameter may be different from the value of the avionics k parameter. Both systems should be advised of both values during the XID exchange.

5.4.2.3 Description of Procedures

Except as noted below, the standard procedures for the options called out in Section 5.1.2 are described in ISO 4335 and ISO 7809 should be followed.

5.4.2.3.1 Modes of Operation

Two modes of operation are defined: an operational mode and a non-operational mode. The operational mode should be Asynchronous Balanced Mode (ABM), which is a balanced operational mode where a data link connection has been established between two service access points. Either data link entity can send commands at any time and initiate responses without receiving permission from the peer data link entity on the connection.

The non-operational mode, Asynchronous Disconnected Mode (ADM), is in effect whenever there is no data link connection set-up. This mode may be entered by issuing a DISC command or if the data link is dropped for abnormal reasons. Note that the Disconnected Mode (DM) response is not supported in the AVPAC context. The DM should not be used and, if received, should be treated as an error. A data link entity indicates that it is in disconnected mode by sending an XID frame with the Link Connection Refused (LCR) bit set to one.

5.4.2.3.2 Procedure for the Use of the P/F Bit

A Data Link entity receiving a command frame with the P bit set to 1 (which can be either an XID, TEST, RR, or REJ), will set the F bit to 1 in the corresponding response frame. Note that the C/R bit in the address field should be referenced to unambiguously differentiate between command and response frames if the P/F bit is set.

After receiving an I frame with the P bit set to 1, a station should send an RR response immediately. After receiving an I frame with the P bit set to 0, a station should set the T2 timer (only if it was not already running), and send an RR or Info response frame with the F bit set to 0 when the T2 timer expires.

COMMENTARY

Because normal 4335 procedures do not allow more than one frame outstanding with the P bit set, the T2 timer procedure is used to insure that an acknowledgment is always generated, even if the last frame in a transmission (which has the P bit set to force an immediate acknowledgment) is not received correctly. By not sending any I-frames with the P bit set, there is a greater likelihood that the receiving station can piggyback the RR on reverse-bound traffic as well as not preventing the transmitting station from sending more traffic immediately.

5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER (cont'd)

5.4.2.3.3 Collision Procedures for Unnumbered Command Frames

Collision refers to the situation when a data link entity receives a conflicting command frame after sending a command frame, but before receiving a response to the command sent. Collision is only a problem with unnumbered frames and is not a problem for commands that do not require conflicting action.

If an unnumbered frame collision occurs, the frame initiated by the station with the lower 27-bit station identification will have precedence.

COMMENTARY

In particular, for XID frames, the station with the higher address will generate an XID_RSP to the XID_CMD from the lower address station (which will ignore the XID_CMD it received).

5.4.2.3.4 Uses of the XID PDU

AVPAC uses the XID frame for the following functions:

- ground station identification: GSIFs are sent by a ground station whenever it has not sent an uplink within the past T5 seconds to permit the aircraft to perform station discovery or the ground system needs to set the system operating parameters for an aircraft.
- parameter information transfer: An XID exchange allows stations to inform each other of various characteristics (e.g., protocol version supported) and capabilities (e.g., modulation scheme support) of the sending station.
- request a handoff: The ground may send an XID to request an aircraft to initiate a handoff (e.g., an autotune).
- initiate/respond to a handoff: An XID exchange is used to perform a handoff from one ground station to another.
- indicate the mode: An XID is used to inform the peer entity that a station is in the ADM state.

GSIFs are sent by a ground station if it has not uplinked anything recently with a broadcast destination address. GSIFs are used to inform any aircraft that is listening of the existence and operational parameters of the sending ground station. These frames are sent in a connectionless and unacknowledged mode with the P/F bit equal to zero.

Once an aircraft has received a GSIF (or any other uplink traffic) it may then respond with an XID command (P = 1) with the destination address of the ground station to set up a link. The ground system must then respond with an XID response (F = 1), from the ground station with which the link has been established. Alternatively an XID frame exchange can be performed without an initial scanning by the aircraft to determine the station by using the Replacement Ground Station Address parameters or other methods which are outside the scope of this document. In this case, the method by which the aircraft or ground station determines the location or operational parameters

of the peer data link entity is outside the scope of this document.

In the general case, an XID frame can be originated from either the aircraft or ground station. It identifies the originator and provides information to the receiver about the characteristics of the originator. Data link connection set-up is performed using an exchange of XID frames. XID frames will also be used when either the aircraft or the ground station wishes to establish a new link while retaining the same network connection or to negotiate changes to the operational characteristics of the link. In this case, the exchange will occur between the aircraft and the new ground station.

The ground station with which the link is established may also request that the aircraft initiate a handoff by sending an XID_CMD_HO (P = 0); if this XID contained an autotune frequency parameter, then the aircraft would retune to the new frequency before attempting a handoff (the ground should speed the recovery process by using the Replacement Ground Station Address parameter so that the aircraft can perform the handoff immediately). If only two XIDs were used for autotuning and if the ground system did not receive a response from the aircraft, the ground would not know whether the initial autotune command was not received (and the aircraft was still on the old frequency) or the response was not received (and the aircraft was on the new frequency). The use of three XID's resolves this problem.

Since there may be no response at the link layer to an XID frame, the originator of an XID frame should retransmit the XID upon expiration of the T3 timer, whenever an XID_CMD (P = 1) was sent. The XID sequencing parameter allows for each determination by the receiving station of whether an XID is new or being retransmitted.

Negotiation of link parameter options is accomplished in a single transaction per ISO 8885. The XID frames contain all of the information required to establish or change the parameters of the data link; the absence of any parameter field should be interpreted to mean that the corresponding data value should maintain its current value.

Finally, the LCR bit is used when a station receives a frame (other than a link establishment XID) with which it does not have a link established or when a mutually agreeable set of parameters cannot be agreed to so a link cannot be established. An XID_CMD_LCR (P = 0) should be used to indicate that a station is in the ADM state. Optionally, after sending the XID_CMD_LCR the station may attempt to advance from the ADM state to the ABM state by attempting to establish a link, or it may wait and let the originating station establish the link. An XID_RSP_LCR (P = 1) should be sent when an XID_CMD was received with unacceptable parameters. An XID_CMD_LCR (P = 1) should never be sent.

5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER (cont'd)**5.4.2.3.5 Uses of the Broadcast Facility**

Either XIDs or UIs can be broadcast to various classes of destinations. XID functionality is described in Section 5.4.2.3.4 and UI functionality is presently undefined.

A station can broadcast a frame to either all stations, all stations of the same type, or all ground stations operated by the same service provider. The operation of the specialized broadcast addresses is not defined. However, it is desired that ground service providers be capable of responding to a link establishment XID broadcast to the service provider with a single response XID frame from the best ground station.

5.4.2.3.6 Procedures for Information Transfer

Except as noted below, the procedures for information transfer should be specified by ISO 4335.

5.4.2.3.6.1 Suspension of the Data Link

If a data link entity is unable to continue to receive, it should send a DISC to terminate the current link.

5.4.2.3.6.2 Queuing of Frames

When the DLS sublayer has frames to transmit, it should send a MA_RTS.request to the MAC layer, queue the frames and wait for the MAC sublayer to generate a MA_CTS.indicate primitive. While waiting for the MA_CTS.indicate primitive, the DLS sublayer should update the transmit queue according to the procedures listed in this section. If all of the frames on the DLS transmit queue are pruned, then the MA_CTS.indicate primitive should be ignored. The DLS sublayer should:

- 1) Eliminate duplicate RRs. At most one RR should be queued up for transmission. Any extra RRs in the transmit queue should be deleted.
- 2) Improve the acknowledgment process. If any good I-frames are received from the peer entity, the DLS sublayer should update the N(r) of all numbered frames in the transmit queue with the latest value, thus improving the probability of the acknowledgment arriving.
- 3) Eliminate unnecessary retransmissions. If any good numbered frames are received from the peer entity, the DLS sublayer should delete any frames in the transmit queue which were acknowledged. If a good REJECT frame is received from the peer entity, the DLS sublayer should delete all I frames in the transmit queue (and by processing the REJECT refill the queue).

5.4.2.3.7 Procedures for Resetting

A data link connection may be reset [V(R), V(S) state variables set to zero] by the transmission or reception of an XID frame with the reset bit set or a FRMR. A FRMR may be responded to with a mode setting command (XID); however, this is not required.

5.4.2.4 DLS Protocol State Machine

The DLS Event Tables and Connection Setup and Handoff State Transition Tables are located in Attachment 4.

5.5 Link Management Entity**5.5.1 Introduction**

The Link Management Entity (LME) resides above the Data Link Layer and appears as a DL_User to the Data Link Layer. The LME controls the operations of:

- a) Data Link Layer, including initial connection establishment, handoffs, and receiving notifications regarding maximum transmission count exceeded for frames,
- b) MAC Layer, including value of p,
- c) Physical Layer, including tuning the modem and preparing it for correct modulation schemes and data rates.

The LME has no peer, but does have an interface to the upper management entity. The data tables will be specified as a Managed Object in future releases.

5.5.2 Functions

The Link Management Entity is responsible for acquiring, establishing, and maintaining a connection with the peer entity. As the aircraft is responsible for initiating contact with the ground, Sections 5.5.2.4, 5.5.2.5 apply only to the aircraft, while sections 5.5.2.1, 5.5.2.2, 5.5.2.3, and 5.5.2.6 apply to both the aircraft and the ground system.

5.5.2.1 Local Handoff Decision Function

The Local Handoff Decision Function maintains the Peer Entity Contact Table (PECT) updates it as a result of the receipt of two primitives, DL_EVENT.indication(sq) and DL_EVENT.indication(t2). Note that aircraft only receive DL_EVENT.indications(sq) for frames transmitted by ground stations, and ground stations only receive DL_EVENT.indications(sq) for frames transmitted by aircraft.

Whenever a DL_EVENT.indication(sq) is received, the TG2 timer for that peer entity is reset and the link quality estimate for that peer entity is updated. When a TG2 timer expires or the link quality estimate falls below LQC, the link quality handoff threshold, then that peer entity is eliminated from the PECT. If a connection exists for the peer entity which has just been deleted from the PECT, then the Site Recovery Function is initiated.

When the link quality parameter of the station to which a connection exists changes compared to the signal quality parameter of other ground stations the Local Handoff Decision Function may decide a handoff is necessary and will send an LME_SITERECOVERY.indication to the Site Recovery Function.

5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER (cont'd)

COMMENTARY

The decision regarding when to perform a handoff and the method by which the candidate station is selected is not limited to the method described above. Particularly, other inputs regarding location, service provider preference, etc., may be used in the handoff decision function.

Primitives associated with the Local Handoff Decision Function are:

DL_EVENT.indication(sqp)
LME_SITERECOVERY.indication
TG2_TIMER.request

5.5.2.2 Handoff Function

One of the main functions of the LME is link maintenance by monitoring and controlling the two state machines in the Data Link Layer during the handoff transition.

The Handoff Function will attempt to transfer the link layer connection from the current ground station, which is no longer acceptable, to a specified ground station.

The primitives associated with handoff are:

LME_HANDOFF.request
LME_HANDOFF.confirm
DL_RESET.indication(ho)
DL_RESET.confirm(fail)
DL_DISCONNECT.confirm(ho)
DL_HANDOFF.request
DL_HANDOFF.indication
DL_HANDOFF.response
DL_HANDOFF.confirm

The Handoff Function is entered when either the Site Recovery or Frequency Recovery Functions have identified a new ground station as a potential candidate for handling the connection. Either of those functions will send an (internal) LME_HANDOFF.request to the Handoff Function with the address of the new ground station. (If necessary, the modem will already be tuned and prepared with the data modulation characteristics.) The Handoff function will send a DL_RESET.request(ho) to the Data Link Layer indicating a handoff. The Data Link Layer will attempt the handoff with the new ground station and the corresponding ground system LME, and will return a DL_HANDOFF.confirm with status indicating the success or failure of the operation. The Handoff Function will then close the old Data Link Layer state table by sending a DL_DISCONNECT.request(ho) and receiving a DL_DISCONNECT.response(ho).

5.5.2.3 Site Recovery Function

The LME enters the Site Recovery Function when the maximum transmission count is exceeded on any frame, when the peer entity has not been heard from in TG2 seconds, or upon receipt of an LME_SITE-RECOVERY.indication.

The aircraft LME will attempt to contact a different ground station on the current frequency. It is important that the Site Recovery Function give priority to ground stations connected to the current router, so that the additional overhead of reestablishing 8208 connections can be avoided. Before deleting the aircraft from the contact table, the ground station LME will attempt to contact the aircraft on the same frequency, although potentially from a different ground station.

When either a DL_EVENT.indication(N2) or a DL_EVENT.indication(sqp) that indicates that a handoff is required is received by the LME, the LME initiates the Site Recovery Function. The aircraft Site Recovery Function will use the PECT to initiate a handoff to the preferred ground station.

The Site Recovery Function can fail in three ways: although communication was established a connection could not be negotiated with the desired ground station; the handoff request retransmission count, N2, was exceeded; or an XID waited more than TM2 seconds in the MAC queue. If a suitable link could not be negotiated, then the Site Recovery Function should attempt to connect to a ground station associated with a different router. If no valid response was heard after N2 transmissions, then the Site Recovery Function should attempt to connect to the next preferred ground station listed in the PECT on the current frequency. If an XID was not transmitted after TM2 seconds in the MAC queue, then the Site Recovery Function should pass a LME_SITERECOVERY.indication primitive to the Frequency Recovery Function.

An intra-router handoff is a handoff from one ground station to another ground station where both ground stations are connected to the same router. In an intra-router handoff the 8208 connection remains in place, and neither 8208 nor any other upper layers are involved.

An inter-router handoff is a handoff from one ground station to another ground station when the two ground stations are connected to different routers. During an inter-router handoff the 8208 connection is closed and another one is established.

The LME must be able to determine if connectivity to a router would change during a handoff by examining the AVLC address of the ground station. To accomplish this goal, the following algorithm is used.

When an aircraft hears two ground stations transmitting it compares the source addresses.

Each address is logically 'and'ed with the appropriate address mask of the ground station with which a connection currently exists. If an address mask has been provided in a GSIF then that address mask is used. If no address mask has been provided then the one shown below is used.

5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER (cont'd)**5.5.2.3 Site Recovery Function (cont'd)**

Address type	24 ----- Router Mask ----- 1
Class A address	1111 1111 0000 0000 0000 0000
Class B address	1111 1111 1111 0000 0000 0000
Class C address	1111 1111 1111 1111 0000 0000

If the resulting bit fields after the 'and'ing operation are different then the ground stations are attached to two different routers, and thus a handoff between those ground stations would be an inter-router handoff. If the resulting bit fields after the 'and'ing operation are the same then the ground stations belong to the same service provider and the same router and thus a handoff between those ground stations would be an intra-router handoff.

A service provider that has several routers will assign the ground station addresses in such a manner that the address mask in the XID frame allows an aircraft to determine when a handoff to a new ground station would cause a change in ground router connections.

COMMENTARY

For instance, if a service provider maintained 4 ground routers, the upper two bits of each ground station's address should be configured such that they identify the router.

E.g., a service provider with a class A block of addresses (e.g., 83 XXXX) and that operated four ground routers would assign the addresses of the ground stations connected to router #1 in the range of 83 0000 - 83 3FFF. The ground stations attached to router #2 would have addresses in the range of 83 4000 - 83 7FFF. The address mask broadcast in the XID frame would be "FF C000". Each time a handoff occurred, the ground station address would be bit-wise anded with the address mask. If the anded bits didn't change from the last ground station address then a handoff between those ground stations would be an intra-router handoff.

The primitives associated with site recovery are:

DL_EVENT.indication(N2)
DL_EVENT.indication(sqp)
LME_HANDOFF.request
LME_HANDOFF.indication
LME_SITERECOVERY.indication
DL_HANDOFF.indication

The ground station Site Recovery Function will use the information available from the various PECTs to reestablish communications, and handoff the aircraft to a different ground station if necessary. If a handoff through the several ground stations which have the aircraft in their PECTs fails, the aircraft will be deleted from the PECTs and the connection closed.

5.5.2.4 Frequency Recovery Function

The aircraft LME enters the Frequency Recovery Function upon either the failure of the Site Recovery

Function or the expiration of the TM2 timer indicating that a frame is "stuck" in the MAC transmit queue. The Frequency Recovery Function will attempt to contact a known ground station on a different frequency which is specified in the Ground Station Table.

If the TM2 timer expires then the frame could not even gain access to the medium because the frequency was congested. Thus, the ground station may be operable but the current frequency is not usable.

The primitives associated with the Frequency Recovery Function are:

DL_EVENT.indication(tm2)
TG1_TIMER.indication
PH_FREQUENCY.request
DL_EVENT.indication(sqp)
LME_HANDOFF.request
LME_HANDOFF.indication
LME_FREQRECOVERY.indication

The MAC Layer will notify the LME when the TM1 timer expires. The aircraft LME will then initiate the Frequency Recovery Function. The Frequency Recovery Function will attempt a handoff to a known ground station using each frequency listed in the PECT for this ground station. If no handoff can be achieved a LME_FREQUENCY.indication primitive is sent to the Frequency Search Function.

5.5.2.5 Frequency Search Function

The LME performs frequency search upon commanded startup or when other search algorithms have failed.

The Frequency Search Function will attempt to establish a Data Link Connection with any station on any frequency.

The LME User is responsible for starting operation of the LME. The system start command will start operation of the LME. This is not a confirmed service. There is no response from this function to the upper layer.

The service primitives associated with the frequency search function are:

LME_START.action
LME_FREQRECOVERY.indication
LME_BADLINK.indication
PH_FREQUENCY.request
PH_DATARATE.request
DL_EVENT.indication(sqp)
DL_CONNECT.request
DL_CONNECT.confirm
DL_DISCONNECT.confirm
TG2_TIMER.request
TG2_TIMER.indication

The LME_START.action primitive is passed from the upper layer management entity to the LME. The LME will step through the Frequency Preference Table tuning the modem and listening for a DL_EVENT.indication(sqp) from any ground station, then

5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER (cont'd)

trying to establish a Data Link Layer connection with any of those ground stations. If no stations are heard or a connection cannot be established, the process repeats forever.

COMMENTARY

The use of a common signalling channel will reduce or eliminate the need for the Frequency Search Function.

5.5.2.6 Autotune Function

The ground station may, at times, command the aircraft to change frequencies. This function, an autotune, is initiated by the ground station transmitting a XID_CMD (with P/F=0) with the autotune private parameter. The aircraft will transmit a XID_CMD (with PF=1) on the new frequency with the handoff bit set. The ground station will respond with a response XID (as would occur in a normal handoff). If the ground station does not receive the handoff attempt on the new frequency it will retransmit the autotune command XID on the old frequency. The aircraft will retransmit the XID on the new frequency.

5.5.3 Service Primitive Specification

Link Management Entity Handoff Request LME_HANDOFF.request is the internal service request primitive that will initiate the Handoff Algorithm. The handoff algorithm operates as a confirmed service.

Parameters: Peer Entity Station Address (M)
XID parameters to change (O)

COMMENTARY

This primitive is included for explanatory purposes only. Its use is not required.

5.5.3.1 Link Management Entity Handoff Confirmation

LME_HANDOFF.confirm is the internal service confirmation primitive that reports to the requesting entity the success or failure of the handoff attempt.

Parameters: Success/Failure (M)
Negotiated parameters (O)

COMMENTARY

This primitive is included for explanatory purposes only. Its use is not required.

5.5.3.2 Link Management Entity Start Action

LME_START.action is the service request primitive that the upper layer manager sends to the LME requesting startup of all operations.

Parameters: None

5.5.3.3 Link Management Entity Frequency Recovery Algorithm Failure

LME_FREQRECOVERY.indication is the internal primitive that indicates failure of the Frequency Recovery Algorithm to achieve a handoff.

Parameters: None

COMMENTARY

This primitive is included for explanatory purposes only. Its use is not required.

5.5.3.4 Link Management Entity Site Recovery Algorithm Failure

LME_SITERECOVERY.indication is the internal primitive that indicates failure of the Site Recovery Algorithm to achieve a handoff.

Parameters: None

COMMENTARY

This primitive is included for explanatory purposes only. Its use is not required.

5.5.3.5 Link Management Entity Timer Request

TG_TIMER.request is the request service primitive to the system to start a timer to expire in the future. If the parameter has a non-zero value the timer is started. If the parameter is zero the current timer is canceled.

Parameters: Time value or 0 (M)
Timer (M)

5.5.3.6 Link Management Entity Timer Indication

TG_TIMER.indication is the service primitive indicating that the specified timer has expired. This is used as an incoming event in the state tables.

Parameters: Timer (M)

5.5.4 Link Management Entity Parameters

5.5.4.1 Timer TG1 - Maximum Frequency Dwell Time

The TG1 timer is the maximum time for an aircraft to dwell on a given frequency for ground station traffic before tuning to a new frequency while in the Frequency Recovery or Frequency Search Function. If a DL_EVENT.indication(sqp) is received, then the timer is canceled. If the timer expires, then the function proceeds to the next frequency. This timer is undefined for ground stations.

Function	Min	Max	Default	Notes
Frequency Search	T5	3 * T5	1.2 * T5	
Frequency Recovery	Use value found in Frequency Search Table			

5.0 SERVICES AND PROTOCOL OF LAYER 2 - THE LINK LAYER (cont'd)**5.5.4.2 Timer TG2 - Contact Timeout**

This timer is used by the Peer Entity Preference Table Maintenance Function to delete a peer entity from the preference table after no DL_EVENT.indication(sq) has been received from that station. If a connection exists with the entity for which the timer expired, then the Site Recovery Function is initiated.

	Min	Max	Default	Notes
aircraft	T5	3 * T5	1.2 * T5	
ground station	T4	3 * T4	1.2 * T4	T4(aircraft)

COMMENTARY

The effect of this timer (for entries other than the one with an active connection), is to not use an old PECT entry. As such, the explicit use of a timer is not required, as the effect can be achieved by other means.

5.5.4.3 Link Quality Handoff Threshold - LQ

This threshold determines what is the minimum acceptable signal quality for a connection to be maintained.

6.0 SERVICES AND PROTOCOL OF LAYER 3 - THE NETWORK LAYER (cont'd)

6.1 Introduction

6.1.1 Model

Layer 3 in the OSI model is called the Network Layer. It provides the upper layers with independence from the data transmission and routing functions used to connect systems. The Network Layer is responsible for routing and relaying functions both within any subnetwork and throughout the Aeronautical Internetworking domain.

Within the Aeronautical domain the Network Layer is divided into three sublayers as specified by the Internal Organization of the Network Layer (ISO 8648). These sublayers consist of two network layer protocols and one convergence or mapping function between them. This concept is illustrated in Appendix C.

The network layer protocol used across the air-ground subnetworks is referred to formally as a Subnetwork Access Protocol (SNAP). This will be referred to within this document as the "Subnetwork Protocol". The network layer can also contain a common Internetwork Protocol as well as a mapping function between the Internetwork and Subnetwork protocols. The details of the internetworking protocol and this mapping function are outside the scope of this chapter.

When a received frame passes through the Link Layer, the Layer 2 header and trailer which are used for frame processing, are stripped off. The remaining DLS User-data parameter is passed within a Data Link service primitive up to the Subnetwork layer. This remainder is a Subnetwork Protocol Data Unit (SNPDU) or informally "packet". All nodes within the subnetwork should support the Subnetwork Protocol and exchange SNPDU's.

Some nodes within the subnetwork will act as routers out of the subnetwork. These nodes must support the other two sublayers of the network layer. Any node in the subnetwork which does not support the gateway function will only require the Subnetwork Protocol within its network layer.

6.1.2 General Operation

The subnetwork access layer protocol specified in Section 6.2 is intended to conform to the DTE-DTE X.25 Packet Level Protocol as specified by ISO 8208 (E) 1988-12-22.

The subnetwork service definition in this document is intended to conform to the Network Service Definition (ISO 8348 (E) 1987-07-27). The conventions used for the service definition at the top of the Subnetwork sublayer are drawn from ISO 8348. This connection oriented network layer service definition acts as a guideline for notation and requirements of the subnetwork service definition.

If there are any differences between this specification and the cited documents, this document should have precedence. ISO 8208 is a standard with many optional and suggested features. It is the intention of this document to fully specify the ISO 8208 options to be provided in the air/ground subnetwork environment.

ISO 8208 is a connection-oriented network layer protocol used as a subnetwork access protocol in this environment. The subnetwork sublayer described is responsible for establishing, maintaining and terminating connections. The facilities, both optional and mandatory; and default values for those facilities chosen in this ISO 8208 profile document are intended to increase the user throughput while simplifying the protocol state machine. The use of Permanent Virtual Circuits (PVCs) is not recommended in the AVPAC subnetwork. Although the subnetwork may be used for routing, explicit routing functions in the AVPAC subnetwork are outside the scope of the subnetwork protocol. The primary purposes of the AVPAC subnetwork protocol are to: (1) provide subnetwork administrative and management control across the subnetwork and (2) increase efficiency of data transfers across the air/ground subnetwork.

6.2 Subnetwork Sublayer Service Definition

This section specifies the services offered by the subnetwork sublayer. The services are described in an abstract way and do not imply any particular implementation. Within the context of this document a service user is an entity at a layer or sublayer which makes use of the services provided by the layer or sublayer below. These services are provided through the use of service primitives.

A service primitive is an abstract, implementation-independent description of an interaction between service user and service provider. A service primitive may contain parameters that describe information that is mandatorily (M) or optionally (O) conveyed as part of the interaction. The definition of any implementation of these primitives is outside the scope of this document.

6.2.1 Functions

The SNAP has the responsibility for controlling the data packet flow with respect to duplicated, lost, out of sequence, or invalid packets. Data passing through the subnetwork sublayer for transmission is broken into segments, called SNPDU's, for control and error recovery. c-1

The basic service of the subnetwork layer is to provide for the transfer of data across the subnetwork. The subnetwork protocol is responsible for internal routing and relay functions across a subnetwork. These routing and relaying functions are outside the scope of the level 1 and level 2 routing as defined within the OSI Routing Framework (DTR 9575). The services provided by the subnetwork to the subnetwork service user include the following:

6.2.1.1 Subnetwork Connection Management

A variety of ISO 8208 packet types, procedures, and facilities are used to establish, terminate and manage connections across the subnetwork. Connection status is monitored and controlled at both ends of a connection, allowing existing subnetwork layer connections to be mapped to new data link connections without dropping the subnetwork connection. Connection status information is c-1

6.0 SERVICES AND PROTOCOL OF LAYER 3 - THE NETWORK LAYER (cont'd)**6.2.1.1 Subnetwork Connection Management (cont'd)**

⊘-1 | maximized in order to minimize the information that is passed with each data transfer phase transmission. Connection status information is also maintained to maximize operational control of the subnetwork by the ground system.

6.2.1.2 Packet Fragmentation and Reassembly

⊘-1 | This subnetwork capability allows the fragmenting of large data units passed down from the subnetwork user for transmission across the air-ground portion of the subnetwork. Reassembly is performed at the receiving end of the subnetwork.

6.2.1.3 Subnetwork Connection Quality of Service Management

⊘-1 | Quality of service across the air-ground subnetwork can be negotiated at connection time through the use of optional user facilities. Quality of service may be renegotiated at any time for new calls through the use of the optional ISO 8208 registration facility.

6.2.1.4 Error Recovery

⊘-1 | REJECT packets are used for subnetwork level error recovery. These packets are sent between subnetwork entities to cause retransmission of packets and to recover from error response time-out states. Under no circumstances should RESET or RESTART be used to recover from an error which can be handled by REJECT.

6.2.1.5 Connection Flow Control

⊘-1 | DATA packet sequence numbering combined with the use of a sliding window is used for passive flow control. Receive Not Ready (RNR) packets can be used for explicit flow control.

6.2.2 Connection Phases and Service Primitives

This section is broken into two general parts. The first defines valid sequences for service primitives in the various protocol phases of operation. The second part defines in greater detail the service primitives used. The primitives described in this section define the services offered to the Subnetwork User (SN_User) by the Subnetwork provider (SN_Provider).

6.2.2.1 Subnetwork Connection Establishment Phase

The terms used in this section should be interpreted as defined in ISO 8348 (Network Service Definition).

The SN_User is responsible for initiating a subnetwork connection. SN_CONNECT service is initiated by an initiating SN_User to an accepting SN_User. This service is a confirmed service. This means that an explicit confirmation is passed from the accepting SN_Provider to the initiating SN_User as a response. The service primitives associated with subnetwork connection are:

SN_CONNECT.request
SN_CONNECT.indication
SN_CONNECT.response
SN_CONNECT.confirm

The SN_CONNECT.request primitive is passed from the initiating SN_User to the SN_Provider to request that a subnetwork connection be established between a local SN_User and a remote SN_User.

The SN_CONNECT.indication is passed from the SN_Provider to the accepting SN_User to indicate the results of an attempt by the initiating SN_User to establish a connection to a local SN_Provider.

The SN_CONNECT.response primitive is passed to the SN_Provider from the accepting SN_User to convey the response to a previous associated SN_CONNECT.indication primitive.

The SN_CONNECT.confirm primitive is passed from the SN_Provider to the initiating SN_User to convey the results of the previous associated SN_CONNECT.request. The selection of optional user facilities for a subnetwork connection may be made during the connection set-up phase of subnetwork operation.

6.2.2.2 Data Transfer Phase

Higher layer information is, in general, sent using data transfer service, using the SN_DATA.request primitive. This subnetwork service (SNS) is subject to flow control by higher layers.

The primitives associated with data transfer are:

SN_DATA.request
SN_DATA.indication

The SN_DATA.request primitive is passed to the SN_Provider to request that a SNS_User_Data parameter be sent. The SN_DATA.indication primitive is passed from the SN_Provider to indicate the arrival of a SNS_User_Data parameter.

Subnetwork connections may be reset by the subnetwork user, while in data transfer phase. This is done by the use of the SN_RESET primitives, these are:

SN_RESET.request
SN_RESET.indication
SN_RESET.response
SN_RESET.confirm

6.2.2.3 Subnetwork Connection Release Phase

Either SN_User (ground or avionics) or the SN_Provider (at either location) can initiate a disconnect. These primitives may also be used by the Called SN_User to reject a SN_CONNECT.indication or by the SN_Provider to indicate its inability to establish a requested subnetwork connection.

The primitives associated with connection termination are:

6.0 SERVICES AND PROTOCOL OF LAYER 3 - THE NETWORK LAYER (cont'd)

SN_DISCONNECT.request
SN_DISCONNECT.indication

The SN_DISCONNECT.request is passed from an SN_User to the SN_Provider to initiate the disconnect sequence. The SN_DISCONNECT.indication is passed from the SN_Provider to the requesting SN_User to indicate the termination of a connection by the remote entity.

6.2.2.4 Service Primitive Specification

A detailed description of the subnetwork service primitives can be found in ISO 8348, except that document calls them network primitives instead of subnetwork primitives (i.e. N-DISCONNECT instead of SN_DISCONNECT).

6.2.2.4.1 Subnetwork Connect Primitives

The subnetwork user data field should contain the Fast Select field containing user data for all connect primitives.

6.2.3 Access Points

The Subnetwork Service Access Point (SNSAP) is uniquely identified by the subnetwork DTE address as defined in Section 6.3.1.2. These SNSAPs define the subnetwork point of attachment (SNPA) used by the service primitives that define the subnetwork service to the Subnetwork Dependent Convergence Protocol.

6.2.4 Addressing Issues

The Fast Select field of the Call Setup packets should carry IS-Hello PDUs. A single subnetwork connection will be setup for every NET pair communicating across AVPAC.

6.3 Subnetwork Protocol Specification

This protocol specification is broken into SNPDU format and subnetwork protocol state machine sections. It is the intention of this section to fully clarify the appropriate ISO standards as used in AVPAC.

6.3.1 SNPDU Format

Except as qualified below, the SNPDU format is specified in ISO 8208, Section 12. During Call Setup, AVPAC uses the extended format in conjunction with the Fast Select Facility.

6.3.1.1 General Format Identifier

The Qualifier bit (Q-bit) in DATA packets is set to zero in AVPAC. Modulo 128 sequencing is the only defined sequencing in AVPAC.

6.3.1.2 Calling and Called DTE Addresses

Octet 5 and consecutive octets consist of the Calling and Called DTE addresses in that order. This variable length field is known informally as the address field. This field is encoded in a binary coded decimal form. When appropriate, the address field is rounded-up to an integer number of octets.

Aircraft DTE addresses will be the BCD encoding of the octal representation of the 24-bit ICAO binary address.

Ground AVLIC stations must provide access to ground routers addresses by DTE addresses. Two DTE addresses must be available to links established to ground stations as follows:

801 Service Provider router
802 CAA router

In this method an aircraft may establish an AVLIC connection to a ground station, and then is assured of being able to reach a ground router with the DTE address of '801'. If a CAA router is directly attached to the ground station, it can be reached with the DTE address of '802'; otherwise, the '802' DTE address would also identify the service provider router.

6.3.1.3 Call User Data Field

Within Call Set-up packets (and optionally, other packets) the Facility field may be followed by a Call User Data field. The Fast Select facility should be used to carry the ISH PDU.

COMMENTARY

This allows a reduction in the number of transmissions required to setup the various layers.

6.3.2 Types of SNPDU's

An AVPAC DTE should support the following SNPDU's as specified in ISO 8208, any clarifications to the basic procedures specified in ISO 8208 are noted below.

DTE -> DXE

CALL REQUEST
CALL ACCEPTED
CLEAR REQUEST
CLEAR CONFIRMATION

DATA
RECEIVE READY
RECEIVE NOT READY
RESET REQUEST
RESET CONFIRMATION

RESTART REQUEST
RESTART CONFIRMATION

REJECT
DIAGNOSTIC

DXE -> DTE

INCOMING CALL
CALL CONNECTED
CLEAR INDICATION

CLEAR CONFIRMATION
DATA
RECEIVE READY
RECEIVE NOT READY
RESET INDICATION

RESET CONFIRMATION
RESTART INDICATION
RESTART
CONFIRMATION

REJECT
DIAGNOSTIC

6.0 SERVICES AND PROTOCOL OF LAYER 3 - THE NETWORK LAYER (cont'd)**6.3.2.1 Call Request, Incoming Call, Call Accepted, and Call Connected**

c-1 A CALL REQUEST packet, with the ISH PDU in the Fast Select User Data field, should be passed as a mandatory parameter in the DL_CONNECT.request primitive. An aircraft should request LCNs as a DTE, the ground should request LCNs as a DCE.

6.3.2.2 Clear PDUs, Reset PDUs, and Restart PDUs

c-1 These nine PDUs should only be used to recover from DTE failures. If a DCE between the two DTEs fails, then REJECT should be used to recover the sequencing of messages.

COMMENTARY

Whenever the virtual circuits are reset or cleared, it is necessary to reset the SNDCF compression algorithm to ensure that the dictionaries stay synchronized. Whenever this occurs, the total compression is reduced.

6.3.2.3 Receive Ready

c-1 A RECEIVE READY packet should only be generated whenever a valid DATA packet is received with a P(s) which closes the acknowledgment window. The DTE should immediately transmit a RECEIVE READY packet to acknowledge the outstanding packets.

6.3.3 Facilities and Procedures

All AVPAC DTEs should support the following facilities and procedures, which are documented in ISO 8208.

Optional Facility	ISO 8208 Section	A/C DTE	Ground DTE
Extended Packet Sequence Numbering	13.2	M	M
Packet Retransmission	13.4	M	M
Flow Control Parameter Negotiation	13.12	M	M
Fast Select	13.16	M	M
Fast Select Acceptance	13.17	M	M

c-1 The classification indicates whether the DTE must support a request for or use of that facility (M - Mandatory, O - Optional) by the peer DTE.

Additionally, no AVPAC DTE may support the following optional facilities and procedures, which are documented in ISO 8208 (setting timers to values greater than 3600 seconds is acceptable):

- Qualifier bit procedure
- Window Status Transmission Timer (T24 timer)
- Reject Response Timer (T27 timer)

6.3.3.1 Effects of Layers 1 and 2 on the Packet Layer

The packet layer should not be affected by disruptions of the lower layers while the LME can maintain a connection to a ground station connected to the router. In general, the LME will attempt to maintain a link level connection to a ground station at all times. The choice of ground stations will be influenced by signal quality, identity of the ground station service provider, and other factors such as location of the ground station. During intra-router handoffs the packet layer maintains its connection to its peer. During inter-router handoffs the packet layer connection is cleared and a new call is set up.

6.3.3.2 Acknowledgment Window

AVPAC DTEs should use two windows for data transfer. The transmit window, W, is the maximum number of outstanding packets a transmitter may have before it must wait for an acknowledgment. The acknowledgment window, set to one-half of the transmit window, is the minimum number of packets the receiver must receive before generating a RECEIVE READY packet.

COMMENTARY

c-1 The purpose of the acknowledgment window is to reduce the probability that an explicit acknowledgment needs to be sent. The acknowledgment window is set to one-half of the transmit window to reduce the probability that a station will go into flow control.

6.3.3.3 Nonreceipt of Window-Rotation Information

Whenever the transmit window is full, the transmitting station should use the procedure detailed in Section 6.3.4.1 to ensure the reception of window-rotation information through the use of the T25 timer.

6.3.3.4 Receipt of Erroneous DATA Packets

When a station receives a packet out of order, it should transmit a REJECT as specified in ISO 8208 section 13.4.

6.3.4 Parameters

The basic description of the parameters used in the subnetwork layer can be found in ISO 8208. This section lists any deviations from that document, either in function, default value, or usage. The timers and retransmission count parameter values should be configured to the default values and the other parameter values in this list should be negotiated during call setup to the values listed as default.

6.0 SERVICES AND PROTOCOL OF LAYER 3 - THE NETWORK LAYER (cont'd)

Subnetwork Layer Service System Parameters for 2400 bps

size. The window size should be negotiated to the same value in both directions.

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	Name	Min.	Max.	Default
T20	Restart Request Response Timer	1 sec	300 sec	180 sec
T21	Call Request Response Timer	1 sec	300 sec	200 sec
T22	Reset Request Response Timer	1 sec	300 sec	180 sec
T23	Clear Request Response Timer	1 sec	300 sec	180 sec
T25	Window Rotation Timer	1 sec	300 sec	60 sec
R20	Restart Request Retrans Count	0	7	1
R22	Reset Request Retrans Count	0	7	1
R23	Clear Request Retrans Count	0	7	1
R25	Data Packet Retrans Count	0	7	2
P	Packet Size	128	2048	256
W	Window size	1	127	16

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6.3.4.1 T25 - Window Rotation Timer

The T25 timer should be set whenever the transmit window closes and should be canceled when a response is received which opens the window. If the T25 timer expires, the highest numbered outstanding packet should be retransmitted R25 times (with D-bit set) before error recovery is initiated.

6.3.4.2 R25 - Window Rotation Counter

The R25 counter reset procedure should be invoked as specified in ISO 8208 section 11.2.1(b).

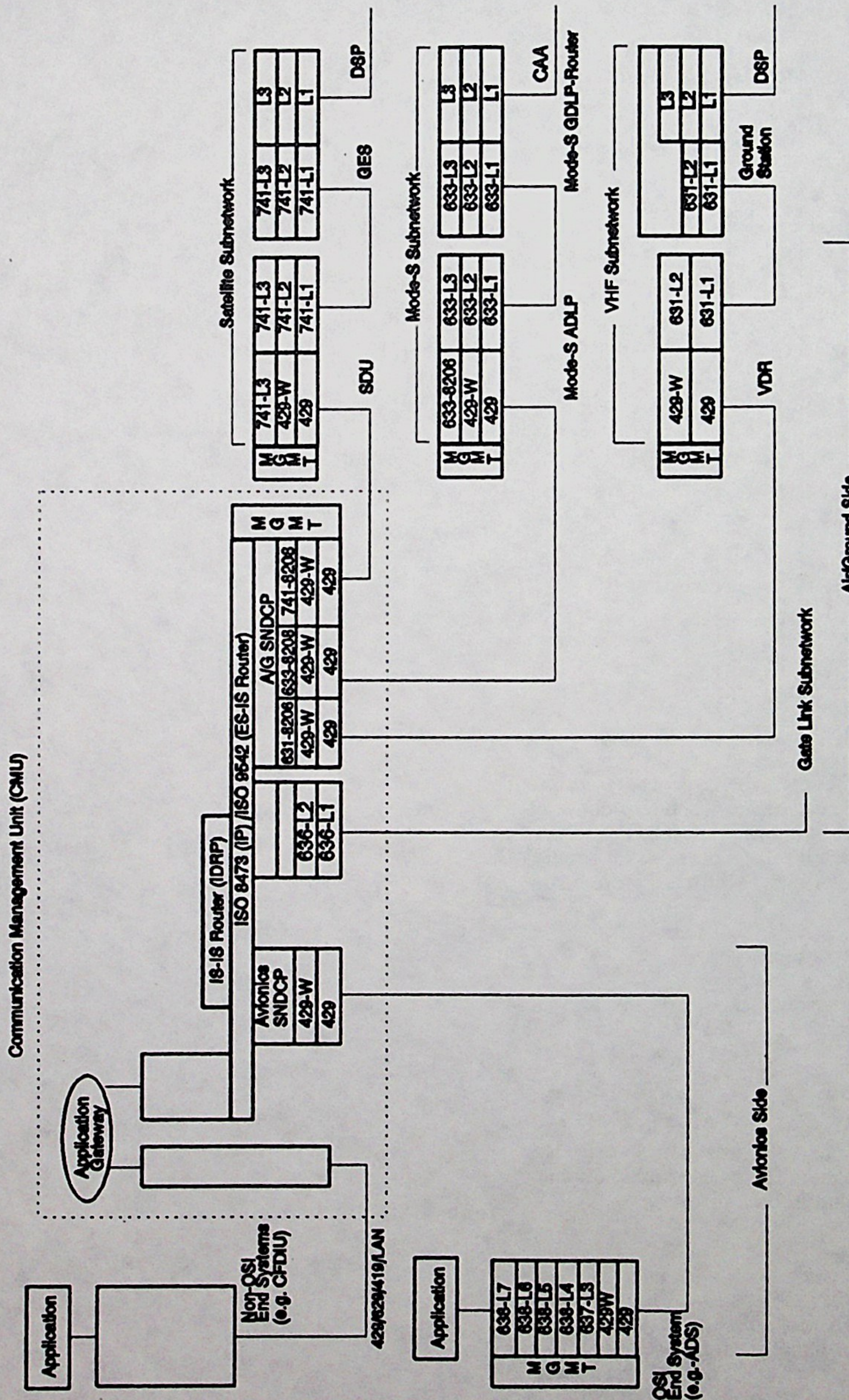
6.3.4.3 P - Packet Size

In the absence of negotiations via the Flow Control Parameter Negotiation Facility, the default packet size for AVPAC should be 256 octets. The packet size should be negotiated to the same value in both directions.

6.3.4.4 W - Window Size

In the absence of negotiations via the Flow Control Parameter Negotiation Facility, the default [transmit] window size for AVPAC should be 16 packets. The acknowledgment window size will not be separately negotiated, but will be one-half of the transmit window

ATTACHMENT 1 INTERFACE DIAGRAM



Note: This figure also appears in other ARINC standards. Due to non-synchronous update of ARINC standards, differences in this figure between standards may arise. In all cases, the figure with the most recent date (see lower left-hand corner) should have precedence.

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ATTACHMENT 2
PHYSICAL SERVICE TABLES

Table A2-1 Physical Service Incoming Events

ABBREVIATED NAME	CATEGORY	NAME
PhDRreq	PhS-user	Ph_DATARATE.request
PhFreq	PhS-user	Ph_FREQUENCY.request
PhPKreq	PhS-user	Ph-PREKEY.request
PhDTreq	PhS-user	Ph_DATA.request
RcvPhPDU	PhPDU	Received PhPDU
CBE	PhS- event	Channel Busy Event
CCE	PhS-event	Channel Clear Event

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Table A2-2 Physical Service State Description

ABBREVIATED NAME	NAME AND DESCRIPTION
NS	Null State: The physical layer is stateless, and has no real state. This is included only to show which outgoing events are triggered by which incoming events.

ATTACHMENT 2 (cont'd)
PHYSICAL SERVICE TABLES

Table A2-3 Physical Service Outgoing Events

ABBREVIATED NAME	CATEGORY	NAME
PhDTind	PhS-provider	Ph_DATA.indication
PhCSind	PhS-provider	Ph_CHANNEL_SENSE.indication
PhSQPind	PhS-provider	Ph_SQP.indication
PhXmtPhPDU	PhPDU	Transmitted PhPDU

Table A2-4 Physical State Transition Table

STATE EVENT	NS
PhDRreq	Set new data rate
PhFreq	Tune VHF
PhPKreq	Set prekey length
CBE	PhCSind
PhDTreq	XmtPhPDU
RcvPhPDU	PhDTind, PhSQPind
CCE	PhCSind

ATTACHMENT 3
MEDIA ACCESS CONTROL (MAC) TABLES

Table A3-1 MAC Incoming Events

ABBREVIATED NAME	CATEGORY	NAME
MRTS.req	MS-user	MA_RTS.request
MTR1.ind	MS-provider	MA-TIMER1.indication
MTR2.ind	MS-provider	MA_TIMER2.indication
PhCS.ind	PhS-provider	Ph.CHANSENSE.indication

Table A3-2 MAC State Description

ABBREVIATED NAME	FULL NAME AND DESCRIPTION
Idle	RF Channel Idle: The RF channel is presently idle
Busy	RF Channel Busy: The RF channel is presently busy
Waiting	Channel Clear, Waiting to Transmit: The RF channel is presently idle and waiting to transmit
Pending	Channel Busy, Waiting to Transmit: The RF channel is presently busy and waiting to transmit

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ATTACHMENT 3 (cont'd)
MEDIA ACCESS CONTROL (MAC) TABLES

Table A3-3 MAC Outgoing Events

ABBREVIATED NAME	CATEGORY	NAME
MCTS.ind	MS-user	MA_CTS.indicate
MTR1.req	MS-provider	MA_TIMER1.request
MTR2.req	MS-provider	MA_TIMER2.request

Table A3-4 MAC State Table ⁽¹⁾

ABBREVIATED NAME	IDLE	BUSY	WAITING	PENDING
PhCS.ind (idle)		:Idle		if (test) successful ⁽²⁾ MCTS.ind MTR2.req (can) :Idle else MTR1.req :Waiting
PhCS.ind (busy)	:Busy		MTR1.req(can) :Pending	
MRTS.req	if (test) successful ⁽²⁾ MCTS.ind MTR2.req(can) :Idle else MTR1.req MTR2.req :Waiting	MTR2.req :Pending	:Waiting	:Pending
MTR2.ind			MTR1.req(can) :Idle	MTR1.req(can) :Busy
MTR1.ind			if (test) successful ⁽²⁾ MCTS.ind MTR2.req(can) :Idle else MTR1.req :Waiting	

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⁽¹⁾ This state table for the Bernoulli process described in Section 5.2.3.

⁽²⁾ A test is successful if either the Bernoulli process is successful, or the maximum number of attempts has been made.

ATTACHMENT 4
DATA LINK SERVICE (DLS) TABLES

Table A4-1 DLS Incoming Events

ABBREVIATED NAME	CATEGORY	NAME
DCONreq	DLS-user	DL_CONNECT.request
DDreq	DLS-user	DL_DATA.request
DRSTreq	DLS-user	DL_RESET.request
DRSTind	DLS-user	DL_RESET.indication
DDICSreq	DLS-user	DL_DISCONNECT.request
DDRreq	DLS-manager	DL_DATARATE.request
DFreq	DLS-manager	DL_FREQUENCY.request
DHOreq	DLS-manager	DL_HANDOFF.request
DHOresp	DLS-manager	DL_HANDOFF.response
RR	DLPDU	Receive Ready frame
REJ	DLPDU	Reject frame
INFO	DLPDU	Information frame
XID	DLPDU	Exchange Identity frame
FRMR	DLPDU	Frame Reject frame
TEST	DLPDU	Test frame
DISC	DLPDU	Disconnect Command frame
UI	DLPDU	Unnumbered Information frame
ET1	DLS-exp-timer	Delay Before Retransmission
ET2	DLS-exp-timer	Max Delay before Ack
ET3	DLS-exp-timer	Link Initialization Time
ET5	DLS-exp-timer	Max Delay since Xmit
ET6	DLS-exp-timer	Connection Time-out

ATTACHMENT 4 (cont'd)
DATA LINK SERVICE (DLS TABLES)

Table A4-2 DLS State Descriptions

- 1) **INIT - Initialization** - The DLS_provider is in the disconnected mode. It can accept an XID from the remote DLS entity, or generate an XID to initiate a connection based on a request from the local DLS_User.
- 2) **LN - Local Negotiation** - The peer DLS entities are engaged in link establishment initiated by the local entity. The local DLS_Provider has just issued an XID command frame and is waiting for a response.
- 3) **DTS - Data Transfer State** - A data link connection exists between the local DLS_User and the remote DLS_User. Sending and receiving of information and supervisory PDUs can be performed.
- 4) **LWS - Local Wait State** - A data link entity goes to this state after issuing an XID_CMD to hand-off to a new ground station.
- 5) **RWS - Remote Wait State** - A data link entity goes to this state after receiving an XID_CMD frame to hand-off to a new ground station.

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ATTACHMENT 4 (cont'd)
DATA LINK SERVICE (DLS) TABLES

Table A4-3 DLS Outgoing Events

ABBREVIATED NAME	CATEGORY	NAME
DCONind	DLS-provider	DL_CONNECT.indication
DCONconf	DLS-provider	DL_CONNECT.confirm
DDind	DLS-provider	DL_DATA.indication
DRSTind	DLS-provider	DL_RESET.indication
DRSTconf	DLS-provider	DL_RESET.confirm
DDISCind	DLS-provider	DL_DISCONNECT.indication
DFINind	DLS-manager	DL_FRAMEINFO.indication
DHOind	DLS-manager	DL_HANDOFF.indication
DHOconf	DLS-manager	DL_HANDOFF.confirm
PDTreq	MS-user	PH_DATA.request
RR	DLPDU	Receive Ready frame
REJ	DLPDU	Reject frame
INFO	DLPDU	Information frame
XID	DLPDU	Exchange Identity frame
FRMR	DLPDU	Frame Reject frame
TEST	DLPDU	Test frame
DISC	DLPDU	Disconnect Command frame
UI	DLPDU	Unnumbered Information frame
ST1	DLS-set-timer	Delay Before Retransmission
ST2	DLS-set-timer	Max Delay Before Ack
ST3	DLS-set-timer	Link Initialization Time
ST5	DLS-set-timer	Max Delay since Xmit
ST6	DLS-set-timer	Delay Before Retransmission
CT1	DLS-cncl-timer	Delay Before Retransmission
CT2	DLS-cncl-timer	Max Delay Before Ack
CT3	DLS-cncl-timer	Link Initialization Time
CT5	DLS-cncl-timer	Max Delay since Xmit
CT6	DLS-cncl-timer	Delay Before Retransmission

ATTACHMENT 4 (cont'd)
DATA LINK SERVICE (DLK) TABLES

Table A4-4. Data Link Layer Timer Actions

TIMER	LAYER	STARTED	CANCELED OR RESTARTED	ACTION WHEN TIMER EXPIRES
TM1	MAC	By random backoff algorithm	Canceled when transmission of the frame is canceled.	Attempt to gain access to channel
TM2		When performing channel sensing	Canceled upon detecting an idle media	Begin Frequency Recovery LME function
T1	Link	Upon end of transmission	Canceled when an ack is received for the frame	Retransmit the frame
T2		Upon receipt of frame requiring an acknowledgement and no T2 timer is running	Canceled upon transmission of frame containing N(r)	Send an acknowledgement
T3		Upon transmission of XID_CMD	Canceled upon receipt of XID_RSP	Retransmit the XID_CMD
T4		Upon receipt of any frame	Upon receipt of any frame	Send an RR (P/F = 1) up to N2 times
T5 (ground only)		Upon transmission of any frame	Restarted upon transmission of any frame	Transmit a GSIF
TG1 (aircraft only)	LME	By Frequency Search or Frequency Recovery algorithms when listening begins on a frequency	Canceled upon receipt of DEVNT.ind	LME State Machine transition
TG2		Upon receipt of DEVNT.ind for a particular station	Restarted upon receipt of DEVNT.ind for a particular station	If no v.c. exists to that address: remove entry from PECT. If v.c. exists to that address: Initiate Site Recovery

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ATTACHMENT 4 (cont'd)
DATA LINK SERVICE (DLS) TABLES

Table A4-5 AVPAC DLS Connection Set-up and Hand-off Input Events

ABBREVIATED NAME	NAME
DCONreq	Connect request primitive
DRSTreq	Reset request primitive
XID_CMD(acc)	XID command frame with acceptable link parameters
XID_CMD(unac)	XID command frame with unacceptable link parameters
XID_CMD_HO	XID command frame which indicates a hand-off to a new frequency or ground station
XID_CMD_LCR	XID command frame refusing a connection
XID_RSP(acc)	XID response frame with acceptable link parameters
XID_RSP(unac)	XID response frame with unacceptable link parameters
XID_RSP_LCR	XID response frame refusing a connection
DDISCreq	Disconnect request primitive
DCONind	Connect indication primitive
DCONconf	Connect confirm primitive
DDISind	Disconnect indication primitive
DRSTind	Reset indication primitive
DRSTconf	Reset confirm primitive
XID-RSP_HO(acc)	XID response frame with HandOff bit set and acceptable link parameters

ATTACHMENT 4 (cont'd)
DATA LINK SERVICE (DLK) TABLES

Table A4-6 DLS Connection Set-Up and Handoff State Transitions

INPUT EVENTS	DLS CONNECTION SET-UP AND HANDOFF STATE TRANSITIONS					
	INIT	LN		DTS	LWS	
DCONreq	XID_CMD :LN	(in progress) :LN		(invalid) :DTS	(invalid) :LWS	(invalid) :RWS
DRSTreq	(invalid) :INIT	(invalid) :LN		XID_CMD :LN	(invalid) :LWS	(invalid) :RWS
XID_CMD(acc)	DCONind XID_RSP :DTS	LAr<LAs :LN	LAr>LAs DCONconf XID_RSP :DTS	DRSTind XID_RSP :DTS	(ignore) :LWS	(invalid) :RWS
XID_CMD(unac)	XID_RSP_LCR :INIT	LAr<LAs :LN	LAr>LAs DDISCconf XID_RSP_LCR :DTS	DDISCind XID_RSP_LCR :INIT	(ignore) :LWS	(invalid) :RWS
XID_RSP(acc)	(invalid) :INIT	DCONconf :DTS		(invalid) :DTS	XID_CMD_HO :LWS	(invalid) :RWS
XID_RSP(unac)	(invalid) :INIT	DDISCconf :INIT		(invalid) :INIT	XID_CMD_LCR :LWS	(invalid) :RWS
DHOreq	(invalid) :INIT	DHOconf :INIT		XID_CMD_HO :LWS	:LWS	(invalid) :RWS
DHOresp	XID_RSP_HO DDISCreq(ho) :DTS	(invalid) :LN		XID_RSP_HO :DTS	(invalid) :LWS	XID_RSP_HO :RWS
XID_CMD_HO(acc)	DRSTind(ho) :INIT	DHOind :RWS		DHOind :RWS	LAr<LAs (invalid) :LWS	LAr>LAs DRSTind(ho) :DTS
XID_CMD_HO(unac)	DRSTind(ho) :INIT	DHOind :RWS		DHOind :RWS	LAr<LAs (invalid) :LWS	LAr>LAs DRSTind(ho) :DTS
XID_CMD_LCR	(ignore) :INIT	DDISCind :INIT		DDISCind :INIT	DDISCind :INIT	
XID_RSP_LCR	:INIT	DDISCind :INIT		DDISCind :INIT	DDISCind :INIT	
XID_RSP_HO(acc)	DTRANconf(ho) :DTS	(invalid) :INIT		(invalid) :DTS	DRSTconf(ho) :DTS	
XID_RSP_HO(unac)	(invalid) :INIT	(invalid) :INIT		(invalid) :DTS	DRSTind(ho) XID_CMD_HO :LWS	
DDISCreq	(invalid) :INIT	DDISCconf DISC :INIT		DDISCconf DISC :INIT	DDISCconf DISC :INIT	
DDISCreq(ho)	(invalid) :INIT	DDISCconf (invalid) :INIT		(invalid) :DTS	DDISCconf(ho) :INIT	

ATTACHMENT 5
DATA RATE PARAMETER ENCODING TABLE

BIT POSITION	DATA RATE	MODULATION TECHNIQUE
xxx1	2400 bps	MSK
xx1x	21000 bps	4-OQAM
x1xx	42000 bps	16-OQAM
1xxx	Reserved for future use	

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ATTACHMENT 6
LINK MANAGEMENT ENTITY (LME) SERVICE TABLES

Table A6-1 LME Incoming Events

ABBREVIATED NAME	FUNCTION	CATEGORY	NAME
DCONconf	Handoff	DLS-Provider	DL_CONNECT.confirm
DDISCconf		DLS-Provider	DL_DISCONNECT.confirm
GHOreq		Internal	LME_HANDOFF.request
DHOind		DLS-Provider	DL_HANDOFF.indication
DHOconf		DLS-Provider	DL_HANDOFF.confirm
DDISCconf(ho)		DLS-Provider	DL_DISCONNECT.confirm(ho)
DEVNTind(N2)		DLS-Provider	DL_EVENT.indicate(N2)
DEVNTind(N2)	Site Recovery	DLS-Provider	DL_EVENT.indicate(N2)
DEVNTind(sqp)		DLS-Provider	DL_EVNT.indicate(sqp)
GHOind		Internal	LME_HANDOFF.indicate
DEVNTind(TM1)	Frequency Recovery	M-Provider	DL_EVENT.indication(tm1)
GT1ind		Internal	LME_TG1_TIMER.indication
DFREQreq		LME	DL_FREQUENCY.request
DEVNTind(sqp)		DLS-Provider	DL_EVENT.indication(sqp)
GHOind		Internal	LME_HANDOFF.indication
GSITEind		Internal	LME_SITERECOVERY.indication
GBOOTreq	Frequency Search	LME-User	LME_BOOT.request
GFREQind		Internal	LME_FREQRECOVER.indication
GBADalarm		LME	LME_BADLINK.alarm
DEVNTind(sqp)		DLS-Provider	DL_EVENT.indication(sqp)
DCONconf		DLS-Provider	DL_CONNECT.confirm
DDISconf		DLS-Provider	DL_DISCONNECT.confirm
TG1ind		Internal	LME_TG1_TIMER.indication

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ATTACHMENT 6 (cont'd)
LINK MANAGEMENT ENTITY (LME) SERVICE TABLES

Table A6-2 LME State Descriptions

Handoff Function:

- 1) INIT - Initialization - The DLS-Provider is in the disconnected state.
- 2) DTS - Data Transfer State - The DLS-Provider has a virtual connection established.
- 3) RWS - Remote Wait State - The LME has initiated a handoff sequence and is waiting for a response back from the DLS-Provider.

Site Recovery Function:

- 1) INIT - Initialization - The Site Recovery Function is not running.
- 2) RWD - Are We Done - An intermediate state to compare the value of the table index against the size of the table and either continue operation of the function or exit.
- 3) WFT - Wait For Handoff - The Site Recovery Function has initiated the Handoff Function and is waiting for a response.

Frequency Recovery Function:

- 1) INIT - Initialization - The Frequency Recovery Function is not running.
- 2) RWD - Are We Done - An intermediate state to compare the value of the table index with the size of the table and either continue operation of the function or exit.
- 3) WFT - Wait For Traffic - The Function is listening on a particular frequency for traffic.
- 4) WFH - Wait For Handoff - The Frequency Recovery Function has initiated the Handoff Function and is waiting for a response.

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Frequency Search Function:

- 1) INIT - Initialization - The Frequency Search Function is not running.
- 2) RWD - Are We Done - An intermediate state to compare the value of the table index with the size of the table and either continue operation of the function or exit.
- 3) WFT - Wait For Traffic - The Function is listening on a particular frequency for traffic.
- 4) WFC - Wait For Connection - The Function has initiated a Data Link Connect Request and is waiting for a response.

ATTACHMENT 6 (cont'd)
LINK MANAGEMENT ENTITY (LME) SERVICE TABLES

Table A6-3 LME Outgoing Events

ABBREVIATED NAME	FUNCTION	CATEGORY	NAME
GHOconf	Handoff	Internal	LME_HANDOFF.confirm
DHOreq		DLS-Provider	DL_HANDOFF.request
DHOreq		DLS-Provider	DL_HANDOFF.request
GHOreq	Site Recovery	Internal	LME_HANDOFF.request
GSITEind		Internal	LME_SITERECOVERY.indicate
TG1ind	Frequency Recovery	Internal	LME_TG1_TIMER.indicate
DFREQreq		LME	DL_FREQUENCY.request
GHOreq		Internal	LME_HANDOFF.request
DRSTreq		DLS-Provider	DL_RESET.request
GFREQind		Internal	LME_FREQRECOVERY.indicate
GBADevnt	Frequency Search	LME-User	LME_BADLINK.event
GFREQind		DLS-Provider	DL_FREQUENCY.request
DDRreq		DLS-Provider	DL_DATARATE.request
DCONreq		LME	DL_CONNECT.request
TG1req		Internal	LME_TG1_TIME.request

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ATTACHMENT 6 (cont'd)
LINK MANAGEMENT ENTITY (LME) SERVICE TABLES

Table A6-4 Handoff Algorithm

Input: New ground station address

Objective: Transfer HDLC connection from old ground station to new ground station

Initiated by: Receipt of frame whose signal value indicated it is a preferred station, site recovery function, or frequency recovery function

INPUT EVENTS	STATES		
	INIT	DTS	HO
DCONconf	GCONconf :DTS		
DDISCconf		GDISCconf :INIT	
GHOreq	:INIT	DHOreq :HO	DHOreq :HO
DHOind		DHOresp :DTS	GHOconf :DTS
DDISCconf(ho)		GHOconf :DTS	DDISCreq(ho) ₁ :DTS
DEVNTind(N2) DEVNTind(T4) DHOconf(fail)			GHOconf(fail) :DTS
DEVNTind(TM2)		:INIT	:INIT

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ATTACHMENT 6 (cont'd)
LINK MANAGEMENT ENTITY (LME) SERVICE TABLES

Table A6-5 Site Recovery Algorithm

Input: List of peer entities that have been heard on this frequency ordered by local priorities.

Aircraft Objective: Contact different ground station on this frequency.

Initiated by: Retransmission count exceeded
 DT_EVENT.indication(sq) with a weak signal strength
 Received LME_TG2_TIMER.indication (have not heard from peer entity).

INPUT EVENTS	STATES		
	INIT	RWD (ARE WE DONE?)	WFH (WAIT FOR HANDOFF)
DEVNTind(N2) DEVNTind(sq) TG2ind	K := 1 :RWD		
K < N ¹		GHOreq gs(k) :WFH	
K ≥ N		GSITEind :INIT	
GHOind(ok)			:INIT
GHOind(fail)			K += 1 :RWD
DEVNTind(TM2)		:INIT	:INIT

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N == size of GroundStationTable
 gs(k) == GroundStationTable[k].groundStationAddress

Note 1: skip over gs(k) == this_ground_station_address

ATTACHMENT 6 (cont'd)
LINK MANAGEMENT ENTITY (LME) SERVICE TABLES

Table A6-6 Frequency Recovery Function

Input: List of frequencies supported by the current ground station.

Objective: Contact the same ground station that we were talking to on a different frequency that the GS supports.

Initiated by: Frequency congested (TM2 timer expires, frame in MAC queue too long)
Site Recovery Algorithm fails (use parameter list from desired staton)

INPUT EVENTS	STATES			
	INIT	RWD (ARE WE DONE?)	WFT (WAIT FOR TRAFFIC)	WFH (WAIT FOR HANDOFF)
DEVNTind(TM1) GSITEind	K:=1 :RWD			
K < N		TG1req TG1 Dfreq fr[k] :WFT		
K >= N		GBADevnt DRSTreq GFREQind(fail) :INIT		
TG1ind			K += 1 :RWD	:INIT
DEVNTind(sqp)			TG2req 0 GHOreq :WFH	K += 1 :RWD
GHOind(ok)				
GHOind(fail)				:INIT

N == size of PeerEntityContactTable[this_ground_station].xIDParameters.frequency_list

fr(k) == PeerEntityContactTable[this_ground_station].xIDParameters.frequency_list[k]Address

ATTACHMENT 6 (cont'd)
LINK MANAGEMENT ENTITY (LME) SERVICE TABLES

Table A6-7 Frequency Search Function

Input: Static ordered set of known frequencies (with no dynamic knowledge of local transmitters and no connection currently open).

Objective: Contact any ground station on any frequency.

Initiated by: Boot Sequence
 Failure of Frequency Recovery algorithm to achieve handoff/contact.

INPUT EVENTS	STATES			
	INIT	RWD (ARE WE DONE?)	WFT (WAIT FOR TRAFFIC)	WFH (WAIT FOR CONNECTION)
GBOOTreq GFREQind(fail)	K := 1 :RWD			
K < N		TG1req t[k] Dfreq fr[k] DDRreq dr[k] :WFT		
K ≥ N		K := :RWD		
TG2ind			K += 1 :RWD	
DEVNTind(sq)			TG1req 0 DCONreq ¹ :WFH	
DCONconf ¹				GCONconf ¹ :INIT
DDISconf				K += 1 :RWD

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t[k] == FrequencyPreferenceTable[k].scanTimeout

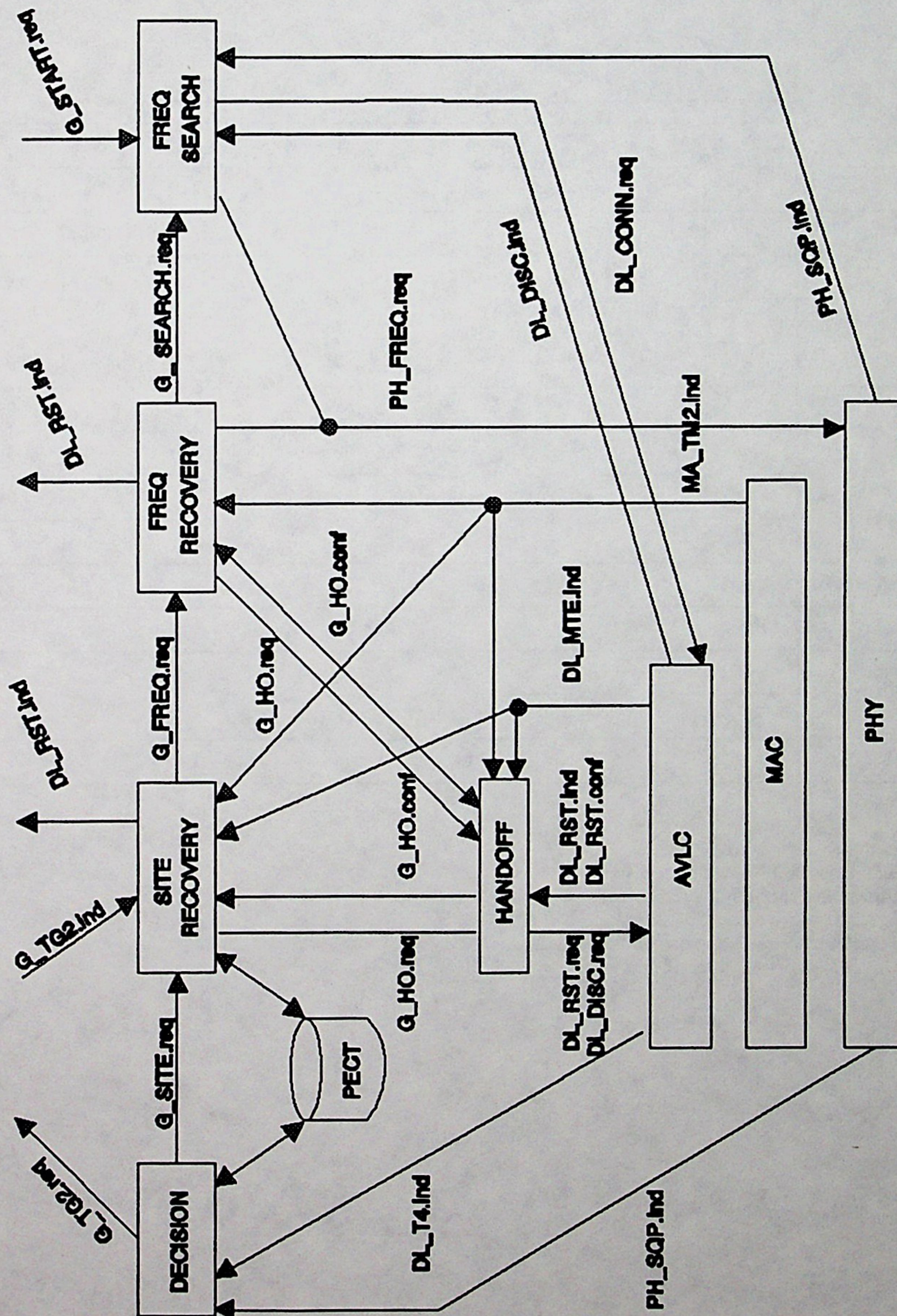
fr(k) == FrequencyPreferenceTable[k].frequency

dr[k] == FrequencyPreferenceTable[k].modulationScheme

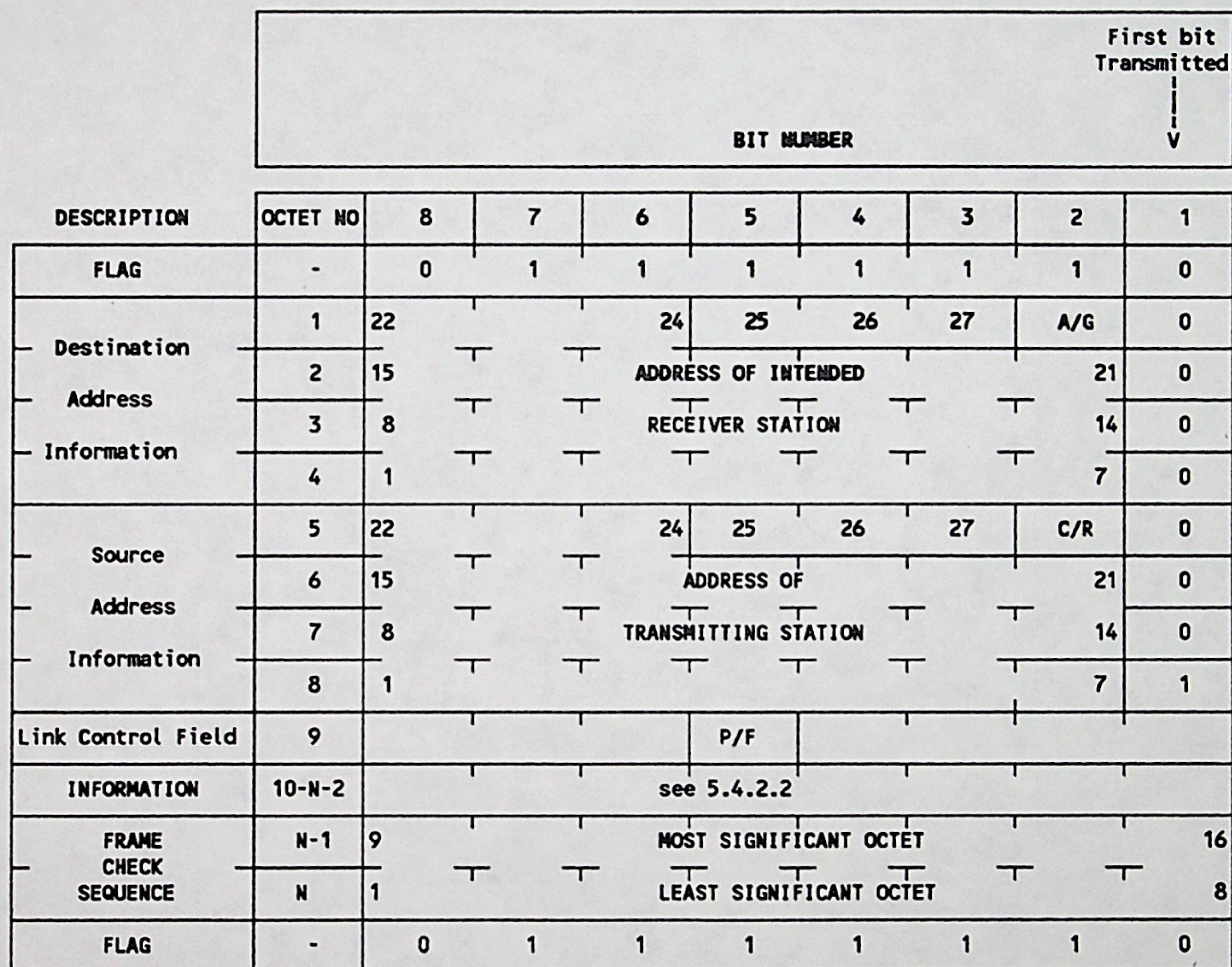
Note 1: The Upper layer will receive a DCONconf without having sent a DCONreq.

ATTACHMENT 6 (cont'd)
LINK MANAGEMENT ENTITY (LME) SERVICE TABLES

Table A6-8 LME Primitive Flow Diagram



ATTACHMENT 7
LINK LAYER HEADER
BASIC FORMAT

Figure A7-1 Link Layer Header

Address Structure: See below

Control Field: See ISO 4335 Section 6

P/F: Poll/Final, see section 5.4.2.3.2

A/G: Air/Ground, see section 5.4.2.3.2

C/R: Command/Response, see section 5.4.2.3.2

Information: Information field of frame

ATTACHMENT 7 (cont'd)
LINK LAYER HEADER
BASIC FORMAT

Table A7-1 Address Type Field

Bit Encoding 27 26 25	Type Description	Comments
0 0 0	Undefined	Future use
0 0 1	Aircraft ICAO	24 bit aircraft
0 1 0	Base Station	Fixed ground station address
0 1 1	Mobile not ICAO	May be fuel or baggage handlers
1 0 0	Undefined	Future Use
1 0 1	Undefined	Future Use
1 1 0	Undefined	Future Use
1 1 1	Broadcast	All stations

Table A7-2 Address Allocation

Bit 24	Description
0	Address space administered by ICAO
1	Address space administered by AEEC

Table A7-3 Allocation of AEEC-administered Addresses

Bit Encoding 2 2 1 4321 0987 6543 2109 8765 4321	Description
10ss ssss xxxx xxxx xxxx xxxx	Class A address
110s ssss ssss xxxx xxxx xxxx	Class B address
1110 ssss ssss ssss xxxx xxxx	Class C address

where 's' denotes bit position identifying a service provider;
'x' denotes bit position identifying a ground router

Table A7-4 Defined Service Providers

Hexadecimal Address	Service Provider
80XXXX	ARINC
81XXXX	SITA
C00XXX	Japan
C01XXX	Air Canada
E000XX	Malaysia

APPENDIX A
LINK LAYER HEADER
SAMPLE

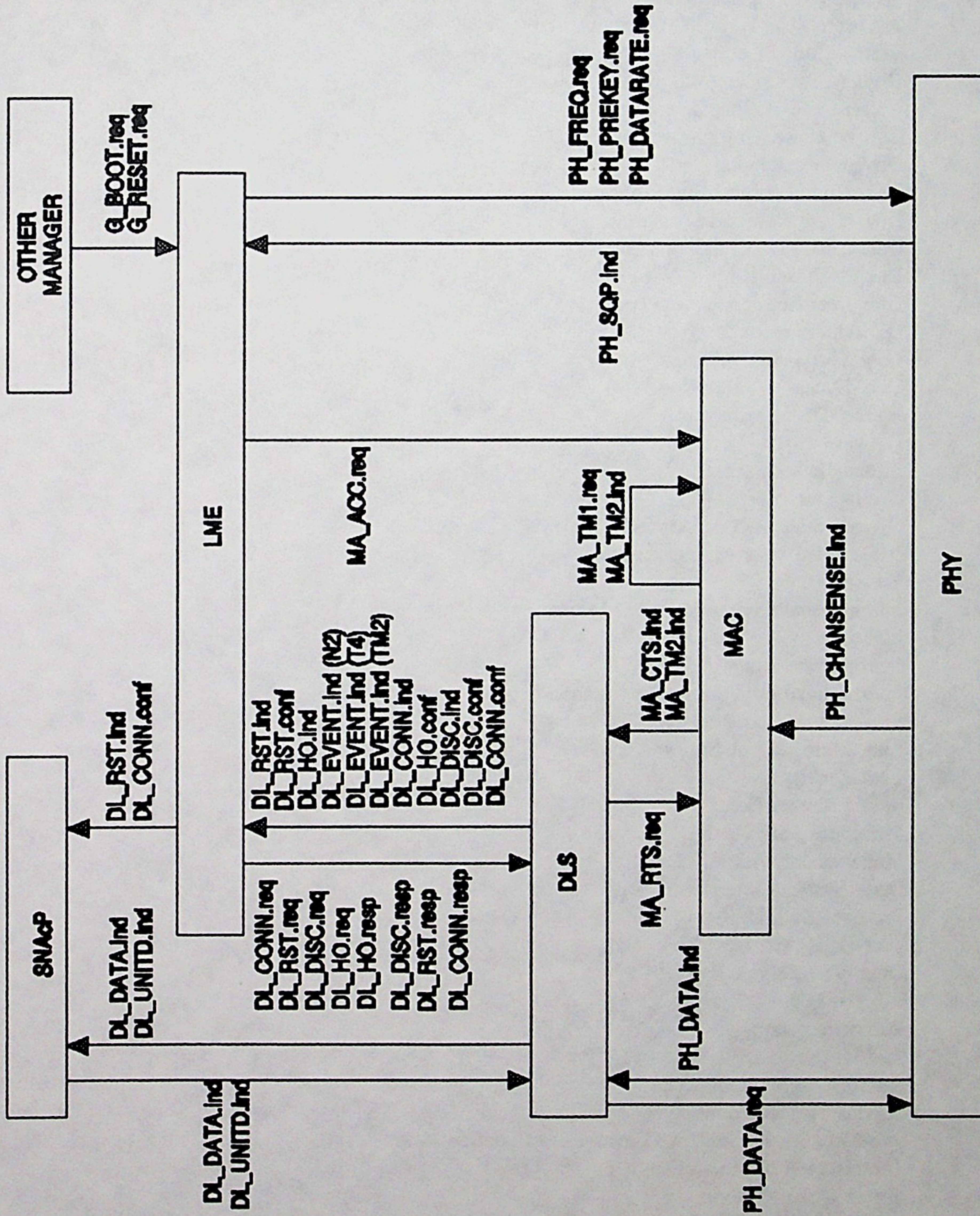
For example, a frame transmitted from N13285 to an ARINC ground station with a hexadecimal address of 800280 would have the address bits as follows:

	<u>Octal</u>	<u>Hex</u>	<u>24 ----- Binary ----- 1</u>	<u>Type</u>	<u>Address</u>
Src:	50103055	A0862D	1010 0000 1000 0110 0010 1101	Aircraft ICAO	ICAO 24-bit address of N13285
Dst:	40001200	800280	1000 0000 0000 0010 1000 0000	Base Station	ARINC Ground Station address

BIT NUMBER									
									First bit Transmitted ↓ V
DESCRIPTION	OCTET NO	8	7	6	5	4	3	2	1
FLAG	-	0	1	1	1	1	1	1	0
Destination	1	0	0	1	0	1	0	1	0
	2	0	0	0	0	0	0	0	0
Address	3	1	0	1	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
Source	5	1	0	1	1	0	0	1	0
	6	0	1	0	0	0	0	0	0
	7	0	0	1	1	0	0	0	0
	8	1	0	1	1	0	1	0	1

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APPENDIX B
PRIMITIVE FLOW DIAGRAM



APPENDIX C
ACRONYM LIST

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ACARS	Aircraft Communications Addressing and Reporting System
AEEC	Airlines Electronic Engineering Committee
A/G	Air-ground
AM	Amplitude Modulation
ATN	Aeronautical Telecommunications Network
AVLC	Aviation VHF Link Control
AVPAC	Aviation VHF Packet Communications
BCD	Binary Coded Decimal
CAA	Civil Aeronautical Authority
CSC	Common Signalling Channel
CSMA	Carrier Sense Multiple Access
DA	Destination Address
DCE	Data Circuit-terminating Equipment
DISC	Disconnect Command
DLDPDU	Data Link Protocol Data Unit
DLS	Data Link Service
DLSAP	Data Link Service Access Point
DM	Disconnected Mode
DTE	Data Terminal Equipment
DXE	Data Exchange Equipment??
FCS	Frame Check Sequence
FEC	Forward Error Correction
FRMR	Frame Reject Frame
GI	Group Identifier
GSIF	Ground Station Information Frame
HDLC	High Level Data Link Control
HO	Handoff
ICAO	International Civil Aviation Organization
ID	Identifier
ISH	Intermediate Systems Hello PDU
ISO	International Organization for Standardization
LCR	Link Connection Refused
LME	Link Management Entity
LQ	Link Quality
MAC	Media Access Control
MSK	Minimum Shift Keying
MU	Management Unit
OSI	Open Systems Interconnection
PDU	Protocol Data Unit
PECT	Peer Entity Contact Table
QOS	Quality of Service
REJ	Reject PDU
RF	Radio Frequency
RR	Receive Ready
SABM	Set Asynchronous Balance Mode
SAP	Service Access Points
SNDCF	Sub-Network Dependent Convergence Function
SNPDU	Sub-Network Protocol Data Unit
SQP	Signal Quality Parameter
TEST	Test Frame
UA	Unnumbered Acknowledgement Frame
UI	Unacknowledged Information
VHF	Very High Frequency
XID	Exchange Identity

APPENDIX D
REFERENCES

ARINC Characteristic	Title	Date Published
410	Mark 2 Standard Frequency Selection System	10/61
429-10	Mark 33 Digital Information Transfer System (DITS)	3/87
	Supplement 8	12/84
	Supplement 9	4/85
	Supplement 10	11/86
	Supplement 11	*****
597-4	Aircraft Communications Addressing and Reporting System (ACARS)	7/87
	Supplement 4	3/87
	Supplement 5	2/88
597A	Enhanced ACARS Avionics	11/86
637	Internetworking Specification	8/91
724B	Aircraft Communications Addressing and Reporting System (ACARS)	2/88
748	Communications Management Unit	8/91

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ARINC Project Paper	Title	Date Published
638	Upper Layer Specification	10/91

ISO	Title	Date Published
3309 (E)	HDLC Procedures - Frame Structure, Version 3	10/84
4335 (E)	HDLC Elements of Procedures, Version 3	8/87
7498	OSI Basic Reference Model, Version 1	10/84
7809 (E)	HDLC Procedures - Consolidation of Classes of Procedures, Version 1	2/84
TR 8509	OSI Service Conventions, Version 1	9/86
8885 (E)	HDLC Procedures - General Purpose XID Fram Information Field Content and Format, Version 1	8/87
8886.3	OSI Data Link Service Definition, Version 3	6/88

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SUPPLEMENT 1
TO
ARINC SPECIFICATION 631-1©
AVIATION VHF PACKET COMMUNICATIONS (AVPAC)
FUNCTIONAL DESCRIPTION

Published: January 22, 1993

Prepared by the Airlines Electronic Engineering Committee

Specification 631-1

Adopted by the Airlines Electronic Engineering Committee: November 3, 1992

A. PURPOSE OF THIS DOCUMENT

This Supplement introduces a major rework of ARINC Specification 631 to reflect an evolving AVPAC system. The normal practice of publishing a separate supplement to update an existing document has not been followed. A detailed overview of the changes is provided in Section C below. A general overview of the changes made is as follows:

In Chapter 1 "Introduction" the commentary (referring to Mark 3 MUs) was removed and ARINC Characteristic 750 was referenced. Descriptions of the conventions used in the document and the state tables were added.

In Chapter 2 "Interoperability" the commentary was updated

In Chapter 3 "System Overview" the functional organization and RF management sections were updated and the Signal in Space section was removed.

In Chapter 4 "Interfaces and Protocols for Layer 1 - The Physical Layer" the primitives were rewritten to be consistent with new RTS/CTS operation and the modulation scheme information was removed. The OQAM modulation scheme is now documented in ARINC Project Paper 750, "VHF Data Radio and the MSK scheme is now documented in ARINC Project Paper 618, "Air Ground Character Oriented Protocol Specification".

In Chapter 5 "Services and Protocol of Layer 2 - The Link Layer" the MAC Layer was changed to a nonadaptive P-persistent CSMA. Also, in the Data Link Layer - ISO 8802, which is a LAN Standard for Logical Link Control, is no longer referenced. Instead ISO 8886, which is a Data Link Service, is referenced. As a result, LLC has been globally replaced with DLS. In general all text that can be referenced in ISO standards has been removed and appropriately referenced. Only extensions or deviations from the ISO standards has been noted. A connectionless mode unacknowledged broadcast service was added at the link layer. Both UI's and DISC's are no longer acknowledged. (The P/F bit is now set to 0). The XID bit encodings changed to incorporate ISO 8885 parameters wherever possible. Negotiation of XID's is now per ISO 8885 which specifies a single transaction; therefore, the NFN bit was deleted. When busy, a station will no longer send out RNR's, instead it should acknowledge outstanding frames and disconnect. New primitives were added to the link layer to accommodate the new link Management Entity in Chapter 5.5.

In Chapter 6 "Services and Protocol of Layer 3 - The Network Layer" Subnetwork was changed to Network in the title. The DTE addresses were revised. ISO documents were referenced rather than repeated. The profile was added and the use of acknowledgement packets and acknowledgement timers were defined.

In general most of the Attachments have been updated or removed and replaced with new information. The acronym list and references were also edited.

B. ORGANIZATION OF THIS DOCUMENT

Due to the extensive nature of the changes incorporated into this Supplement, ARINC Specification 631 has been reproduced in its entirety. The modified and added

material on each page is identified by a C-1 symbol in the margins.

Copies of ARINC Specification 631 adopted by the AEEC November 6, 1990 and published December 20, 1991, should be considered obsolete.

C. CHANGES TO ARINC SPECIFICATION 631 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete tabulation of the changes and additions to the Characteristic introduced by this Supplement. Each change or addition is defined by the section number and the title that will be employed when the Supplement is eventually incorporated. In each case a brief description of the change or addition is included.

1.1 Purpose of this Document

A minor editorial change was made in the first paragraph.

1.2 Background

The last sentence of the second paragraph and the commentary were deleted.

1.3 Relationship of this Document to ARINC Characteristics

References to ARINC Characteristic 748, "Communications Management Unit (CMU)" and ARINC Characteristic 750 "VHF Data Radio" have been added. "Chapter TBD" was changed to "Section 2". The second paragraph was deleted and references to ARINC project Papers 637 and 638 were added.

1.3.1 Characteristic 748

The last sentence was deleted and an editorial change was made.

1.3.2 Characteristic 724B

An editorial change was made.

1.3.5 Characteristic 750

A new section was added which refers to the development of the Data Radio.

1.4 Relationship to Other OSI Protocols

Reference to the Subnetwork Layer has been removed from the AVPAC functions. References were added for the High-Level Data Link Control (HDLC) as specified in ISO 3309(E) version 3 10/84, ISO 4335(E) version 3 8/87, ISO 7809(E) version 1 2/84 and ISO 8885(E) second edition 6/91 except as noted in Sections 4 and 5 of this Specification. The second paragraph and both commentaries were deleted.

1.5 Conventions Used in This Document

This is a new section.

1.5.1 State Tables

This is a new section.

2.1 Subnetwork Interoperability

The third paragraph was deleted.

2.2 AVPAC/ACARS RF Coexistence

The first sentence of the commentary was deleted.

3.2 System Architecture

An editorial change was made in the eighth paragraph. The last paragraph, referencing the International Standards Organization (ISO) 8208, was deleted.

3.2.2.3 Layer 3, The Network Layer

The third sentence of the first paragraph was deleted. Flow control, Duplicate control and Sequencing were deleted from the list of Network Layer responsibilities.

3.2.3 AVPAC Functional Organization

A reference to Appendix B was added to the second paragraph. The reference to Attachment 1 was deleted from the third paragraph. The first sentence of the fourth paragraph was moved to the end of the third paragraph. The second sentence of the fourth paragraph was deleted.

3.3 Radio Frequency Management

The second paragraph and commentary were deleted. The last sentence of the fourth paragraph was deleted. The fifth paragraph and commentary were deleted. The last paragraph was deleted.

3.5 Signal in Space

This entire section was deleted.

4.1 Introduction

Editorial changes were made to the first paragraph. The remainder of the section was deleted. A new paragraph was added to refer to ARINC Specification 618 and ARINC Characteristic 750 for defined AVPAC modulation techniques.

4.2 Physical Layer Service Definition

An editorial change was made in the first paragraph. Commentary was added after the first paragraph. The third paragraph was deleted. The last sentence of the fifth paragraph was deleted.

4.2.1 Functions

In the first sentence, the words "Physical Layer of the modem" was changed to "Physical Layer". The second paragraph and commentary were deleted.

4.2.1.1 Transceiver Control

The second paragraph and commentary were deleted. A new paragraph was added to indicate that AVPAC will

not support voice/data mode as defined in ACARS, but instead will execute a DISC upon switching from data to voice and the link re-established once the radio is returned to data mode.

4.2.1.2 Data Reception

Editorial changes were made to the section header and text.

4.2.1.3 Data Transmission

Editorial changes were made to the section header and text.

4.2.1.4 Notification Services

"Transceiver" was changed to "modem" and references to "MU" were deleted in the first paragraph. The second paragraph and the commentary were deleted and rewritten to indicate how the signal quality analysis can be performed on the demodulator evaluation process.

4.2.2 Service Primitives

The first paragraph was changed to indicate that all primitive parameters are mandatory for the correct operation of the protocol state machine. References to a Table and an Attachment were changed in both paragraphs.

4.2.2.1 Physical Layer Data Request

Transfer was changed to transmission editorial changes were made for clarity. The phrase "(contains Data Link PDU, in general)" was deleted from the parameters.

4.2.2.2 Physical Layer Data Indication

Editorial changes were made for clarity. The phrases "(contains Data Link PDU, in general)" and "PhS signal quality parameter (O)" were deleted from the parameters.

4.2.2.4 Physical Layer Prekey Request

A new sentence was added to indicate that this primitive is used only for the AM MSK data rate/modulation scheme defined in Attachment 5. "Pre-key length (M)" was changed to "AM MSK Pre-key length (M)".

4.2.2.5 Physical Layer Chansense Indication

"This primitive" was changed to "Ph_CHANNELSENSE.indication" in the first sentence. A reference was made to ARINC Characteristic 750 and the commentary was deleted.

4.2.2.6 Physical Layer Data Rate Request

A change was made to indicate that the receipt of the Ph_DATARATE.request by the Ph Provider causes the local Ph Provider to set the physical data rate and modulation for the requested speed. A reference to Attachment 5 was added. The commentary was deleted.

4.2.2.7 Physical Layer Signal Quality Indication

This is a new section that describes the Ph_SQP.indication primitive for the signal quality service.

4.3 Protocol State Machine

This section was formerly section 4.3.4 and now only refers to the physical layer Event and State Transition tables in Attachment 2. The former section 4.3 "Protocol Specification" was deleted.

4.3.1 Modem Characteristics

This section was deleted"

4.3.1.1 Data Transmission

This section was deleted; references are now made to ARINC Specification 618 and ARINC Characteristic 750 in section 4.1 instead.

4.3.1.2 Analog Signal Transmission

This section was deleted; references are now made to ARINC Specification 618 and ARINC Characteristic 750 in section 4.1 instead.

4.3.1.3 RF Frequency

This section was deleted; references are now made to ARINC Specification 618 and ARINC Characteristic 750 in section 4.1 instead.

4.3.1.4 Data Rate

This section was deleted; references are now made to ARINC Specification 618 and ARINC Characteristic 750 in section 4.1 instead.

4.3.1.5 Pre-Key

This section was deleted; references are now made to ARINC Specification 618 and ARINC Characteristic 750 in section 4.1 instead.

4.3.1.6 Modulator Specifications

This section was deleted; references are now made to ARINC Specification 618 and ARINC Characteristic 750 in section 4.1 instead.

4.3.1.7 Demodulator Specifications

This section was deleted; references are now made to ARINC Specification 618 and ARINC Characteristic 750 in section 4.1 instead.

4.3.2 Transceiver Interface

This section was deleted.

4.3.2.1 Radio Transmitter Keying

This section was deleted; references are now made to ARINC Specification 618 and ARINC Characteristic 750 in section 4.1 instead.

4.3.2.2 Radio Transmitter Tuning

This section was deleted; references are now made to ARINC Specification 618 and ARINC Characteristic 750 in section 4.1 instead.

4.3.2.3 Transceiver Characteristics

This section was deleted; references are now made to ARINC Specification 618 and ARINC Characteristic 750 in section 4.1 instead.

4.3.3 Synchronization and Ambiguity Resolution

This section was deleted; references are now made to ARINC Specification 618 and ARINC Characteristic 750 in section 4.1 instead.

4.3.3.1 Bit Ambiguity Resolution

This section was deleted; references are now made to ARINC Specification 618 and ARINC Characteristic 750 in section 4.1 instead.

4.3.4 Protocol State Machine

This section is now section 4.3.

4.3.4.1 Conventions

This section was deleted and rewritten in Section 1.5 "Conventions Used in This Document".

4.3.4.2 State Definitions and Event Tables

This section was deleted and rewritten in Section 1.5.1 "State Tables".

5.1.1 Model

This section has been rewritten to indicate that the Link Layer is divided into three sublayers: the Media Access Control (MAC) sublayer, the Data Link Service (DLS) sublayer and the Link Management Entity (LME). "Logical Link Control (LLC)" was changed to "Data Link Service (DLS)" and LME was added.

5.1.2 General Operation

References to ISO 8208 were changed to ISO 8886 and references to LLC were change to DLS.

5.2 AVLC Media Access Control Sublayer

Most of section 5.2 and the subsections were extensively revised. In general, VT-csma was replaced with p-persistent csma, the frame queue was removed from the MAC and an RTS/CTS scheme was specified for acquisition of the media.

5.3 AVLC Data Link Service Definition and

5.4 AVLC Data Link Service Protocol Specification

Most of Sections 5.3 and 5.4 and the subsections were extensively revised. The Link layer was edited to keep the queue of frames until time for transmission. Handoff primitives were added. The address format and definition was updated (it now has a variable field size, definitions for broadcast addresses were added, and ground station address space was partitioned between ICAO and AEEC). The XID frame was revised extensively to contain login and handoff parameters and use standard ISO parameters where possible. There is no negotiation at login so the NFN bit was deleted. Timer parameters were modified,

5.3 AVLC Data Link Service Definition and
5.4 AVLC Data Link Service Protocol Specification
(cont'd)

and very low rate keep-alive messages were added explicitly (they were there implicitly before). References to ISO documents were added and text from ISO documents was removed. Operation on queued frames was defined. The autotune function was fixed. Some protocol modifications were made based on simulations that showed improved performance. Explanatory text was added/updated.

5.5 Link Management Entity

All of section 5.5 and the subsections are new.

6.1.1 Model

Minor editorial changes were made.

6.1.2 General Operation

Editorial changes were made.

6.2.1 Functions

The first sentence was deleted and "Network Layer" was changed to "SNACP".

6.2.1.1 Subnetwork Connection Management

This section was formerly section 6.2.1.2. The former section 6.2.1.1 Equipment Address Management was deleted.

6.2.1.2 Packet Fragmentation and Reassembly

This section was formerly section 6.2.1.3. Fragmentation was added to the header and "disassembly" was changed to "fragmenting" in the text.

6.2.1.3 Subnetwork Connection Quality of Service Management

This section was formerly section 6.2.1.4. Minor editorial changes were made.

6.2.1.4 Error Recovery

This section was formerly section 6.2.1.6. DIAGNOSTIC packet type was deleted. The last sentence of the first paragraph and the entire second paragraph has been deleted. New text was added to indicate that RESET or RESTART should not be used to recover from an error which can be handled by REJECT.

6.2.1.5 Connection Flow Control

This section was formerly section 6.2.1.7. Editorial changes were made. The former section 6.2.1.5 Subnetwork Connection Selection and Management was deleted.

6.2.1.8 Priority Handling

This section was deleted.

6.2.2.2 Data Transfer Phase

The last paragraph on expedited data was deleted.

6.2.2.4 Service Primitive Specification

This section was rewritten in its entirety. Section 6.2.2.4.1 Subnetwork Connect Primitives is a new section. All remaining subsections of 6.2.2.4 were deleted.

6.2.4 Addressing Issues

The first sentence was replaced to indicate that the Fast Select field of the Call Setup packets should carry IS-Hello PDUs. "NSAP" was changed to "NET" in the second sentence.

6.3 Subnetwork Protocol Specification

Editorial changes were made to indicate that the intent of this section is to clarify the appropriate ISO standards as used in AVPAC rather than to fully specify the subnetwork protocol.

6.3.1 SNPDU Format

New text was added to indicate that the SNPDU format is specified in ISO 8208 except as qualified in the following subsections. The former subsections 6.3.1.1 General Packet Structure, 6.3.1.1.2 Logical Channel Identifier, 6.3.1.1.3 Packet Type Identifier, 6.3.1.1.4 Address Length Indicators, 6.3.1.1.6 Facilities Length Indicator, 6.3.1.1.7 Facility Field, 6.3.1.1.9 Cause Fields, 6.3.1.1.10 Diagnostic Code, 6.3.1.1.11 Packet Send Sequence Number, 6.3.1.1.12 Packet Receive Sequence Number and 6.3.1.1.13 More Data Mark were deleted.

6.3.1.1 General Format Identifier

This was formerly section 6.3.1.1.1. It was rewritten to indicate that modulo 128 sequencing is the only defined sequencing in AVPAC. The former section 6.3.1.1 General Packet Structure was deleted.

6.3.1.2 Calling and Called DTE Addresses

This was formerly section 6.3.1.1.5. An editorial addition was made to the first paragraph. The remainder of the section was replaced with new addressing information that accommodates Service Provider and CAA routers.

6.3.1.3 Call User Data Field

This was formerly section 6.3.1.1.8. This section was edited to indicate that the Fast Select Facility should be used to carry the ISH PDU. Commentary was added.

6.3.2 Types of SNPDU's

This was formerly section 6.3.1.2. This section was completely rewritten to show the DTE-to-DXE and DXE-to-DTE SNPDU's that an AVPAC DTE should support as specified in ISO 8208 and clarified in this section. The former subsections 6.3.1.2.3 Clear Request and Clear Indication, 6.3.1.2.4 Clear Confirmation, 6.3.1.2.5 Data, 6.3.1.2.6 Interrupt, 6.3.1.2.7 Interrupt Confirmation

6.3.1.2.9 Receive Not Ready, 6.3.1.2.10 Reset Request and Reset Indication, 6.3.1.2.11 Reset confirmation, 6.3.1.2.12 Restart Request and Restart Indication, 6.3.1.2.13 Restart Confirmation, 6.3.1.2.14 Reject, 6.3.1.2.15 Diagnostic, 6.3.1.2.16 Registration Request and 6.3.1.2.17 Registration Confirmation were deleted. In addition, the former section 6.3.2 Protocol State Machine and subsections 6.3.2.1 Phases of Operation, 6.3.2.1.1 Connection Establishment Phase, 6.3.2.1.2 Data Transfer Phase, 6.3.2.1.3 Disconnection Phase and 6.3.2.2 Optional User Facilities and Subnetwork Parameters were deleted.

6.3.2.1 Call Request, Incoming Call, Call Accepted, and Call Connected

This new section consists of former sections 6.3.1.2.1 and 6.3.1.2.2 which were combined and rewritten.

6.3.2.2 Clear PDUs, Reset PDUs, and Restart PDUs

This is a new section.

6.3.2.3 Receive Ready

This was formerly section 6.3.1.2.8 and has been completely rewritten.

6.3.3 Facilities and Procedures

This is a new section.

6.3.3.1 Effects of Layers 1 and 2 on the Packet Layer

This is a new section.

6.3.3.2 Acknowledgement Window

This is a new section.

6.3.3.3 Nonreceipt of Window-Rotation Information

This is a new section.

6.3.3.4 Receipt of Erroneous DATA Packets

This is a new section.

6.3.4 Parameter

This is a new section.

6.3.4.1 T25 - Window Rotation Timer

This is a new section.

6.3.4.2 R25 - Window Rotation Timer

This is a new section.

6.3.4.3 P- Packet Size

This is a new section.

6.3.4.4 W - Window Size

This is a new section.

ATTACHMENT 1, INTERFACE DIAGRAM

This diagram has been updated.

ATTACHMENT 2, PHYSICAL SERVICE TABLES

These tables were previously in Attachment 3 "SERVICE TABLES" and they have been updated. The former Table A3-1 "Service Primitive List" was deleted. The former Attachment 2 "MESSAGE CONSTRUCTION PROGRAM" was deleted.

ATTACHMENT 3, MEDIA ACCESS CONTROL (MAC) TABLES

These tables were previously in Attachment 4 "MAC TABLES" and they have been updated.

ATTACHMENT 4, DATA LINK SERVICE (DLS) TABLES

In general, Attachment 4 was edited to reflect the deletion of the NFN bit and to be integrated with the LME. These tables were previously in Attachment 6 "LLC TABLES". The LLC Connection Set-Up and Hand-Off Input Events Table and the LLC Transition Elements Table were deleted. The other Tables were edited and LLC was changed to DLS in the title. New Tables were added on Data Link Timer Actions and AVPAC DLS Connection Set-up and Hand-off Input Events.

ATTACHMENT 5, DATA RATE PARAMETER ENCODING TABLE

This table was previously in Attachment 8 "DATA TABLES" as Table A8-2 and has been updated to include 4-OQAM and 16-OQAM. The former Attachment 5 "CONTROL FIELD BITS CHART" has been deleted.

ATTACHMENT 6, LINK MANAGEMENT ENTITY (LME) SERVICE TABLES

These are new tables to accommodate the new Link Management Entity functions in section 5.5. A new LME Primitive Flow Diagram was added. The former Attachment 6 "LLC TABLES" is now in Attachment 4 "DATA LINK SERVICE (DLS) TABLES".

ATTACHMENT 7, LINK LAYER HEADER BASIC FORMAT

This is a new Attachment and provides new information on the Link Layer Header Basic Format and link layer address format. A Link Layer Header Sample is included in Appendix 1. The former Attachment 7 "INTERMEDIATE SYSTEM" was deleted.

ATTACHMENT 8, DATA TABLES

Attachment 8 was deleted. Table A8-2 was updated and moved to Attachment 5 "DATA RATE PARAMETER ENCODING TABLE".

ATTACHMENT 9, SUBNETWORK LAYER TIMER PARAMETERS

Attachment 9 was deleted.

APPENDIX A, LINK LAYER HEADER SAMPLE

This table is new and complements the Link Layer Basic Format in Attachment 7. The former APPENDIX A "LINK LAYER HEADER" was deleted.

APPENDIX B, PRIMITIVE FLOW DIAGRAM

This is a new diagram. The former APPENDIX B "SUBNETWORK LAYER PACKET STRUCTURES" was deleted.

APPENDIX C, ACRONYM LIST

This APPENDIX has been updated.

APPENDIX D, REFERENCES

This APPENDIX has been updated.