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**EXECUTIVE SUMMARY**

The purpose of this document is to define Minimum Aviation System Performance Standards (MASPS) for the signal-in-space characteristics for advanced Very High Frequency (VHF) digital data communications, including compatibility with digital voice techniques. The MASPS document is divided into three sections; an introduction, aviation user requirements, and technical characteristics.

The introductory section provides VHF communications system characteristics including aeronautical VHF communications frequencies utilized and its implications to spectrum congestion. Service rules as defined by the Federal Communications Commission (FCC) and the Federal Aviation Administration (FAA) are also provided. Principles of operation of the current VHF voice and data systems and the proposed future system are presented. General applications are divided into three categories; they are Air Traffic Services (ATS) communications, Aeronautical Operational Communications (AOC), and Aeronautical Administrative Communications (AAC). Current system interconnection, routing, integration considerations and deficiencies are highlighted.

The aviation user requirements section identifies the users of the systems and specific aircraft characteristics. The expected availability and integrity of the avionics are described. System interoperability and compatibility requirements are emphasized to assure coexistence with the present analog voice system.

The technical characteristics section describes the VHF Data Link (VDL) system. Two modes of operation are defined: VDL Mode 2 and VDL Mode 3. VDL Mode 2 refers to the operation of the Carrier Sense Multiple Access (CSMA) Media Access Control (MAC) protocol to support data link compatibility. VDL Mode 3 refers to the functionally simultaneous voice and data link capability of the Time Division Multiple Access (TDMA) MAC protocol.

The signal-in-space may be used for either or both modes of operation provided implementation is in accordance with the VDL Mode 2 and VDL Mode 3 characteristics described herein and with other relevant industry standards. The definition, description, and specification of both modes are expected to continue to evolve as the industry, the service providers, and the users further develop future system concepts and capabilities.

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[Table I-30: XDCE Effect on DCE Call Setup and Clearing States I-](#_Toc520711307)**[Error! Bookmark not defined.](#_Toc520711307)**

[Table I-31: XDCE Effect on DCE Reset States I-](#_Toc520711308)**[Error! Bookmark not defined.](#_Toc520711308)**

[Table I-32: RESERVED I-](#_Toc520711309)**[Error! Bookmark not defined.](#_Toc520711309)**

[Table I-33: GNI (ANI) Effect on ADCE (GDCE) Packet Layer Ready States I-](#_Toc520711310)**[Error! Bookmark not defined.](#_Toc520711310)**

[Table I-34: GNI (ANI) Effect on ADCE (GDCE) Call Setup and Clearing States I-](#_Toc520711311)**[Error! Bookmark not defined.](#_Toc520711311)**

[Table I-35: GNI (ANI) Effect on ADCE (GDCE) Reset States I-](#_Toc520711312)**[Error! Bookmark not defined.](#_Toc520711312)**

[Table I-36: RESERVED I-](#_Toc520711313)**[Error! Bookmark not defined.](#_Toc520711313)**

[Table I-37: GNI (ANI) Effect on ADCE (GDCE) Flow Control Transfer States I-](#_Toc520711314)**[Error! Bookmark not defined.](#_Toc520711314)**

[Table I-38: DCE Effect on ADCE (GDCE) Call Setup and Clearing States I-](#_Toc520711315)**[Error! Bookmark not defined.](#_Toc520711315)**

[Table I-39: DCE Effect on ADCE (GDCE) Reset States I-](#_Toc520711316)**[Error! Bookmark not defined.](#_Toc520711316)**

[Table I-40: RESERVED I-](#_Toc520711317)**[Error! Bookmark not defined.](#_Toc520711317)**

[Table J-1: CT1 Parameter J-](#_Toc520711318)**[Error! Bookmark not defined.](#_Toc520711318)**

[Table J-2: CT2 Timer J-](#_Toc520711319)**[Error! Bookmark not defined.](#_Toc520711319)**

[Table J-3: CT3 Timer J-](#_Toc520711320)**[Error! Bookmark not defined.](#_Toc520711320)**

[Table K-1: Free Space and Ground Reflection Loss vs. Range, Aircraft Flight Level and Ground Antenna Height, (Median refractive conditions or effective Earth radius factor](#_Toc520711321) *[](#_Toc520711321)* [= 4/3) K-](#_Toc520711321)**[Error! Bookmark not defined.](#_Toc520711321)**

[Table K-2: Free Space and Ground Reflection Loss vs. Range, Aircraft Flight Level and Ground Antenna Height (Worst case sub-refractive conditions or effective Earth radius factor](#_Toc520711322) *[](#_Toc520711322)* [= 1) K-](#_Toc520711322)**[Error! Bookmark not defined.](#_Toc520711322)**

[Table K-3: Parameters for Sample Link Budgets K-](#_Toc520711323)**[Error! Bookmark not defined.](#_Toc520711323)**

[Table K-4: Sample Ground-to-Air Long-Range Link Budgets Using Ray-Tracing and Effective Earth Radius Factor  (Median) K-](#_Toc520711324)**[Error! Bookmark not defined.](#_Toc520711324)**

[Table K-5: Sample Ground-to-Air Long-Range Link Budgets Using Ray-Tracing and Effective Earth Radius Factor (Worst Case) K-](#_Toc520711325)**[Error! Bookmark not defined.](#_Toc520711325)**

[Table K-6: Sample Ground-to-Air Long-Range Link Budgets Using Johnson-Gierhart Propagation Model (95](#_Toc520711326)[th](#_Toc520711326) [Percentile) K-](#_Toc520711326)**[Error! Bookmark not defined.](#_Toc520711326)**

[Table K-7: Sample Air-to-Ground Long-Range Link Budgets Using Ray-Tracing and Effective Earth Radius Factor  (Median) K-](#_Toc520711327)**[Error! Bookmark not defined.](#_Toc520711327)**

[Table K-8: Sample Air-to-Ground Long-Range Link Budgets Using Ray-Tracing and Effective Earth Radius Factor  (Worst Case) K-](#_Toc520711328)**[Error! Bookmark not defined.](#_Toc520711328)**

[Table K-9: Sample Air-to-Ground Long-Range Link Budgets Using Johnson-Gierhart Propagation Model (95](#_Toc520711329)[th](#_Toc520711329) [Percentile) K-](#_Toc520711329)**[Error! Bookmark not defined.](#_Toc520711329)**

[Table L-1: VHF Channel Labels L-](#_Toc520711330)**[Error! Bookmark not defined.](#_Toc520711330)**

1 INTRODUCTION

The purpose of this document is to provide RTCA Minimum Aviation System Performance Standards (MASPS) that define the signal-in-space characteristics for advanced Very High Frequency (VHF) digital data communications, including compatibility with digital voice techniques. This document examines the VHF communications system characteristics and principles of operation for both VHF voice and data system elements. Aviation user requirements and system requirements are considered, and technical characteristics are developed for aircraft transceivers and ground transmitters/receivers. Finally, considerations are examined with regard to accommodating existing systems while making a transition to a new improved VHF data link.

1.1 VHF Communications System Characteristics

### 1.1.1 Reference Documents

The characteristics of the present air/ground VHF communications system are contained in the Federal Communications Commission (FCC) Rules (47 CFR Part 87), the International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPs) (Annex 10, Volume I, Chapter 4 Paras. 4.5 - 4.7), and RTCA/DO-186B *Minimum Operational Performance Standards for Airborne Radio Communications Equipment*. These documents set forth the minimum mandatory and desired operational performance standards for VHF air/ground communications systems. The following list summarizes pertinent industry standards.

| **Reference Document Name** | **Doc. #** |
| --- | --- |
|  |  |
| ARINC Specification – Air-Ground Character-Oriented Protocol Specification | 618-9 |
| ARINC Specification – Data Link Ground System Standard and Interface Specification (DGSS/IS) | 620-10 |
| ARINC Specification – VHF Digital Link (VDL) Mode 2 Implementation Provisions | 631-8 |
| ARINC Characteristic – VHF Data Radio | 750-4 |
| ARINC Characteristic – Communications Management Unit (CMU) Mark 2 | 758-4 |
|  |  |
| ICAO Document - Manual of Technical Provisions for the Aeronautical Telecommunication Network | 9880 |
| ICAO Document - Comprehensive Aeronautical Telecommunication Network Manual | 9739 |
| ICAO Document - Manual on VHF Digital Link (VDL) Mode 2 | 9776 |
| ICAO Document - Manual on VHF Digital Link (VDL) Mode 3 | 9805 |
| ICAO Document - Manual for the ATN using IPS Standards and Protocols | 9896 |
| ISO Standard - Information Technology -- Telecommunications and information exchange between systems -- High-level data link control (HDLC) procedures -- Frame Structure | 3309\* |
| ISO Standard - Information Technology -- Telecommunications and information exchange between systems -- High-level data link control (HDLC) procedures -- Elements of procedures | 4335\* |
| ISO Standard - Information Technology -- Telecommunications and information exchange between systems -- High-level data link control (HDLC) procedures -- Classes of procedures | 7809\* |
| ISO Standard - Information Technology -- Data Communications -- X.25 Packet Layer Protocol for Data Terminating Equipment | 8208-1990 |
| ISO Standard - Information Technology -- Protocol for providing the connectionless-mode network service | 8473 |
| ISO Standard - Information Technology -- Telecommunications and information exchange between systems -- High-level data link control (HDLC) procedures -- General purpose XID frame information field content and format | 8885-1993\* |
| ISO Standard - OSI Data Link Service Definition | 8886.3 |
| ISO Standard - Information Technology -- Telecommunications and information exchange between systems -- End system to intermediate system routing exchange protocol for use in conjunction with the Protocol for providing the connectionless-mode network service (ISO 8473) | 9542 |
| ISO Standard - Local Area Networks -- MAC Service Definition | DP 10039 |
| ISO Standard - Information Technology -- Telecommunications and information exchange between systems -- Protocol for exchange of Inter-Domain Routing Information among intermediate systems to support forwarding of ISO 8473 PDUs | 10747 |
|  |  |
| ITU-T Standard - International Numbering Plan for Public Data Networks | X.121 |
| RTCA VHF Air-Ground Communications System Improvements Alternatives Study and Selection of Proposals for Future Action | DO-225 |
| ARINC Specification - Internet Protocol Suite (IPS) for Aeronautical Safety Services Part 1 Airborne IPS System Technical Requirements | 858P1 |
| Add IPS references | TBD |
| VHF Radio Communication Transceiver Equipment Operating Within the Radio Frequency Range 117.975 - 137.000 MHz | TSO-C169 |
| MOPS for Aircraft Radio Communications Equipment Operating within the Frequency Range 117.975 - 136.000 MHz | DO-156 |
| MOPS for Aircraft Radio Communications Equipment Operating within the Frequency Range 117.975 - 136.000 MHz | DO-157 |
| MOPS for Aircraft Radio Communications Equipment Operating Within the Frequency Range 117.975 - 137.000 MHz | DO-186B |
| Minimum Operational Performance Standards (MOPS) for Aircraft VDL Mode 2 Physical Link and Network Layer | DO-281D |
| Report on VHF Air-Ground Communications System Improvements Alternatives Study | SC-172 WG-1 |
| VHF Air-Ground Communications System Improvements Alternatives Study and Selection of Proposals for Future Action | DO-225 |

*\*It should be noted that the HDLC standards referenced are obsolete by ISO and have been replaced by ISO13239. It should be noted that there are still sources for these obsolete standards and that ISO13239 is not fully interoperable with the referenced standards.*

All of these documents in the list above fall under the proprietary disclaimer note.

1.1.2 Definitions of Terms

Please note that these terms and definitions are to be used for the purposes of this MASPS.

**ACARS (Aircraft Communication and Reporting System):** A datalink communication network originally derived from teletype protocol. The ACARS network is a character based network.

**ACARS Over AVLC (AOA)**: The means by which ACARS character based messages are encapsulated and transport by VDL Mode 2.

**Administration Field**: A field within the Aeronautical Telecommunications Network (ATN) Network Service Access Point (NSAP) address which is used to sub-divide the Network Addressing Domain that is identified in the Version field of the address. The partition of the Network Addressing Domain permits domain management by separate administrations or organizations.

**Administration Region Selector (ARS)**: A field within the ATN NSAP address which identifies a Network Addressing Domain that will correspond to each identified Routing Domain.

**Aeronautical Mobile Service**: A mobile service between aeronautical stations and aircraft stations, or between aircraft stations, in which survival craft stations may participate; emergency locator transmitter (ELT) stations may also participate in this service on designated distress and emergency frequencies.

**Aeronautical Mobile (Route) Service (AM(R)S)**: An aeronautical mobile service reserved for communications relating to safety and regularity of flight, primarily along national or international air routes.

**Aeronautical Station**: A land station in the aeronautical mobile service.

**Aeronautical Telecommunications Network (ATN)**: An internetwork architecture that allows ground, air-ground, and aircraft data subnetworks to interoperate by adopting common interface services and protocols based on the International Organization for Standardization (ISO) Open Systems Interconnection (OSI) Reference Model.

**Aircraft Station**: A mobile station in the aeronautical mobile service, other than a survival craft station, located on board an aircraft.

**Air-Ground Communication**: Two-way communications between aircraft and stations on the surface of the earth.

**Aircraft Address**: A unique combination of 24 bits available for assignment to an aircraft for the purpose of air-ground communications, navigation and surveillance.

**Assigned Frequency**: The center of the frequency band assigned to a station.

**Assigned Frequency Band**: The frequency band within which the emission of a station is authorized; the width of the band equals the necessary bandwidth plus twice the absolute value of the frequency tolerance.

**Asynchronous Balanced Mode (ABM)**: A balanced operational mode in which 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.

**Asynchronous Disconnected Mode (ADM)**: A balanced non-operational mode in which no logical data link connection exists between two link layer entities. A connection must be established before data can be sent.

**ATN Router**: An intermediate system used to interconnect subnetworks conforming to ICAO Document 9880 Manual on ATN Technical Provisions.

**Autotune Function**: The function, performed by the Link Management Entity, which allows a ground station to command an aircraft to change frequencies.

**Basic Voice Service**: The provision of push-to-talk voice services without the support of using discretely addressable Local User IDs for signaling between the ground station and aircraft stations (aircraft stations use the dummy Aircraft ID, i.e., 61). The Basic Voice service is available to aircraft stations in TS1, TS2, or TS3 timing state.

**Bit Error Rate (BER):** BER is expressed as the ratio of the number of erroneous bits received to the total number of bits received. As used in this document, the term BER always refers to the uncorrected BER, that is, the BER experienced on the channel without the benefit of Forward Error Correction (FEC).

**Broadcast**: A transmission intended to be received by all stations.

**Broadcast Handoff**: The process by which a ground Link Management Entity (LME) commands certain aircraft to execute a link handoff and optionally maintain its current subnetwork connections, without the need to explicitly confirm the link handoff or optionally the subnetwork connection maintenance.

**Broadcast Link Handoff**: The process by which the ground LME commands certain aircraft to execute a link handoff to a specific ground station without the need to explicitly confirm the link handoff.

**Broadcast Subnetwork Connection Handoff**: The process by which a ground LME commands certain aircraft to execute a link handoff to a specific ground station and maintain its current subnetwork connections without the need to explicitly confirm the link handoff or the subnetwork connections maintenance.

**Burst**: A time-defined, contiguous set of one or more related signal units which may convey user information and protocols, signaling and any necessary preamble.

**Coast Timing**: A timing state where the aircraft radio is not receiving timing synchronization pulses from the ground station. The aircraft user will attempt to synchronize with any non-coasting aircraft users instead.

**Code Rate**: The ratio of information bits to overall transmitted bits for an error correction code.

**Common Signaling Channel (CSC)**: The common signaling channel is a world-wide VDL Mode 2 channel on the frequency 136.975 MHz that is used to announce the availability of any VDL mode 2 services.

**Class of Emission**: The set of characteristics of an emission, designated by standard symbols, e.g., type of modulation of the main carrier, modulating signal, type of information to be transmitted, and also, if appropriate, any additional signal characteristics. (47 CFR Section 2.201)

**Communication Management Unit (CMU):** In this document, the term CMU refers to the data communication functions not allocated to the radio. Typically, the CMU contains the datalink protocols and functions between the physical layer and the data link applications. In some cases, the lower portion of the Data Link Layer is allocated to the radio. The VDL mode 2 functionalities are distributed between the VHF Data Radio (VDR) and Communication Management Unit (CMU). The hardware implementation can take many forms, such as that defined in ARINC 758 or other avionic configurations such as an avionics cabinet or integrated VDR/CMU. The term CMU is used herein to refer to this portion of the avionics datalink system.

**Current Link (or current ground station)**: Either the ground-to-aircraft link or the active link when in the process of a handoff.

**Data Circuit-terminating Equipment (DCE)**: A DCE is a network provider equipment used to facilitate communications between Data Terminal Equipment (DTE).

**Data Link Entity (DLE)**: A protocol state machine capable of setting up and managing a single data link connection.

**Data Link Service Sub-layer (DLS)**: The sub-layer that resides above the MAC sub-layer. The DLS manages the transmit queue, creates and destroys DLEs for connection-oriented communications, provides facilities for the LME to manage the DLS, and provides facilities for connectionless communications.

**Data Terminal Equipment (DTE)**: A DTE is an endpoint of a subnetwork connection. Immediately above the DTE is the ATN.

**Effective Data Rate**: The actual instantaneous data throughput realized after overheads imposed by bit stuffing and by any forward error correction encoding, but not retransmissions.

**Emission**: Radiation produced, or the production of radiation, by a radio transmitting station.

**Enhanced Voice Service**: Enhanced Voice service, which provides operational enhancements to the Basic Voice service, relies on signaling between the ground station and the aircraft stations using Local User IDs for aircraft station addressing. The Enhanced Voice service features are defined in RTCA/DO-279 Next Generation Air/Ground Communications (NEXCOM) Principles of Operations VDL Mode 3. The Enhanced Voice service is available to aircraft stations that have received discrete Local User IDs by successfully completing the net entry process (see Section 3.3.2.3.2.1.2) and are in TS1 timing state. The ground station has the option not to support certain Enhanced Voice features through the Supported Options message signaling during the net entry process (see Section 3.3.2.3.2.1.2.1).

**Enhanced Voice and Data Service**: Provides all the Enhanced Voice functions described above in addition to a data link capability employing at least one of the protocol stacks described in this specification in the VDL mode 3 section. (These services are available after the successful completion of the net entry procedure and Initial Link Negotiation.)

**Expedited Subnetwork Connection Establishment**: The process by which an aircraft DTE establishes a subnetwork connection with a ground DTE with which it does not have a subnetwork connection during link establishment (or aircraft-initiated handoff).

**Expedited Subnetwork Connection Maintenance**: The process by which an aircraft DTE maintains a subnetwork connection with a ground DTE with which it has a subnetwork connection during the link handoff.

**Explicit Subnetwork Connection Establishment**: The process by which an aircraft DTE establishes a subnetwork connection with a ground DTE with which it does not have a subnetwork connection only after completing the link establishment (or handoff).

**Explicit Subnetwork Connection Maintenance**: The process by which an aircraft DTE maintains a subnetwork connection with a ground DTE with which it has a subnetwork connection only after completing the link handoff.

**Extended Golay code**: A rate 1/2 error correction code capable of correcting any error pattern of three or less bit errors and detecting four-bit error patterns within a 24-bit block size.

**Former\_GNIP**: During handoff between GNI groups, the previous GNIP to which the aircraft was connected.

**Frame**: The link layer frame is composed of a sequence of address, control, information and FCS fields, bracketed by opening and closing flag sequences.

**Frequency Stability**: The maximum permissible departure by the center frequency of the frequency band occupied by an emission from the assigned frequency, or by the characteristic frequency of an emission from the reference frequency. The frequency stability is expressed in parts per million or in Hertz.

**Ground Network Interface**: The VDL mode 3 ground equipment that interfaces with the voice switch, ATN router, and the remote radio via the VDL mode 3 protocols.

**Harmful Interference**: Interference which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radio communication service operating in accordance with the International Telecommunication Union (ITU) Radio Regulations.

**Initiated Handoff**: The transmission process by which a station initiates link handoff.

**Integrity**: The measure of induced errors in messages transferred by a system. An error is considered to include extraneous, modified, or missing information; failure of delivery to the intended recipient; and miss delivery. Integrity is expressed in terms of residual error probability: packet error probability in the case of packet-mode communications, bit error probability in the case of circuit-mode communications. (See also Residual Error Probability)

**Interference**: The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radio communication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy.

**Internetworking Protocol**: A protocol that transfers data packets between intermediate systems (IS) and end systems (ES) interconnected by subnetworks and that is supported by the routing protocols and addressing plan.

**Internet Protocol Suite (IPS):** The set of technical provisions and standards that define the architecture and operation of Internet Protocol-based networking services for the Aeronautical Telecommunication Network communication of avionics systems and ground systems such as the Air Traffic Control, Airlines, and third parties.

**IPS Over AVLC (IOA):** The set of technical provisions and standards required to transport IPS data via the VDL mode 2 air-ground subnetwork.

**Link**: A link connects an aircraft DLE and a ground DLE and is uniquely specified by the combination of aircraft DLS address and the ground DLS address.

**Link Establishment**: The process by which an aircraft and a ground LME discover each other, determine to communicate with each other, decide upon the communications parameters, create a link and initialize its state before beginning communications.

**Link Handoff**: The process by which peer LMEs, already in communication with each other, create a link between an aircraft and a new ground station before disconnecting the old link between the aircraft and the current ground station.

**Link Layer**: The layer that lies immediately above the physical layer in the Open Systems Interconnection protocol model. The link layer provides for the reliable transfer of information across the physical media. It is subdivided into the data link sub-layer and the media access control sub-layer.

**Link Management Entity (LME)**: A protocol state machine capable of acquiring, establishing, and maintaining a connection to a single peer system. An LME establishes data link connections, "hands off" those connections, and manages the media access control sub-layer and physical layer. An aircraft LME tracks how well it can communicate with the ground stations of a single ground system.

**Local User ID**: A unique identification of a specific aircraft that is used by the participants in a VDL subnetwork. The Local User ID consists of a 2-bit User Group ID prefix followed by a 6-bit numerical suffix.

**MAC Cycle**: The standard timing cycle that consists of two consecutives (even and odd) TDMA frames.

**M Burst**: A management channel data block of symbols. This burst contains signaling information needed for media access and link status monitoring. The uplink M burst is used for timing and network management. The downlink M burst is used for management functions and may also include additional optional voice features: i.e., message waiting indications.

**Mean Power (of a radio transmitter)**: The average power supplied to the antenna transmission line by a transmitter during an interval of time sufficiently long compared with the lowest frequency encountered in the modulation taken under normal operating conditions.

**Media Access Control (MAC)**: The sub-layer that acquires the data path and controls the movement of bits over the data path.

**Minimum Shift Keying (MSK):** original ACARS VHF amplitude modulation consisting of 1200 and 2400 Hertz tones to encode the data bits.VDL mode 0 and VDL mode A are two implementations of POA and use MSK.

**Multicast**: A transmission intended to be received by multiple stations.

**Necessary Bandwidth**: For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specific conditions.

**Network Entity Title (NET):** The network address of an ATN/OSI End System or ATN/OSI Intermediate System. Also, an address that may be used to find the Network Entity.

**Network Layer**: The layer that 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.

**New Link (or new ground station)**: After successful completion of handoff (or link establishment), the new "current" link or ground station.

**N(r)**: The receive sequence number at the link layer, which indicates the sequence number of the next expected frame (and explicitly acknowledges all lesser numbered frames).

**N(s)**: The send sequence number at the link layer, which indicates the sequence number associated with a transmitted frame.

**Occupied Bandwidth**: The width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage B/2 of the total mean power of a given emission. Unless otherwise specified by the ITU-R (Formerly CCIR) for the appropriate class of emission, the value of B/2 should be taken as 0.5% (ITU).

**Old Link (or old ground station)**: Following link establishment during a handoff, the link that was previously the "current" link becomes the "old" link.

**Operating Parameters**: The collection of XID parameters used to define the configuration of a VDL mode 2 or 3 station.

**Operative\_GNIP**: The current Primary GNI servicing VDL mode 3 data communications for an aircraft.

**Out-of-Band Emission**: Emission of a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process but excluding spurious emissions.

**Peer Entity Connection** (PEC) **table:** a table ofpeer VDL mode 2 stations maintained by a VDL mode 2 station.

**Peer Entity Connection Table(PECT):** a table ofpeer VDL mode 2 stations maintained by a VDL mode 2 station.

**Physical Layer**: The lowest level layer in the Open Systems Interconnection protocol model. The physical layer is concerned with the transmission of binary information over the physical medium (e.g., VHF).

**Plain Old ACARS (POA):** An ACARS network air/ground subnetwork using the original MSK RF amplitude modulation, either Mode 0 or Mode A.

**Polling**: A procedure by which the ground station interrogates aircraft stations, one at a time, to determine status/control functions.

**Primary GNI (GNIP)**: The Ground Network Interface (GNI) within a GNI group that physically attaches to an ATN router and provides connectivity to the router for the rest of the GNI group, which are referred to as Secondary GNIs. Part of a VDL mode 3 network.

**Private Parameters**: The parameters that are contained in exchange identity (XID) frames and that are unique to the VHF digital link environment.

**Proposed Link (or proposed ground station)**: The link being negotiated (in a handoff) to replace the current link.

**Quality of Service**: The information relating to data transfer characteristics used by various communication protocols to achieve various levels of performance for network users.

**Real-Time**: When the delay in receiving transmitted digital information (latency) is tolerable compared to a human being's expectation of "instantaneous" transmission.

**Reed-Solomon Codes**: Error correction codes capable of correcting symbol errors.

**Requested Handoff**: The one-transmission process by which a station requests its peer entity to initiate a link handoff.

**Residual Packet Error Probability**: (Applicable to packet-mode data communications.) Defined by International Organization for Standardization (ISO) as the likelihood that a particular packet will be lost, duplicated or delivered incorrectly. An incorrectly delivered packet is one in which the user data are delivered in a corrupted condition (see Undetected Packet Error Probability), or the user data are delivered to an incorrect receiving user. The probability is estimated as the ratio of lost, duplicated, or incorrectly delivered packets to total packets transmitted by the system (or subsystem) during a measurement period. Packets lost due to error by the user are not included.

**Safety Service**: Any radio communication service used permanently or temporarily for the safeguarding of human life and property.

**Service Primitives**: The status and control information that must be available to the receiving entity to properly process incoming information. A service primitive may contain parameters. If parameters exist, they describe information that is defined either as mandatory (M) or optional (O) for conformance to a particular communications standard.

**Service Provider**: An entity at a layer that provides services to the layer above. These services are provided at service access points through the use of service primitives.

**Service User**: An entity at a layer that makes use of the services that are provided at service access points by the layer below through the use of service primitives.

**Silent Disconnect**: The disconnection of an existing link without sending of a DISC frame. Typically, this is performed when the peer entity can be assumed to have also disconnected the link by procedural means, such as expiration of a timer.

**Simplex**: Transmission or reception on a single frequency but not simultaneously.

**Slotted Aloha**: A media access control technique for multiple access transmission. A station can only transmit at the beginning of a time slot.

**Spurious Emissions**: Emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

**Squelch Window**: The time period a radio searches for the beginning of a message.

**Station** : A VDL-capable entity. A station may either be an aircraft station or a ground station. A station is a physical entity that transmits and receives frames over the air-ground interface and comprises, at a minimum: a physical layer, media access control sub-layer, and a unique DLS address.

**Stuck Microphone**: Transmitter operation when such operation is not intended.

**Subnetwork Connection**: A long-term association between an aircraft DTE and a ground DTE using successive virtual calls to maintain context across link handoffs.

**Subnetwork Connection Maintenance**: The process by which the VDL mode 2 SNDCF maintains subnetwork context from one subnetwork connection to the next during handoffs.

**Subnetwork Connection Management**: The process by which the VDL mode 2 SNDCF initially establishes a connection and then maintains it during handoffs.

**Subnetwork Dependent Convergence Function (SNDCF)**: A function that matches the characteristics and services of a particular subnetwork to those characteristics and services required by the internetworking process.

**Subnetwork Entity**: A subnetwork entity is a packet layer entity as defined in ISO 8208. In this document, the phrase "ground DCE" will be used for the subnetwork entity in a ground station communication with an aircraft; the phrase "ground DTE" will be used for the subnetwork entity in a ground router communication with an aircraft station; and, the phrase "aircraft DTE" will be used for the subnetwork entity in an aircraft communicating with the station.

**Subnetwork System Management Entity (SN\_SME)**: The main role of the SN\_SME is to generate events which advertise a change in the subnetwork connectivity.

**Subnetwork Layer**: The layer that establishes, manages, and terminates connections across a subnetwork.

**Switching Time**: In VDL Mode 3, the switching time is the time for a radio to switch from reception to transmission (R/T), or from transmission to reception (T/R). This time should be measured from the center of the last transmitted symbol to the center of the first symbol of the unique word of the received signal.

**Switched Virtual Circuit (SVC)**: When the aircraft desires to used then ATN then the aircraft establishes and maintains an ISO 8208 Switched Virtual Circuit (SVC) between the ground station and aircraft station.

**Symbol**: Element of modulation where a number of data bit patterns are mapped to defined phase changes for on-air transmission.

**System**: A VDL-capable system comprises one or more stations and the associated VDL mode 2 management entity. A system may either be an aircraft or a ground system.

**System Configuration**: Each VDL mode 3 system configuration defines the allocation of TDMA time slot resources to various user groups supported by one or more ground stations sharing the same 25 kHz VHF channel frequency.

**T**: The symbol period.

**TDMA Frame**: The basic unit of time in VDL mode 3 the Time Division Multiple Access (TDMA) scheme (120 ms), which consists of 3 or 4 time slots. In any voice communication, a radio will transmit digitized voice bits periodically once per frame.

**Time Slot**: A TDMA timing unit allocated for an M burst and V/D burst in VDL mode 3.

**Truncation**: A VDL mode 3 timing state where the aircraft timing uncertainty is such that the V/D (voice) burst duration is reduced to increase the guard time. The additional guard time provides more room for timing error without interfering with adjacent time slots.

**Undetected Packet Error Probability**: The likelihood that a packet delivered by the system (or subsystem) contains one or more erroneous data bits as compared with the data presented to the system. This is one component of Residual Packet Error Rate (see Residual Packet Error Probability). In practice, higher protocol layers, external to the system, can be employed to reduce significantly the probability of data error.

**Unicast**: A transmission addressed to a single station.

**Unwanted Emissions**: Consist of spurious emissions and out-of-band emissions.

**User Group**: A group of ground and/or aircraft stations which share voice and/or data connectivity. For voice communications all members of a user group can access all communications. For data, communications include point-to-point connectivity for air-to-ground messages, and point-to-point and broadcast connectivity for ground-to-air messages.

**User Group ID**: User Group ID, which is synonymous with Group ID, is a 2 bit code (at most A to D) that together with the channel frequency uniquely identifies the VDL Mode 3 circuit.

**V/D Burst**: A VDL mode 3 burst that is used for the transmission of a user's voice or data. V/D (voice) is used for voice transmission and V/D (data) is used for data transmission.

**VDL Management Entity (VME)**: A VDL-specific function that provides, inter alia, the quality of service requested by the ATN-defined SN\_SME. A VME uses the LMEs (that it creates and destroys) to negotiate the quality of service available from peer systems.

**VDL Mode 2**: A constituent mobile subnetwork of the Aeronautical Telecommunication Network (ATN) and IPS network and ACARS network. VDL Mode 2 was originally created for the ATN. Support for the ACARS Network was added later by defining ACARS Over AVLC (AOA). MASPS revision E added support for the IPS network. VDL Mode 2 operates in the aeronautical mobile VHF frequency band. VDL Mode 2 uses a Differential Eight Phase Shift Keyed (D8PSK) modulation scheme providing a 31.5 kbps data rate and uses a Carrier Sense Multiple Access (CSMA) media access control (MAC) protocol.

**VDL Mode 3**: A constituent mobile subnetwork of the ATN (operating in the aeronautical mobile VHF frequency band). VDL Mode 3 uses the D8PSK modulation scheme and the TDMA media access control (MAC) protocol. VDL Mode 3 allows for functionally simultaneous voice and data link.

**VHF Digital Link (VDL)**: Radio standards defined by ICAO.

**VDL Specific DTE Addressing (VSDA)**:The VDL mode 2 subnetwork specific ground DTE address (VSDA) is the binary representation of the ATN/OSI NET parameter (the facility is to convey the called address that was received from the ground station GSIF).

**Vocoder**: A low bit rate voice encoder/decoder.

**Vocoder Frame**: A window of time in which the analog speech waveform is used by the vocoder to process and generate the encoded digital voice output or to perform the reverse process to regenerate from a digital voice data block the corresponding analog speech waveform.

**Voice Analysis**: The process where speech is modeled and converted into parameters.

**Voice Synthesis**: The process where voice analysis parameters are used to generate speech.

**Voice Unit**: A device that provides a half duplex audio and signaling interface between the user and VDL mode 3 VDL.

1.1.3 Aeronautical VHF Communications Frequencies

The VHF band 117.975 - 137 MHz is allocated to Aeronautical Mobile (Route) Service (AM(R)S) on an exclusive basis. The lowest assignable frequency is 118 MHz and the highest is 136.975 MHz.

*Note: In the future, the allocation for AM(R)S may be extended down to 108 MHz.*

1.1.4 Spectrum Congestion

It has long been recognized that the civil aviation requirements for air-ground voice communications in the 117.975 - 137 MHz VHF band vary widely from region to region, just as the frequency and number of flights vary. It is becoming apparent that there is a shortage of assignable aeronautical VHF communications channels in some parts of the world. Shortages of communications channels could seriously affect the implementation of Air Traffic Services (ATS) communications and Aeronautical Operational Communications (AOC) enhancements needed to cope with current and projected air traffic communication needs. Studies are being conducted by ICAO and other agencies to improve the utilization of the 117.975 - 137 MHz VHF band to satisfy current and projected communications requirements.

1.1.5 Service Rules

The service rules for the use of 117.975 - 137 MHz Aeronautical Mobile (Route) Service are contained in Federal Communications Commission Rules Part 87 -- Aviation Services (47 CFR Part 87). General operating and flight rules are contained in the Federal Aviation Regulations (14 CFR Part 91). Rules pertaining to aeronautical VHF communications are established by the Federal Communications Commission (FCC) and the Federal Aviation Administration (FAA).

1.1.5.1 Federal Communications Commission (FCC)

FCC Rules Part 87 Subpart C (Sections 87.69 - 87.111) -- Operating Requirements and Procedures for the Aviation Radio Services addresses, among other things, maintenance tests, frequency measurements, and transmitter adjustments and test. Subpart D (Sections 87.131 - 87.187) -- Technical Requirements addresses power and emissions, frequency stability, bandwidth of emission, types of emission, emission limitations, modulation requirements, transmitter control requirements, acceptability of transmitters for licensing, and type acceptance of equipment.

1.1.5.2 Federal Aviation Administration (FAA)

Avionics units operating in the VHF AM(R)S air-ground communications frequency band, in general, meet the following Technical Standard Order (TSO) or satisfy the essential technical requirements of this TSO as required during the installation certification process: TSO-C169, VHF Radio Communication Transceiver Equipment Operating Within the Radio Frequency Range 117.975 - 137.000 MHz. This TSO requirement is based in large part on RTCA/DO-156 and RTCA/DO-157, *MOPS for Aircraft Radio Communications Equipment Operating within the Frequency Range 117.975 - 136.000 MHz*. Updates to TSO-C169 are based on RTCA/DO-186B, *MOPS for Aircraft Radio Communications Equipment Operating Within the Frequency Range 117.975 - 137.000 MHz*. FAA VHF air-ground transmitters must satisfy the following requirement: any spurious frequency emission are to be at least 80 dB below the carrier level of the subject transmission. Ground transmitter power can range from below 10 Watts to 50 Watts; the higher level is normally used only for service radii that are over 60 nautical miles, or in particularly difficult terrain.

1.2 VHF Voice and Data System Elements and Principles of Operation

The VHF Mode 2 digital communications system was developed to support bit-oriented air-ground data communications services. VDL Mode 2 was initially developed as a subnetwork for the Aeronautical Telecommunications Network (ATN). Subsequently, support for the ACARS network was added to VDL Mode 2 by the creation of AOA. Thus, VDL Mode 2 subnetwork augmented the existing ACARS subnetworks (VDL Mode 0/A (aka POA), SATCOM and HF datalink) and its superior performance allowed new uses of existing services such as domestic FANS 1/A.

ATN is based on the OSI architecture as defined in the ISO documents. VDL mode 2 supports the Aeronautical Telecommunications Network (ATN) and the bit oriented applications Contact Management (CM) and Controller Pilot Data Link Communication (CPDLC).

ACARS POA is a historical datalink system that has been in use since the late 1970s. The ACARS network protocols were derived from the teletype network used by operators at that time. The VHF air-ground subnetwork was constrained by the limitation of the analog VHF voice radios in use at that time. This VHF air-ground subnetwork came to known as mode 0 then mode A. The ACARS network expanded to include an ACARS SATCOM air-ground subnetwork and an ACARS HF air-ground subnetwork.

IPS…

The dynamic optimization of VDL mode 2 media specific parameters permits the optimization of the VDL mode 2 performance.

1.2.1 Principles of Operation for VHF Packet Data System Elements

VDL Mode 2 protocol is used to exchange bit-oriented data across an air-ground VHF data link. Accommodation of the VDL Mode 2 protocol by the ground network permits bit-oriented data transfer between the aircraft and the user host via the service provider’s ground network. Non-adaptive, p-persistent CSMA was chosen for VDL Mode 2. Selection of the best ground station for communication with the aircraft is negotiated by the ground network and the aircraft. Periodic uplink transmission of Ground Station Information Frames (GSIF), provides the data required by the avionics to manage its connection with the ground station and access the desired services (ATN/OSI, ACARS AOA, ATN/IPS).

system of systemssone or more link (e.g. ATN/OSI, ACARS AOA, ATN/IPS)VDL mode 2system

1.2.2 VDL mode 3 VHF Integrated Voice and Data System Elements

The principal elements of the VDL mode 3 VHF integrated voice and data system are: 1) preservation of essential capabilities of the current VHF analog voice system, such as "real-time" operation, the "party line", and air-to-air communications for certain applications; 2) solutions to present deficiencies, such as susceptibility to some forms of RF interference, lack of security, "step-on", the "stuck mic" problem, and occasional occurrences of unacceptable voice message integrity/quality; and 3) desirable future system features such as emergency access, integrated data communications, computer-assisted controller handoff, and automated frequency changes. VDL mode 3 uses a fundamental time division multiple access (TDMA) scheme which was selected as the one best suited to support the above voice system elements. Other multiple accessing schemes such as frequency division multiple access (FDMA) and code division multiple access (CDMA) were also considered but were rejected for reasons of higher system complexity and/or greater uncertainly in performance.

1.2.3 VDL Mode 3 VHF Integrated Voice and Data Principles of Operation

The VDL mode 3 integrated voice and data link system was designed to satisfy the future system requirements and desirable features identified in the RTCA SC-172 WG-1 report, published as DO-225, *VHF Air-Ground Communications System Improvements Alternatives Study and Selection of Proposals for Future Action*. This fully digital system provides functionally simultaneous access to voice and data link through the implementation of the TDMA system architecture. This architecture utilizes three or four time slots per 120 ms frame, each of which may be independently assigned to transmit voice or data. A full description of the VDL mode 3 TDMA architecture is found in Section 3.3.1.3. The voice portion of this architecture is meant to continually support real time capability. The vocoder operates at a channel nominal data rate of no more than 4800 bps including any error correction overhead inherent in the performance of the devices.

1.3 General Applications

1.3.1 Overview of Data Services

The data communication system used for air-ground data communication can be categorized into three main services:

* Air Traffic Services (ATS) communications
* Aeronautical Operational Communications (AOC)
* Aeronautical Administrative Communications (AAC)

The first two types are services for the safety and regularity of flight and must be accorded appropriate priority, as specified by FCC Part 87.265, whereas AAC messages are associated with management communications. Aeronautical Public Communications (APC) and Entertainment Services are prohibited in the VHF system.

1.3.2 Data Services

Rapidly increasing usage of air-ground data link has occurred and is expected to continue for all categories of data communications. For ATS applications, data communications is essential for the implementation of new communications/navigation/surveillance services and continued operation of existing communications/navigation/surveillance services which support Air Traffic Management (ATM) procedures. VDL mode 2 and VDL mode 3 both support data services. Only VDL mode 3 supports digital voice. There are some similarities and some notable differences between VDL mode 2 and 3.

1.3.2.1 Air Traffic Services (ATS) Communications

Air Traffic Services (ATS) communications encompasses a broad variety of safety communications required to support civil aviation system safety. These communications include Air Traffic Control (ATC) and Flight Information Services (FIS). Digital communications offer the potential to improve the capacity and capability of the communications system supporting ATS, thereby improving air traffic management efficiency and safety. Data link is expected to relieve congestion on existing voice radio channels while increasing the overall safety and productivity of the ATC system. Digital information transfer provides the ability to discretely address individual aircraft and to link the automated processes on the aircraft, particularly the flight management computer functions, with those on the ground. In addition to providing a means to exchange ATC data messages, air-ground data link is used for aircraft access to ground databases and the relay of air-derived data.

1.3.2.2 Aeronautical Operational Communications (AOC)

ICAO defines AOC as communications required for the exercise of authority over the initiation, continuation, diversion or termination of a flight in the interest of safety of the aircraft and the regularity and efficiency of a flight. AOC communications are characterized by messages exchanged between an aircraft and its operating agency. Examples of AOC messages include the following:

* Weather Information
* Flight Plan Data
* Weight and Balance Data
* Pilot/Dispatcher Communications
* Flight Progress Information
* Position Information/Flight Following
* Maintenance Communication
* Gate Assignment
* In-Flight Emergencies
* Airframe/Avionics Monitoring Data
* Engine Monitoring Data
* Departure Delay Information
* Special Medical Requests
* Out-Off-On-In (OOOI) Information
* Checklists

1.3.2.3 Aeronautical Administrative Communications (AAC)

AAC in the VHF band is only authorized in the domestic United States for data services in the AOC allotment. Aeronautical stations may transmit AAC messages on a secondary basis and AOC messages must be given absolute priority over AAC messages (47 CFR Section 87.265). Administrative communications must directly relate to the business of a participating aircraft operator in providing travel and transportation services to the flying public or to the travel, transportation or scheduling activities of the aircraft operator itself. Stations transmitting AAC must provide absolute priority for operational control and other safety communications by means of an automatic priority control system.

1.3.3 VDL mode 3 Digital Voice

Digital voice communication capability is a part of the VDL mode 3 system and **shall** satisfy the requirements for ATS and AOC services.

1.3.4 VDL Mode 3 Configuration Description

The VDL Mode 3 architecture provides the flexibility to accommodate a range of operational requirements through a set of predefined system configurations. In the Air Traffic Control (ATC) environment the airspace is divided into distinct sectors. All the users in a sector form a user group and maintain a degree of mutual connectivity. A user group normally includes a ground user (e.g., an air traffic controller) and the client aircraft of that ground user. The services provided to a particular user group depend on the requirements of the sector and the capabilities of the ground system.

To meet the required degree of flexibility, different configurations provide different mixes of voice and/or data capabilities. At any given time, different sectors can be supported by different configurations, and the configuration that applies in a particular sector is communicated to the aircraft radios through a beacon signal that is periodically broadcast by the ground station. It is expected that the configuration that applies to any given sector will be quasistatic and will not change often.

VDL mode 3 has 4-slot configurations and 3-slot configurations. The applicability of these two basic types is range dependent as indicated in Table 3-52. The 4-slot configurations provide guard time sufficient to allow interference-free communication for up to 200 nautical miles (NM). For longer range scenarios, the 3-slot configurations can be used. Each of the configurations occupies one or more time slots available within one 25 kHz frequency assignment. In the descriptions below the phrase “independent voice and data” implies that up or down link voice communication and up or down link data communication can be occurring simultaneously (on a single platform) with no mutual interference.

The 4-slot VDL mode 3 configurations are:

4V Provides a VDL mode 3 voice channel using 1 of the 4 time slots for each user group. A data capability is not provided. Can support up to 60 addressed aircraft per user group.

2V2D Provides independent VDL mode 3 voice and data channels using one dedicated time slot for voice and one dedicated time slot for data for each user group. Can support up to 120 addressed aircraft per user group.

3V1D Provides independent VDL mode 3 voice and data channels using one dedicated time slot for voice for each of the three user groups and a time slot shared by up to three of the user groups for data. Can support up to 60 addressed aircraft per user group.

3T Provides a channel supporting VDL mode 3 voice and data using all (4) time slots. This is primarily a data channel in which VDL mode 3 voice communication is treated on a nearly equal basis as data, i.e., real-time voice access is not provided. Can support up to 180 aircraft in one (large) group.

1V3D Provides independent VDL mode 3 voice and data using one time slot for VDL mode 3 voice and three time slots for data by a single user group. This is used to support sectors with more than 60 users that also require real-time voice service. Can support up to 240 addressed aircraft in one (large) user group.

The 3-slot VDL mode 3 configurations are:

3V Provides a VDL mode 3 voice channel using 1 of the 3 time slots for each user group. A data capability is not provided. Can support up to 60 addressed aircraft per user group.

2V1D Provides independent VDL mode 3 voice and data channels using one dedicated time slot for VDL mode 3 voice for each of the two user groups and a time slot shared by up to two of the user groups for data. Can support up to 120 addressed aircraft per user group.

3S Provides a single VDL mode 3 voice channel using all (3) time slots. A data capability is not provided. This is used to support very large sectors in which three ground stations are required to provide complete coverage. Can support up to 60 addressed aircraft for the user group.

2S1X Provides a single VDL mode 3 voice channel using 2 of the 3 time slots for one user group. The third time slot can be used to provide an independent channel for another user group. A data capability is not provided. This is used to support very large sectors in which two ground stations are required to provide complete coverage. Can support up to 60 addressed aircraft per user group.

1V2D Provides independent VDL mode 3 voice and data using one time slot for voice and two time slots for data by a single user group. This is used to support sectors with more than 60 users that also require real-time voice service. Can support up to 240 addressed aircraft in one (large) user group.

*Note: Overlapping sectors can use different* VDL mode 3 *configurations on the same 25 kHz frequency assignment provided that: (1) they all use either 3-slot or 4-slot configurations, (2) they don’t use the same time slots, and (3) they are geographically compact enough so that time slot boundaries are not violated. For example, a 2V2D sector using slots A and C can be collocated with a 4V sector using slot B and another 4V sector using slot D.*

1.4 System Interconnection and Routing

The VDL mode 2 system is used to provide authorized data Aeronautical Mobile Services between users in aircraft and users on the ground. The VDL mode 3 system is used to provide authorized data and voice Aeronautical Mobile Services between users in aircraft and users on the ground.

1.4.1 Data

#### 1.4.1.1 ATN/OSI Data

Figure 1-1 illustrates the connectivity for the users of ATN-compatible data services wherein the system is depicted as the Digital VHF Air/Ground Subsystem. Other subsystems required for end-user connectivity are the Aircraft User, Terrestrial, and Ground User Subsystems.

The ATN concept encompasses all avionics, air-ground and ground communications facilities that would provide packet-mode data services between aircraft mobile terminals and ground-based users. It is intended that these MASPS be consistent with ATN guidelines, to the extent that the reference points and interfaces correspond. It is expected that the system will support subnetwork specific data services as well. Anticipated applications include FIS broadcasts.

#### 1.4.1.2 ACARS Data

ARINC 618 illustrates the connectivity for the users of ACARS data services wherein the system is depicted as the analog VHF Air/Ground Subsystem. Other subsystems required for end-user connectivity are the Aircraft User, Terrestrial, and Ground User Subsystems as defined in ARINC 620.

The ACARS network concept encompasses avionics, air-ground and ground communications facilities that provide character oriented data services between aircraft mobile terminals and ground-based users.

#### 1.4.1.3 ATN/IPS Data

TBD illustrates the connectivity for the users of IPS-compatible data services wherein the system is depicted as the Digital VHF Air/Ground Subsystem. Other subsystems required for end-user connectivity are the Aircraft User, Terrestrial, and Ground User Subsystems as defined in TBD.

The IPS concept encompasses avionics, air-ground and ground communications facilities that would provide IPV6-based connectivity data services between aircraft mobile terminals and ground-based users. It is intended that these MASPS be consistent with the ATN/IPS guidelines, to the extent that the reference points and interfaces correspond. It is expected that the system will support subnetwork specific data services including subnetwork cyber security.

1.4.2 VDL mode 3 Voice

Figure 1-2 illustrates the connectivity for these users for VDL Mode 3 voice services.

1.5 System Integration Considerations

A VDL mode 2 digital system design capable of providing high performance data link allows a variety of ATS and AOC service provision arrangements to be implemented. A full digital data communication system provides the performance required for ATS datalink services. The ATS datalink services reduce the labor intensive and error prone task of VHF voice communication, while simultaneously reducing voice traffic.

A VDL mode 3 digital system design capable of providing both voice and data link on the same RF channel in a rapid sequential manner would allow a variety of ATS and AOC service provision arrangements to be implemented. A time division multiplexed system will satisfy a key design objective providing user access to both voice and data link capability. For example, a user with a single avionics unit could receive ATS voice and data link capabilities on a single RF channel. A full digital communications system could also allow automatic channel management to be accomplished from the ground. This would free the pilot from the labor intensive and error prone task of VHF communication channel tuning, while simultaneously reducing voice traffic.

1.6 VHF Datalink Back Ground and Overview

VHF radios are used extensively for voice and data communications. The voice signal-in-space is conventional double-sideband amplitude modulation (DSB-AM) with no carrier suppression.

Significant usage of data link over VHF channels appeared in the decade of the 1980's. Internationally recognized standards exist for Aircraft Communications Addressing and Reporting System (ACARS)[[1]](#footnote-1), and numerous service providers offer ground networks throughout the world. A form of minimum-shift keying (MSK) modulation is used (VDL mode 0 and A); however, full advantage of digital modulation is not realized because of the necessity of reducing the modulation to the audio baseband for interfacing with existing DSB-AM transmitters and receivers. This, coupled with the current VHF channelization, limits the channel data rate to approximately 4800 bps. ACARS POA VHF air/ground subnetwork operates at a channel data rate of 2400 bps. VHF communications, voice and data, operate in simplex fashion; i.e., alternately transmit and receive on the same frequency. VHF radios are the mainstay of aeronautical communications worldwide. Almost all civil aircraft, including the vast majority of the general aviation fleet, are equipped with at least one VHF voice radio.

VHF radio equipage is required of certain categories of aircraft, and of any aircraft type conducting particular operations in certain classes of airspace (for example, in Class B Airspace). VHF ground stations provide nearly complete coverage in most high-density regions of the world; nearly all commercial airports provide VHF radio services within their control zones. ACARS is a data link system which allows communication of character-oriented data between aircraft systems and ground systems. This communications facility enables the aircraft to operate as part of an airline's command, control and management system. The portion of the system incorporated by the service provider's ground network and the equipment on board the aircraft are required to facilitate the transfer of the messages. The ACARS service provider’s ground network comprises, as a minimum, an ACARS data link service processor and communications networks connecting the processor with the ground stations and ground users with the host system. The ground stations consist of a microcomputer connected to multiple VHF receivers and transmitters. The aircraft system consists of a Communication Management Unit (CMU) which interfaces with a VHF transceiver (either embedded, dedicated or multi-purpose), a control/display unit (either embedded, dedicated or multi-purpose), and any other equipment that supports or uses datalink, such as the Flight Management Computer (FMC), Digital Flight Data Acquisition Unit (DFDAU) or cockpit printer, just to name a few.

Several variations of avionics partitioning exist; from standalone (aka federated) avionics boxes to fully integrated avionics. The term CMU is used to refer to the datalink functions regardless of the hardware size or shape.

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Figure 1-1: End-to-End ATN/OSI Compatible Data System Structure



Figure 1-2: VDL Mode 3 End-to-End Voice Services System Structure

1.6.1 Propagation Characteristics of the VHF Band

The propagation characteristics of the VHF band restrict transmission and reception to essentially line-of-sight conditions. The maximum line-of-sight range for an enroute aircraft at an altitude of 30,000 feet is about 250 nautical miles. The radio range decreases at lower altitudes to a strictly localized coverage when the aircraft is on the ground. The normal index of refraction of the atmosphere is greater than unity, which extends the possible range of VHF transmissions most of the time. However, the refractivity varies widely, resulting in a significantly lower reliability of extended-range communications. The VHF radio channel is subject to slow and fast fading due to time varying multipath, obstruction of the radio line of sight, and changes in atmospheric conditions. The predominantly line-of-sight nature of VHF radio limits its use for air-ground and ground-air communications to airspace that can be served by land-based stations. Thus, coverage is limited to reasonably accessible over-land areas.

Substantial reuse of VHF frequencies is made possible by line-of-sight characteristics. The degree of reuse possible is one of the key indicators of a system's capacity. In the ATC environment, which essentially operates in real time, reuse distance for a given frequency depends on the dimensions of the service volumes established for each ground station and the co-channel interference criteria. The airspace within defined service volumes provides protection from undesired signals. Figure 1-3 shows the basic geometry used for two service volumes that reuse the same frequency. For a simplex system, reuse distance is dictated by air-to-air interference between aircraft in opposing service volumes when aircraft are at their worst case "critical points." Some co-channel interference can be tolerated because interference appears as a packet collision. The retry algorithms maximize the probability the collided packets are retransmitted and received properly.



Figure 1-3: Establishing VHF Frequency Reuse Distance

1.6.2 ACARS Network Overview

ACARS is an air-ground communications network operating in the VHF aeronautical band. The ACARS network consists of an aircraft subsystem and a ground station network. The ground network is connected with the networks of subscribers. With the support of the ground-based service provider's network, the aircraft part of the ACARS network enables equipment onboard an aircraft to function as a mobile communications terminal, performing as an integral part of a user's internal data communications system.

The format and protocols used to transfer messages between an ACARS user's ground system and the Data Link Service Provider's (DSP) network differs from the format and protocol used to exchange messages between the aircraft user and the DSP. The DSP provides translation between these formats and message routing as defined in ARINC 620.

The format used to transmit messages between the ACARS ground user and the ACARS ground network is referred to as Standard Message Text (SMT), which uses Standard Message Identifiers (SMI) and Text Element Identifiers (TEI). The DSP converts messages received from aircraft (downlink messages) into SMT format for consumption by the data link user and transfers them to their ultimate destinations. Similarly, the DSP converts messages received in SMT from the data link ground-based user into air-ground message formats having labels/sublabels and then pass the reformatted messages on to the aircraft user as defined in ARINC 618 and 620.

1.6.3 ATN/OSI Network Overview

ATN/OSI is an air-ground communications network operating in the VHF aeronautical band. The ATN/OSI network consists of an aircraft subsystem and a ground ATN/OSI network. The ground network is connected with the networks of ANSPs. With the support of the ground-based service provider's network, the aircraft part of the ATN/OSI network enables equipment onboard an aircraft to function as a mobile datalink communications terminal for the pilot to exchange datalink messages with the air traffic controller.

The format and protocols used to transfer messages between a ground ATN/OSI end system (e.g. air traffic control work station) and the aircraft ATN/OSI end system (e.g. CMU or FMC or equivalent) is defined in ICAO document 9880 and 9739 and related documents.

1.6.4 ATN/IPS Network Overview

ATN/IPS is an air-ground IP based communications network operating in the VHF aeronautical band. The ATN/IPS network consists of an aircraft subsystem and a ground ATN/IPS network. The ground network is connected with the networks of ANSPs. With the support of the ground-based service provider's network, the aircraft part of the ATN/IPS network enables equipment onboard an aircraft to function as a mobile datalink communications terminal for the pilot to exchange datalink messages with the air traffic controller.

The format and protocols used to transfer messages between a ground ATN/IPS end system (e.g. air traffic control work station) and the aircraft ATN/IPS end system (e.g. CMU or FMC or equivalent) is defined in ICAO document 9896 and related documents such as ARINC 858 Part 1 and ATN/IPS MASPS and profiles from RTCA/EUROCAE. ATN/IPS also introduces secure air-ground communications

2. Aviation User Requirements

This section contains the broad requirements of the aviation users for a the VHF aeronautical communications system.

2.1 System Users

The system is capable of supporting all categories of users including the following:

a. Scheduled air transport carriers (including international, trunk, regional, commuter and air freight carriers)

b. Non-scheduled air carriers

c. General aviation (including operators of turbine-powered and reciprocating engine aircraft)

d. Rotor wing aircraft (including helicopters and gyro craft)

e. Unpowered aircraft (including gliders and lighter-than-air)

f. Military aircraft

g. Certain ground and maritime vehicles (e.g., airport service vehicles, those vehicles coordinating in a search-and-rescue mission)

2.2 Aircraft Characteristics

The system is capable of operation with appropriately-equipped aircraft of all types, and all flight regimes including at rest.

There are no limitations imposed by the intrinsic characteristics of the ground system or the signal-in-space that limit suitable equipage of any type of aircraft, or for the following specific boundaries of flight conditions:

- Relative aircraft velocities ± 1,200 knots (two aircraft converging or diverging, each at 600 knots)

- Relative Ground speed 0 to 850 knots (600 knots aircraft speed plus 250 knots wind)

- Altitude Ground Level to 70,000 feet above MSL

*Note:*

*1. These do not include requirements for extremely high-speed aircraft (e.g., hypersonic transport).*

*2. Relative aircraft velocity is important for air-to-air communications among aircraft, for technical reasons (see Section 3.5.1.1).*

The VDL mode 2 system attempts to provide no less coverage to maneuvering aircraft (roll, pitch, and yaw) than the historical VHF system (VDL mode 0).

2.3 User Applications

The VDL mode 2 system should satisfy data communication requirements for use in any authorized category of communications service, including ATS, AOC, and AAC.[[2]](#footnote-2)

The VDL mode 3 system should satisfy voice (speech) and data communications requirements for use in any authorized category of communications service, including ATS, AOC, and AAC.[[3]](#footnote-3)

2.4 Availability and Integrity

2.4.1 Availability

The allocation of the availability and loss-of-service duration goals to the VHF system defined in this MASPS depends on the architecture and availability characteristics of the overall system and subsystems (see Figures 1-1 and 1-2).

*Note:*

*1. The service availability goal of the end-to-end communication system, of which the new system will be a part, is 0.99999 for voice service and 0.999 for data service. The goal for the duration of a single loss of service event in the end-to-end communications system is to be no more than 6 seconds. No single failure of equipment, system installation or facility will cause loss of service.*

*2. The VDL mode 3 system will provide voice services equivalent to current ATC services which, if lost, would prevent the exercise of control for safe separation of aircraft. In the United States, the requirements of the National Airspace System (NAS) document SR-1000 apply to the ground equipment, where the category of service is Critical.*

*3. The aircraft equipment is subject to availability and certification criteria that may differ from the above, and hence, is excluded from this paragraph.*

2.4.2 Integrity

The integrity of the system is expressed in terms of Residual Packet Error Probability for data communications, and speech transmission quality for voice communications.

The system should provide the following integrity of communications requirements in the subnetwork: For data, with a packet length of 128 octets in length, the residual packet error rate should be not greater than 10-6 in the to-aircraft direction, and not greater than 10-5 in the from-aircraft direction.

*Note 1: Residual packet error rate includes miss delivery and non-delivery. The from-aircraft residual packet error rate is dominated by packets that may not be delivered in a timely manner in the system aircraft-to-ground link. Of the aircraft-to-ground packets successfully delivered, the undetected packet error rate should be not greater than 10-6 at the MAC sublayer.*

Services requiring a greater degree of integrity can utilize additional error protection mechanisms; e.g., within the layers above the MAC sublayer of the protocol structure for data services.

For voice, the VDL mode 3 channel bit error rate should be not greater than 10-3.

*Note 2: It is expected that the codec(s) used for digitized voice transmission in the VDL mode 3 system will be qualified to provide acceptable voice quality when presented a radio frequency (RF) channel bit error rate not greater than 10 -3.*

2.4.3 Continuity of Function

Continuity of function is defined as the probability that a communication system will operate without unscheduled interruptions over a specified exposure time, given that the communication system was operational when the exposure time interval was initiated.

The determination of the exposure time and the continuity characteristics of the overall system and the allocation of those characteristics to the VDL mode 2 subsystem will be determined from the overall communication system requirements.

*Note: The continuity of function value for VDL mode 3 voice communications must be equivalent to that currently provided for ATC voice services.*

2.5 System Interoperability and Compatibility

The avionics equipment communicates with any compatible ground system.

The VHF system should be capable of implementation, installation and operation anywhere in the world.

The design of the VDL mode 3 system should include capabilities to assure coexistence with the present analog voice system. The two systems must coexist over a transition period from analog-to-digital operations without compromising either ATS or AOC voice communications requirements.

The system, VDL mode 2 and VDL mode 3, should support ATN compatible data services.

For VDL mode 3 digital voice operation, the system codec should be capable of meeting all the voice channel access, voice message length, and voice quality requirements imposed by ATS and AOC.

~~To accommodate existing aircraft VHF communications equipment for an indefinite transition period, no degradation of existing VHF services~~ **~~shall~~** ~~be caused by any element of the system.~~

2.5.1 Provision of VDL mode 3 Digital Voice and Data Link

The VDL mode 2 system is a data only system and does not support digital voice.

The VDL mode 3 system defines a mode of operation capable of satisfying voice and data link requirements in a functionally simultaneous manner on a single RF channel. ~~The ATS and AOC requirements do not have to be satisfied on the same RF channel~~. Functionally, simultaneous provision is interpreted to mean that the RF channel has the capability to provide the voice and data link communications in such a way that data and real time voice requirements are met.

2.5.2 Coexistence with Analog Voice

Analog voice will remain in the civil aviation system for many years to support the needs of many users. As these users are attracted to the benefits available in the VDL mode 3 digital system, it is expected that there will be a gradual transition from analog to digital operations. In the meantime, however, it is recognized that analog users may not invest in digital equipment until it is in their best interest to do so, e.g., until the cost-benefit tradeoff is acceptable, or until the investment required to accomplish their operational objectives is recognized.

2.6 Delay

The VDL Mode 2 transfer delay **shall** be measured between points B and C in Figure 1-1.

*Note:* *Supporting material can be found in Appendix A.*

2.6.1 VDL Mode 2

The VDL Mode 2 transfer delay **shall** not be greater than 3.5 seconds for the 95th percentile of the cumulative distribution.

*Note: There are at least six basic components that comprise the overall time delay, D, of a data packet in a point-to-point context. Namely: Receive/transmit turnaround time, packet transmission time, propagation time, processing time (including block interleaving and de-interleaving delays, coding and decoding delays, etc.), and access time which includes delays due to collisions with other packets in the transmission channel.*

2.6.2 VDL Mode 3

2.6.2.1 Data

As a design goal, high priority data messages of 192 application bits or less **shall** be delivered within one second with a probability of 0.95 and delivered within five seconds with a probability of 0.999.

2.6.2.2 VDL Mode 3 Voice

Total VDL Mode 3 voice delay **shall** be less than 236 ms between points B and C of Figure 1-2.

3. TECHNICAL CHARACTERISTICS

The primary impetus for the development of this MASPS was derived from the pressing needs of civil aviation for a higher throughput data mode and compatibility with the ATN. It was also necessary to consider compatibility with future digital voice techniques to satisfy "real time" requirements. Accordingly, technical characteristics have been included, which span a range of performance capabilities. These are embodied in Section 3 by two basic modes called VDL Mode 2 and VDL Mode 3.

VDL Mode 2 is oriented toward statistical sharing of a channel. Depending on the applications and requirements, statistical sharing results in efficient channel utilization. On the other hand, VDL Mode 3 is intended to provide a more deterministic service performance for time critical applications such as voice.

The same signal-in-space is used for both modes of operation provided implementation is in accordance with VDL Mode 2 and VDL Mode 3 described herein and with industry standards. The definition, description, and specification of both modes are expected to continue to evolve as the industry, providers, and users further collaborate on future system concepts and capabilities.

3.1 Modes of Operation

VDL Mode 2 is appropriate for aperiodic traffic where the entire message is ready before transmission of individual message packets begins. VDL Mode 2 is not suitable for real-time applications such as real-time digital voice. (See definition of real-time in Section 1.1.2.)

VDL Mode 3 provides datalink and real-time voice operation and is able to guarantee delivery time within the slot/frame structure provided.

3.2 VDL Mode 2

3.2.1 Physical Layer Protocols and Services

The aircraft radio and ground station radios access the physical medium operating in simplex mode.

3.2.1.1 Physical Layer Functions

The physical layer provides the following functions:

1. Transceiver (or where physically separate, transmitter and receiver) frequency control

2. Data reception by the transceiver or receiver

3. Data transmission by the transceiver or transmitter

4. Notification services

3.2.1.1.1 Transceiver Frequency Control

The VDL mode 2 physical layer sets the transceiver (or where physically separate, transmitter and receiver) frequency as commanded by the link management entity (LME).

*Note: The LME is a Link layer entity specified in Section 3.2.2.*

3.2.1.1.2 Data Reception by the Transceiver or Receiver

Signals received by the transceiver or receiver are decoded so that the signals may be accurately read at the higher layers.

3.2.1.1.3 Data Transmission by the Transceiver or Transmitter

The VDL mode 2 physical layer **~~shall~~** ~~appropriately~~ encodes the data received from the link layer and transmits it over the RF channel.

3.2.1.1.4 Notification Services

Signal quality analysis is performed by the demodulator evaluation process and receive evaluation process. The signal quality analysis results should be normalized on a scale of 0 to 15, where 0 to 3 is considered poor, 4 to 12 is adequate, and 13 to 15 is excellent. ARINC 750 defines one possible signal quality analysis.

*Note:*

*1. Processes that may be evaluated in the demodulator include BER, SNR, and timing jitter. Processes that may be evaluated in the receiver include received signal level and group delay.*

1. *Receive evaluation processes may be based on the received signal strength.*

3.2.1.2 Modulation Scheme

The signal-in-space for VDL Mode 2 is differentially encoded 8 phase shift keying (D8PSK), using a raised cosine filter with α = 0.6 (nominal value). The information to be transmitted **shall** be differentially encoded with 3 bits per symbol transmitted as changes in phase rather than absolute phase. The data stream to be transmitted **shall** be divided into groups of 3 consecutive data bits as described in Section 3.2.1.2.1. Zeros **shall** be padded to the end of the transmissions if needed for the final channel symbol.

The outputs of the baseband filters are applied to the inputs of ideal 4-quadrant multipliers whose RF inputs are driven in quadrature by RF at the desired transmitting frequency. The outputs of the two multipliers are summed in-phase to provide the transmitted signal. The resulting signal has eight equal amplitude states with an angular spacing of π/4 radians.

*Note 1: The above method describes a means of generating the desired signal-in-space. Other methods that provide equivalent results may be used.*

Because of amplitude variation of the composite signal, any amplification following the modulation process must be sufficiently linear so as to provide the adjacent channel performance in Section 3.2.1.10.3.

*Note 2: The above chosen for no more than 1 dB transmitter implementation loss.*

3.2.1.2.1 Data Encoding

A binary data stream entering a differential data encoder **shall** be converted into three separate binary streams X, Y, and Z so that bits 3n form X, bits 3n+1 form Y, and bits 3n+2 form Z. The triplet, or symbol, at time k (Xk, Yk, Zk) **shall** be converted to a change in phase as shown in Table 3-1, and the absolute phase φk is the accumulated series of Δφk, that is:

φk = φk-1 + Δφk

Table 3-1: Data Encoding

|  |  |  |  |
| --- | --- | --- | --- |
| **Xk** | **Yk** | **Zk** | **Δφk** |
| 0 | 0 | 0 | 0 π / 4 |
| 0 | 0 | 1 | 1 π / 4 |
| 0 | 1 | 1 | 2 π / 4 |
| 0 | 1 | 0 | 3 π / 4 |
| 1 | 1 | 0 | 4 π / 4 |
| 1 | 1 | 1 | 5 π / 4 |
| 1 | 0 | 1 | 6 π / 4 |
| 1 | 0 | 0 | 7 π / 4 |

*Note: See the ICAO Doc 9805, Manual on VDL Mode 3, Part 1- Implementation Aspects*.

3.2.1.2.2 Transmitted Signal Form

The phase-modulated baseband signal, as defined in Section 3.2.1.2.1, **shall** excite the pulse shape filter.

where:

*h*( ) is the complex impulse response of the pulse shape filter.

*k* is defined in paragraph 3.2.1.2.1.

*φk* is defined in paragraph 3.2.1.2.1.

t is time.

*Ts* is time duration of each symbol.

The output (function of time) of the pulse shape filter **shall** modulate the carrier frequency. The pulse shape filter **shall** have a nominal complex frequency response of a raised-cosine filter with rolloff factor α = 0.6.

The Error Vector Magnitude (EVM) of the transmitter output should be less than 6% rms, which corresponds to a transmitter implementation loss of approximately 1 dB.

3.2.1.2.3 Modulation Rate

The symbol rate **shall** be 10,500 symbols/sec ± 0.005%, resulting in a nominal bit rate of 31,500 bps.

3.2.1.2.4 Emission Designator

The emission designator of this modulation technique for CSMA is 14K0G1DE where:

14K is 14 kHz occupied bandwidth

G is Phase modulation

1 is Single channel digital with no modulating sub carrier

D is Data transmission

E is Multi-condition code

*Note: See the CFR (Code of Federal Regulations) 47 Part 2, Subpart C, Emissions, Sections 2.201 and 2.202.*

3.2.1.2.5 Pulse Shaping Filters

The frequency response of the raised-cosine baseband filter is:



and the impulse response of the raised-cosine filter is:

where *f* is the frequency offset from the channel center, Ts is the symbol period of 1/10500 sec (or approximately 95.2 µsec), and α is 0.6.

3.2.1.3 Training Sequence

Data transmission begins with a demodulator training sequence consisting of five segments:

* Transmitter power stabilization and Receiver AGC Settling
* Synchronization and ambiguity resolution
* Reserved symbol
* Transmission length
* Header FEC

*Note: Immediately after these segments there is an Aviation VHF Link Control (AVLC) frame with the format specified in 3.2.2.4.2.1.*

3.2.1.3.1 Transmitter Ramp-up and Power Stabilization

The purpose of the first segment of the training sequence, called the ramp-up, is to provide for transmitter power stabilization and receiver AGC settling and it **shall** immediately precede the first symbol of the unique word. The duration of the ramp-up **shall** be five symbol periods. However, to facilitate symbol measurement, the time reference point (t) for the following specification is the center of the first unique word symbol, which occurs ½ symbol period after the end of the ramp-up. Conversely stated, the beginning of the ramp-up starts at t = -5.5 symbol periods.

The transmitted power **shall** be less than –40 dBc prior to time t = -5.5 symbol periods. The ramp-up **shall** provide that at time t = -3.0 symbol periods the transmitted power is 90% of the manufacturer’s stated output power or greater. Regardless of the method used to implement (or truncate) the raised cosine filter, the output of the transmitter between times t = -3.0 and t = -0.5 will appear as if ‘000’ symbols were transmitted during the ramp-up period.

Figure 3-1 illustrates the transmitter ramp-up and power stabilization.

*Note:*

1. *For VDL Mode 3, the timing reference point is the same as the “Power Reference Point”.*
2. *It is desirable to maximize the time allowed for the AGC settling time. Efforts should be made to have power above 90% of nominal output power at t = -3.5 symbol periods.*

Figure 3-1: Transmitter Power Stabilization

3.2.1.3.2 Transmitter Power Ramp-Down

The transmitter power **shall** be below –20 dBc within 2.5 symbol periods of the middle of the final symbol of the burst.

The transmitter power leakage when the transmitter is in the “off” state **shall** be less than –83 dBm.

*Note: Reference DO-160G Section 21, category H for antenna radiated signals.*

3.2.1.3.3 Synchronization and Ambiguity Resolution

The second segment of the training sequence **shall** consist of the unique word:

000 010 011 110 000 001 101 110 001 100 011 111 101 111 100 010

and **~~shall~~**be transmitted from left to right.

3.2.1.3.4 Reserved Symbol

The third segment of the training sequence **shall** consist of a single symbol representing 000.

*Note: This field is reserved for future definition.*

3.2.1.3.5 Transmission Length

To allow the receiver to determine the length of the final Reed-Solomon (RS) block, the transmitter **shall** send a 17-bit word as the fourth segment, from least significant bit (LSB) to most significant bit (MSB), indicating the total number of data bits that follow the header FEC.

*Note: The length does not include those bits transmitted for: The Reed- Solomon FEC, extra bits padded so the interleaver generates an integral number of 8-bit words, or the extra bits padded so that the data encoder generates an integral number of 3-bit symbols.*

3.2.1.3.6 Header FEC

To correct bit errors in the header, a (25, 20) block code **shall** be computed over the reserved symbol, the transmission length segments and transmitted as the fifth segment. The encoder **shall** accept the header in the bit sequence that is being transmitted. The five parity bits to be transmitted **shall** be generated using the following equation:

[P1,..., P5] = [R1,..., R3, TL1,..., TL17] HT

Where:

P is the parity symbol. (P1 shall be transmitted first.)

R is the reserved symbol.

TL is the transmission length symbol.

T is the matrix transpose function.

H is the parity matrix defined below.

0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1

0 0 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1

H = 1 1 0 0 0 1 1 1 0 0 1 1 0 0 0 0 1 1 1 1

1 1 0 1 1 0 1 1 0 1 0 1 0 0 1 1 0 0 1 1

0 1 1 0 1 0 0 1 1 1 1 0 0 1 0 1 0 1 0 1

3.2.1.3.7 Bit Transmission Order

The five parity bits of the resultant vector product **shall** be transmitted from the left bit first.

3.2.1.4 Error Correction Encoding Techniques

3.2.1.4.1 Error Correction Encoding of Data

Forward Error Correction (FEC) coding is applied to the digital data communication traffic.

3.2.1.4.2 Error Detection Encoding of Data

Error detection encoding **is** achieved by the Cyclic Redundancy Check (CRC). A 16‑bit field is used for the CRC in each codeword. The generator polynomial (CRC-CCITT) for this code is g(x) = 1 + x5 + x12 + x16.

3.2.1.4.3 Forward Error Correction

In order to improve the effective channel throughput by reducing the number of required retransmissions, FEC **shall** be applied after the training sequence, regardless of the AVLC frame boundaries.

3.2.1.4.3.1 FEC Calculation

The FEC coding **shall** be accomplished by means of a systematic fixed-length Reed‑Solomon (255, 249) 28‑ary code.

*Note: This code is capable of correcting up to three octets for data blocks of 249 octets (1992-bits). Longer transmissions must be divided up into 1992-bit transmissions and shorter transmissions must be extended by virtual fill with trailing zeros. Six RS-check octets are appended for a total block of 255 octets.*

The field defining primitive polynomial of the code **shall** be as follows:

p(x) = (x8 + x7 + x2 + x + 1)

The generator polynomial for VDL Mode 2 only **shall** be as follows:

Where:

α is a primitive element of GF(256), and

GF(256) is a Galois field (GF) of size 256.

*Note:*

*1. The Reed-Solomon codes are described in the Recommendation for Space Data System Standards: “Telemetry Channel Coding," by the Consultative Committee for Space Data Systems.*

*2: See appendix D for more information on Reed- Solomon coding.*

3.2.1.4.3.2 Block Lengths

The six RS-check octets **shall** be calculated as described herein. The six RS-check octets are calculated on blocks of 249 octets. Longer transmissions **are** split into blocks of 249 octets, per Section 3.2.1.5. Blocks of shorter length **are** extended to 249 octets by a virtual fill of trailing zeroes. The virtual fill **is** not transmitted. Blocks **are** coded according to Sections 3.2.1.4.3.2.1 through 3.2.1.4.3.2.4.

3.2.1.4.3.2.1 No Error Correction

For blocks with 2 or fewer non-fill octets, no error correction **shall** be used.

3.2.1.4.3.2.2 Single-Byte Error Correction

For blocks with 3 to 30 non-fill octets, all six RS-check octets **shall** be generated, and only the first two octets transmitted. The last four RS-check octets are treated as erasures at the decoder.

3.2.1.4.3.2.3 Two-Byte Error Correction

For blocks with 31 to 67 non-fill octets, all six RS-check octets **shall** be generated, and only the first four transmitted. The last two RS-check octets are treated as erasures at the decoder.

3.2.1.4.3.2.4 Three-Byte Error Correction

For blocks with 68 or more non-fill octets, all six RS-check octets **shall** be generated and transmitted.

3.2.1.5 Interleaving

To improve the performance of the FEC, an octet based table-driven interleaver as defined herein is used. The interleaver **shall** create a table having 255 octets per row and c columns, where:

c = Ceiling [transmission\_length\_per\_Section\_3.2.1.3.5 / 1992 bits].

WAS: After extending the data to a multiple of 1992 bits, the interleaver **shall** write the transmission stream into the first 249 octets of each row by taking each consecutive group of eight bits and storing them from the first column to the 249th. The first bit in each group of eight bits **shall** be stored in the eighth bit position; the first group of 1992 bits **shall** be stored in the first row, the second group of 1992 bits in the second row, etc. After the FEC is computed on each row, the FEC data (or erasures) **shall** be stored in columns 250 through 255. The interleaver **shall** then pass the data to the scrambler by reading out column by column, skipping any octet that contains erasures or all fill bits. All of the bits in an octet **shall** be transmitted from bit 8 to bit 1.

**Proposed**: The interleaver **shall:**

1. Extend the data to a multiple of 1992 bits, and
2. write the transmission stream into the first 249 octets of each row by taking each consecutive group of eight bits and storing them from the first column to the 249th, and
3. The first bit in each group of eight bits **is** stored in the eighth bit position;
4. the first group of 1992 bits **is** stored in the first row, the second group of 1992 bits in the second row, etc. and
5. After the FEC is computed on each row, the FEC data (or erasures) **is** stored in columns 250 through 255. and
6. then pass the data to the scrambler by reading out column by column, skipping any octet that contains erasures or all fill bits. and
7. All of the bits in an octet **are** transmitted from bit 8 to bit 1.

On reception, the de-interleaver **shall** calculate the number of rows and size of the last (potentially partial) row from the length field in the header and only pass valid data bytes to the higher layer.

The maximum value of (c) **is** 66.

3.2.1.6 Bit Scrambling

To aid clock recovery and to stabilize the shape of the transmitted spectrum, bit scrambling **shall** be applied. The pseudo noise (PN) sequence **shall** be a 15 - stage generator (see Figure 3-2) with the characteristic polynomial:

X15 + X + 1

The PN-sequence **shall** start after the frame synchronization pattern with the initial value 1101 0010 1011 001 with the left-most bit in the first stage of the register per Figure 3-2. After processing each bit, the register **shall** be shifted one bit to the right.

The sequence **shall** be added (modulo 2) to the data at the transmit side (scrambling) and to the scrambled data at the receive side (descrambling) per Table 3-2.



Figure 3-2: PN Generator for BIT Scrambling Sequence

Table 3-2: Scrambler Functions

|  |  |  |
| --- | --- | --- |
| **Function** | **Data in** | **Data out** |
| Scrambling | Clean data | Scrambled data |
| Descrambling | Scrambled data | Clean data |

*Note:*

1. *The concept of a PN scrambler is explained in the International Radio Consultative Committee (CCIR) Report 384-3, Annex III, Section 3, Method 1.*

*2. See Appendix E for a VDL Mode 2 message example.*

3.2.1.7 Channel Sensing

For the purposes of channel sensing, all signal levels are referenced to the receiver input. This allows a Systems Planner to predict performance in a given environment.

3.2.1.7.1 Channel Busy to Idle Detection

When a station receives on-channel power of at least minus 95 dBm ±2 dB for at least 5 ms without detecting a sync sequence and successfully decoding the header, then the station **shall**:

1. With a likelihood of 0.9, continue to consider the channel occupied if the signal level is attenuated to below minus 100 dBm ±2 dB for less than 1 ms; and
2. With a likelihood of 0.9, consider the channel unoccupied if the signal level is attenuated to below minus 100 dBm ±2 dB for at least 1.5 ms

If a station has received a sync sequence and successfully decoded the header, it **shall** not consider the channel idle until the recovered transmission length has expired, even if the RF signal drops below the RF sense level during this period.

If processing the existing signal is abandoned because the receiving station begins processing a stronger signal per Section 3.5.1.4.1 then the receiving station **shall** update the recoveredtransmission length with the transmission length of the stronger signal and process the stronger signal.

If a receiving station is processing a signal and a newer, weaker signal per Section 3.5.1.4.1 is received during the older, stronger signal then the receiving station

**shall** continue to process the older stronger VDL mode 2 signal.

*Note:*

1. *The maximum link throughput available to all users is highly sensitive to the RF channel sense delay (from the time when the channel actually changes state until a station detects and acts on that change) and RF channel seizure delay (from the time when a station decides to transmit until the transmitter is sufficiently ramped up to lock out other stations). Accordingly, it is imperative that all efforts are made to reduce those times as the state-of-the-art advances.*

3.2.1.7.2 Channel Idle to Busy Detection

With a likelihood of at least 0.9, a station **shall** consider the channel occupied within 1 ms after on-channel power rises to at least minus 98dBm ±2 dB.

*Note:*

*1. The goal to detect an occupied channel is detection within 0.5 ms.*

*2. A higher probability of false alarm is acceptable on the idle-to-busy detection than the busy to idle detection because of the effects of the two different errors.*

*3. Provision should be made for possible future incorporation of adjustable channel sense decision powers in the range of ± 5dB of the default values to allow for system optimization on individual platforms.*

**3.2.1.8 Physical Layer System Parameter**

The parameter P1 is the maximum transmission length that a receiver is capable of demodulating without degradation of BER. Maximum transmission length **shall** be 131,071 bits.

3.2.1.9 Receiver/Transmitter Interactions

Refer to Figure 3-3 for turnaround requirements.

3.2.1.9.1 Receive to Transmit Turnaround Time

A station **shall**transmit the training sequence such that the center of the first symbol of the unique word is transmitted within 1.25 ms after the result of an access attempt is successful. The maximum frequency change over the sync preamble **shall** be 100 Hz. This gives a spread of 3.4 degrees over the synchronization sequence. The frequency over the transmission should stay within the ± 5 ppm limits. The frequency has to be measured by averaging over a 10 ms time period. The frequency **shall** change at a rate of no more than 1000 Hz per second, to allow a frequency-tracking loop in the receiver to keep the frequency error at the demodulator sufficiently small. See Figure 3-3.

*Note:* *As an example, a phase acceleration of 1000 Hz per second corresponds to 60 Hz sidebands at a level of –33 dBc. Shorter-term frequency variations are covered by the transmitter phase-error specification.*

3.2.1.9.2 Transmit to Receive Turnaround Time

A station **shall** be capable of receiving and demodulating, with nominal performance, an incoming signal within 1.5 ms after transmitting the final information symbol. See Figure 3-3.

**Ready to Receive**

**1%**

**Center of First Symbol of Unique Word**

**CSMA Access Attempt**

**(Successful)**

**90%**

**Power**

**CSMA Access Attempt**

**(Unsuccessful)**

**Received Carrier**

**.286 ms**

**-100 dBm**

**Transmitter**

**at -40 dBc**

**.238 ms**

**TM1**

**Other Transmission**

**1.5 ms**

**1.25 ms**

**2.75 ms + TM1**

Transmit to Receive Requirements

**1.5 ms**

**.238 ms**

**Center of Final Information Symbol**

Receive to Transmit Requirements

Figure 3-3: Turnaround Time

3.2.1.10 Transmission Characteristics

3.2.1.10.1 Carrier Frequencies

The system **shall** be capable of operating on 25 kHz center frequencies in the 117.975 MHz to 137 MHz frequency band.

3.2.1.10.2 Spurious Emissions

Spurious emissions (see Section 1.1.2 for definition) are usually in accordance with the Code of Federal Regulations, Title 47 (47 CFR), Federal Communications Commission.

*Note: The FCC spurious emissions requirement of -40 dBc may not protect GPS navigation receivers on the same aircraft from harmful interference because more than 100 dB of additional attenuation is required. Of particular concern are VHF 12th and 13th harmonics (especially 121.150, 121.175, 121.2, 131.2, 131.25, and 131.3 MHz). Spurious emissions from the VHF antenna and from the VHF box itself can be a problem. Additional filtering and shielding may be required to protect navigation receivers on the same aircraft. Intersystem electromagnetic compatibility issues are beyond the scope of this document at this time.*

3.2.1.10.3 Adjacent Channel Emissions

The RF power measured over a 16 kHz channel bandwidth centered on the first adjacent channel **shall** not exceed minus 18 dBm.

The RF power measured over a 25 kHz channel bandwidth centered on the first adjacent channel **shall** not exceed plus 2 dBm.

The RF power measured over a 25 kHz channel bandwidth when centered on either the second adjacent channel or the third adjacent channel **shall** not exceed minus 28 dBm.

The RF power measured over a 25 kHz channel bandwidth centered on the fourth adjacent channel **shall** not exceed minus 38 dBm.

Beyond the fourth adjacent channel, the RF power measured in a 25 kHz channel bandwidth **shall** reduce at a minimum rate of 5 dB per octave from the fourth adjacent channel on, to a maximum value of minus 53 dBm.

*Note: The adjacent channel power requirements apply over the entire 117.975 to 137 MHz VHF band*.

The adjacent channel specifications of this section **shall** be met over normal VDL mode 2 operating conditions, including transmitter attack and decay transients occurring at the beginning and end of VDL mode 2 bursts.

3.2.2 VDL Mode 2 Link Layer Protocols and Services

3.2.2.1 Structure

The VHF Digital Link (VDL) Mode 2 link layer provides the following sublayer functions:

1. A Media Access Control (MAC) sublayer which requires the use of the carrier sense multiple access (CSMA) algorithm

2. A Data Link Service (DLS) sublayer, providing connection-oriented point-to-point links using Data Link Entities (DLE) and a connectionless broadcast link over the MAC sublayer

3. A VDL mode 2 Management Entity (VME), which establishes and maintains DLEs between aircraft radio and ground stations using Link Management Entities (LME)

3.2.2.2 Service

3.2.2.2.1 Connection-Oriented

The VDL mode 2 link layer provides a reliable point-to-point service using a connection-oriented DLS sublayer.

3.2.2.2.2 Connection-Less

The VDL mode 2 link layer provides an unacknowledged broadcast service using a connectionless DLS sublayer.

3.2.2.3 MAC Sublayer

The MAC sublayer performs the transparent acquisition of the shared communications path. It makes invisible to the DLS sublayer the way in which supporting communications resources are utilized to achieve this.

*Note: The service specification for the MAC sublayer is modeled on the MAC Service Definition (ISO DP 10039).*

3.2.2.3.1 MAC Services

3.2.2.3.1.1 Multiple Access

The MAC sublayer **shall** implement a non-adaptive p-persistent CSMA algorithm to equitably allow all stations the opportunity to transmit while maximizing system throughput, minimizing transit delays, and minimizing collisions.

3.2.2.3.1.2 Channel Occupancy

The maximum channel occupancy time of a station is limited by the window size, data rate, and maximum frame size. A VDL Mode 2 station **shall** be able to hold the channel for the time required to transmit k - 1 maximum size data frames at the current data rate.

*Note: See Section 3.2.2.4.3.7 for definition of k.*

3.2.2.3.1.3 Channel Congestion

The MAC sublayer **shall** notify the VME sublayer whenever channel congestion is detected. (See Section 3.2.2.3.2.2)

3.2.2.3.2 MAC Service System Parameters

The MAC service **shall** implement the system parameters defined in Table 3-3.

Table 3-3: MAC Service System Parameters

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Symbol** | **Parameter Name** | **Lower Bound** | **Upper Bound** | **Default** | **Increment** |
| TM1 | Inter-access Delay | 0.5 msec | 125 msec | 4.5 msec | 0.5 msec |
| TM2 | Channel Busy | 6 sec | 120 sec | 60 sec | 1 sec |
| p | Persistence | 1/256 | 1 | 13/256 | 1/256 |
| M1 | Maximum Number of Access Attempts | 1 | 65535 | 135 | 1 |

3.2.2.3.2.1 Timer TM1 (Inter-access Delay Timer)

The TM1 timer **shall** be set to the time (TM1) that a MAC sublayer waits between consecutive access attempts as specified in Section 3.2.2.3.3.2. Timer TM1 is managed as specified in section 3.2.2.3.3.2.

3.2.2.3.2.2 Timer TM2 (Channel Busy Timer)

The TM2 timer **is** set to the maximum time (TM2) that a MAC sublayer will wait after receiving a request to transmit. Timer TM2 **shall** be started, if it is not already running, when the MAC sublayer receives a request for transmission. Timer TM2 **shall** be canceled upon a successful access attempt as specified in Section 3.2.2.3.3.2 . When timer TM2 expires, the VME **shall** be informed that the channel is congested.

3.2.2.3.2.3 Parameter p (Persistence)

The parameter *p* (0 < *p* ≤1) **shall** be the probability that the MAC sublayer will transmit on any access attempt (see Section 3.2.2.3.3.2).

3.2.2.3.2.4 Counter M1 (Maximum Number of Access Attempts)

The M1 counter **shall** evaluate the maximum number of attempts (M1) that a MAC sublayer will make for any transmission request. This counter **shall** be reset upon: system initialization, Timer TM2 expiring, or a successful access attempt. The counter **shall** be adjusted after every unsuccessful access attempt. When the value of the counter indicates M1 limit has been reached (M1 unsuccessful access attempts have occurred without the counter being reset), authorization to transmit **shall** be granted as soon as the channel is idle.

3.2.2.3.3 Description of MAC Procedures

3.2.2.3.3.1 Channel Sensing

Before performing an access attempt (see Section 3.2.2.3.3.2), the MAC sublayer **shall** verify that the channel is idle.

3.2.2.3.3.2 Access Attempt

An access attempt is defined as the MAC layer determining whether the transmitter should be immediately enabled, with probability *p*. The result of an access attempt will be either *successful* or *unsuccessful*. If the access attempt is successful, then the transmission **shall** immediately begin.

An access attempt **shall** be made when Timer TM1 expires and the channel is idle or when a transmission request arrives from the DLS while the channel is idle or if the channel is determined to become idle while a message is queued for transmission.

3.2.2.4 Data Link Service Sublayer

The DLS **shall** support bit-oriented simplex air/ground (A/G) communications using the Aviation VHF Link Control (AVLC) protocol specified in this section.

*Note: The DLS is derived from HDLC, as specified by ISO 3309, ISO 4335, ISO 7809, and ISO 8885. Any definitions of service are derived from the OSI Data Link Service Definition ISO 8886.3. AVLC is a variant of HDLC and derived from, but is not fully specified by, options 1, 3.2, 4, 7, and 12 of ISO 7809. Explicit references to these documents are made later in this section.*

3.2.2.4.1 Services

*Note: In this section, the specific functions of the DLS are described with no reference to service primitives used for these functions. The link layer service primitives and protocol state machine are described in the ICAO Doc 9776, Manual on VDL Mode 2, Part 1- Implementation Aspects.*

3.2.2.4.1.1 Frame Sequencing

The receiving DLS sublayer **shall** discard duplicate frames.

The transmitting and receiving DLS sublayers work together in an attempt to deliver every frame at least once over a point-to-point connection.

*Note: Sequence numbers are included in the frame format to facilitate this service.*

3.2.2.4.1.2 Error Detection

The DLS sublayer **shall** discard frames that fail the Frame Check Sequence (FCS).

*Note: FCS is included in the frame format to facilitate this service.*

3.2.2.4.1.3 Station Identification

The receiving DLS sublayer **shall** only pass frames to the upper layers that are addressed to it.

*Note: Unique source and destination addresses are included in the frame format to facilitate this service.*

3.2.2.4.1.4 Broadcast Addressing

VDL Mode 2 supports broadcast addressing.

3.2.2.4.1.5 Data Transfer

Data **is** transferred in the information fields of VDL mode 2 INFO, UI, and XID frames, per ISO 7809. The receiving link layer **shall** be able to receive the largest packet size allowed by the maximum value of N1 (16504 bits per Table 3-7).. The ground station link layer **shall** limit the frame size of uplink frames to the current value of the parameter N1-Uplink.

The aircraft link layer **shall** limit the frame size of downlink frames to the current value of parameter N1-Downlink. The value of parameter N1-Downlink can change dynamically. The aircraft link layer **shall** detect changes in the value of N1-Downlink and adjust the size of downlink frames to stay within the frame size indicated by parameter N1-Downlink.

One and only one data link user packet **shall** be contained in an INFO or UI.

*Note: AOA places some additional requirements on frame size. See section 3.2.6. The aircraft link layer is not required to use the full downlink frame size when the value of parameter N1 Downlink is greater than 2008 bits. However, the aircraft is still required to be able to receive a maximum size uplink frame.*

3.2.2.4.2 AVLC Data Link Service Protocol Specification

3.2.2.4.2.1 Frame Format

AVLC frames **shall** conform to ISO 3309 frame structure except as specified in Figure 3-4.

A station **shall** limit a single physical layer transmission to a maximum of 4 frames, with a single flag separating each frame.

*Note 1: This requirement applies to ground stations and avionics equipment classes 1, 2, 3 and 4 as defined in DO-281/ED-92.*

A station **shall** be able to receive and process at least 4 frames (which can be a combination of frame types for one or more aircraft) in a single physical layer transmission.

*Note 2: If the station receives a single physical layer transmission that contains more than 4 frames, then the receiving station might not process the received signal within the allocated time.*

3.2.2.4.2.2 Address Structure

The address field **shall** consist of eight octets. As described in ISO 3309, option 7, the least significant (first transmitted) bit of each octet **shall** be reserved for address extension. When set to binary 0 it **shall** indicate that the rest of the following octet is an extension of the address field. The presence of binary 1 in the first transmitted bit of the address octet **shall** indicate that the octet is the final octet of the address field.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | First Bit Transmitted  MSB **Bit Number** ↓ LSB | | | | | | | |
| **Description** | **Octet No.** | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| Flag | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| Destination  Address Field | 1 | d22 | d23 | d24 | d25 | d26 | d27 | A/G | 0 |
| 2 | d15 | d16 | d16 | d18 | d19 | d20 | d21 | 0 |
| 3 | d8 | d9 | d10 | d11 | d12 | d13 | d14 | 0 |
| 4 | d1 | d2 | d3 | d4 | d5 | d6 | d7 | 0 |
| Source  Address Field | 5 | s22 | s23 | s24 | s25 | s26 | s27 | C/R | 0 |
| 6 | s15 | s16 | s17 | s15 | s19 | S20 | s21 | 0 |
| 7 | s8 | s9 | s10 | s11 | s12 | s13 | s14 | 0 |
| 8 | s1 | s2 | s3 | s4 | s5 | s6 | s7 | 1 |
| Link Control Field | 9 |  |  |  | P/F |  |  |  |  |
| Information Field | N-2 | USER  DATA | | | | | | | |
| Frame Check  Sequence | N-1 | fcs9 | fcs10 | fcs11 | fcs12 | fcs13 | fcs14 | fcs15 | fcs16 |
| N | fcs1 | fcs2 | fcs3 | fcs4 | fcs5 | fcs6 | fcs7 | fcs8 |
| Flag | N+1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |

Figure 3-4: Link Layer Frame Format

Defined: A/G - Air/Ground bit

C/R - Command/Response bit

P/F - Poll/Final bit

3.2.2.4.2.3 Address Fields

The address field **shall** contain a destination address field and a source address field. The destination address field **shall** contain a destination DLS address or a broadcast address. The source address field **shall** contain a DLS address. There is a status bit in the source address and a status bit in the destination address field, which are set by the transmitting station to reflect status information. The status bits and address details are defined in Sections 3.2.2.4.2.3.1 to 3.2.2.4.2.3.7.

*Note: See the ICAO Doc 9776, Manual on VDL Mode 2, Part 1- Implementation Aspects for information on address fields.*

3.2.2.4.2.3.1 Air/Ground Status Bit

The status bit in the destination address field (bit 2, octet 1) **shall** be the Air/Ground (A/G) bit. The A/G bit **shall** be set to 0 to indicate that the transmitting station is airborne. The A/G bit **shall** be set to 1 to indicate that the transmitting station, either fixed or mobile, remains on the ground. The default value for the A/G bit **shall** be 0 for aircraft that do not provide this information at the link level. The A/G bit value **shall** be 1 for ground stations.

3.2.2.4.2.3.2 Command/Response Status Bit

The status bit in the source address field (bit 2, octet 5) is the Command/Response (C/R) bit. The C/R bit **shall** be set to 0 to indicate a command frame, and set to 1 to indicate a response frame.

3.2.2.4.2.3.3 Data Link Service Addresses

The DLS address **shall** be 27 bits divided into a 3-bit type field and a 24‑bit station specific address field.

3.2.2.4.2.3.4 Address Type

The address type field **shall** be set as defined in Table 3-4.

Table 3-4: Address Type Field Encoding

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Description Type** | **Type Field** | | | **Station Specific Address Field** |
|  | **27** | **26** | **25** |  |
| Reserved | 0 | 0 | 0 | Future use |
| Aircraft | 0 | 0 | 1 | 24-bit ICAO address |
| Reserved | 0 | 1 | 0 | Future use |
| Reserved | 0 | 1 | 1 | Future use |
| Ground Station | 1 | 0 | 0 | ICAO-administered address space |
| Ground Station | 1 | 0 | 1 | ICAO-delegated address space |
| Reserved | 1 | 1 | 0 | Future use |
| All stations broadcast | 1 | 1 | 1 | All stations |

3.2.2.4.2.3.5 Aircraft Specific Addresses

The aircraft specific address field **shall** be the 24-bit ICAO aircraft address.

3.2.2.4.2.3.6 ICAO-Administered Ground Station Specific Addresses

The ICAO-administered ground station specific address consists of a variable-length country code prefix (using the same country codes assignment defined in ICAO Annex 10, Volume III, Chapter 9, Appendix 1, Table 1 to the convention) and a suffix. The appropriate authority assigns the bits in the suffix.

3.2.2.4.2.3.7 ICAO-Delegated Ground Station Specific Addresses

The ICAO-delegated ground station specific address **is** determined by the organization to which the address space is delegated.

3.2.2.4.2.4 Broadcast Address

The broadcast address **shall** be used only as a destination address for unnumbered information (UI) frames or for XID frames broadcasting ground station information.

3.2.2.4.2.4.1 Encoding

The Type Field of broadcast addresses **shall** be encoded as shown in Table 3-5.

Table 3-5: Broadcast Address Encoding

|  |  |  |
| --- | --- | --- |
| **Broadcast Destination** | **Type Field**  **27 26 25** | **Station Specific Address Field** |
| All aircraft | 0 0 1 | All ones |
| All ground stations of a particular provider | 1 0 0  or  1 0 1 | Most significant bits: Variable length provider code.  Remaining bits. All ones |
| All ground stations with ICAO-administered addresses | 1 0 0 | All ones |
| All ground stations | 1 0 1 | All ones |
| All stations | 1 1 1 | All ones |

*Note: "All ground stations" refers to the ground station with ICAO administered addresses and those of a particular provider and "All stations" refers to both "All aircraft" and "All ground stations".*

3.2.2.4.2.4.2 Erroneous Transmission

The aircraft station **shall** prohibit the transmission of any VDL mode 2 frame when the 24-bit ICAO aircraft address is configured with the all ones broadcast address.

3.2.2.4.2.4.3 Erroneous Reception

The ground station **shall** discard without response any received VDL mode 2 frames containing a 24-bit source address of all ones.

3.2.2.4.2.5 Link Control Field

The basic repertoire of commands and responses for AVLC are detailed in Table 3-6 and **shall** be encoded per ISO 4335.

3.2.2.4.2.6 Information Field

The information field of an SREJ **shall** be as defined in Section 3.2.2.4.10.2. The information field of an XID **shall** be as defined in Section 3.2.2.5.2. The information field of all other frames **shall** be as defined in ISO 4335.

Table 3-6:  AVLC Commands and Responses

|  |  |
| --- | --- |
| **Commands** | **Responses** |
| INFO [Information] | INFO |
| RR [Receive Ready] | RR |
| XID [Exchange Identity] | XID |
| TEST | TEST |
| SREJ [Selective Reject] | SREJ [Selective Reject] |
| FRMR [Frame Reject] | UA [Unnumbered Acknowledgment] |
| UI [Unnumbered INFO] | UA [Unnumbered Acknowledgment] |
| DISC [Disconnect] | DM [Disconnected mode] |

3.2.2.4.3 Data Link Service (DLS) System Parameters

The parameters needed by the DLS sublayer are listed in Table 3-7 and their use is detailed in Sections 3.2.2.4.3.1 through 3.2.2.4.3.7. DLS parameter values **shall** be set using XID frames. DLS parameter **shall** be encoded as defined in ISO 4335.

Table 3‑7:  Data Link Service System Parameters

| ***Symbol*** | ***Parameter Name*** | | ***Lower Bound*** | ***Upper Bound*** | ***VDL***  ***Mode 2 Default*** | ***Increment*** |
| --- | --- | --- | --- | --- | --- | --- |
| *T1min* | *Delay before retransmission* | *Minimum* | *0 s* | *20 s* | *1 s* | *1 ms* |
| *T1max* |  | *Maximum* | *1 s* | *20 s* | *15 s* | *1 ms* |
| *T1mult* |  | *Multiplier* | *1* | *2.5* | *1.45* | *0.01* |
| *T1exp* |  | *Exponent* | *1* | *2.5* | *1.7* | *0.01* |
| *T2* | *Delay before ACK* | | *25 ms* | *10 s* | *500 ms* | *1 ms* |
| *T3min* | *Link Initialization Time* | *Minimum* | *5 s* | *25 s* | *6 s* | *1 ms* |
| *T3max* |  | *Maximum* | *1 s* | *20 s* | *15 s* | *1 ms* |
| *T3mult* |  | *Multiplier* | *1* | *2.5* | *1.45* | *0.01* |
| *T3exp* |  | *Exponent* | *1* | *2.5* | *1.7* | *0.01* |
| *T4* | *Max delay between transmissions* | *aircraft* | *1 min* | *1440 min* | *20 min* | *1 min* |
| *T4* | *Max delay between transmissions* | *ground* | *3 min* | *1442 min* | *22 min* | *1 min* |
| *N1* | *Maximum number of bits in any frame* | | *1144 bits* | *16504 bits* | *8312 bits* | *1 bit* |
| *N2* | *Maximum number of transmissions* | | *1* | *15* | *6* | *1* |
| *k* | *Window Size* | | *1 frame* | *4 frames* | *4 frames* | *1 frame* |

3.2.2.4.3.1 Timer T1 (Delay Before Retransmission)

The T1 timer **shall** be set to the time that a DLE will wait for an acknowledgment before retransmitting an INFO, RR (P=1), SREJ (P=1), or an FRMR frame.

The value of Timer T1 **shall** be computed by the following formula:

Timer T1 = T1min + 2T1int + 2TD99 + min(U(x),T1max)

Where:

TD99 = (TM1\*M1)/(1-u)

and is the running estimate for the 99th percentile transmission delay (between the time at which the frame is sent to the MAC sublayer and the time at which its transmission is completed).

u is a measurement of channel utilization with a range of value from 0 to 0.99, with 0.99 corresponding to a channel that is 99 percent or higher occupied.

*U(x)* is a uniform random number generated between 0 and x.

*x* = T1mult\* TD99 \*T1expretrans

*retrans* is the largest retransmission count of all of the outstanding frames.

T1int is the propagation delay between the VDL mode 2 mode components in the CMU and the VDL mode 2 mode components in the VDR. This term was added to the equation in the Manual on VDL mode 2 because the Manual on VDL mode 2 does not take the CMU-VDR interface into consideration. If T1min is set to a small value and the channel loading is very light it is possible to calculate a T1 value that is smaller than the propagation delays between the CMU and VDR. T1int includes the estimated ARINC 429 access delay, file transfer time and ARINC 429 receive processing delay. T1int is set to 0.5 seconds.

Timer T1 **shall** be started after any INFO, RR (P=1), SREJ (P=1), or FRMR frame is queued for transmission unless it is already running. If the timer expires, all outstanding INFO, RR (P=1), SREJ (P=1), or FRMR frames that have been queued for at least T1min + 2TD99 **shall** be retransmitted. The timer **shall** be canceled upon receipt of an acknowledgment.

After processing an acknowledgment or Timer T1 expires, Timer T1 **shall** be restarted if there are still frames outstanding. Whenever the T1 timer is restarted, the timer **shall** be set as if it had been started when the oldest outstanding frame was queued.

*Note: There is one Timer T1 per DLE.*

3.2.2.4.3.2 Parameter T2 (Delay Before Acknowledgment)

Parameter T2 defines the maximum time allowed for the DLE to respond to any received frame (other than an XID) in order to maximize the probability that the response is received before the peer DLE's Timer T1 expires.

A DLE **shall** respond to any received frame (other than an XID) within parameter T2 time in order to in order to maximize the probability the response is received before the peer DLE's Timer T1 expires.

*Note: The period T2 should be a delay (shorter than the T1min value of the peer DLE) to permit the acknowledging DLE to schedule the response as an event in normal data processing and to allow sufficient time for an acknowledgment while maximizing the likelihood that an INFO frame will be transmitted and eliminate the need for an explicit acknowledgment.*

3.2.2.4.3.3 Timer T3 (Link Initialization Time)

Timer T3 **shall** be set to the time that a DLE waits for an XID response before retransmitting an exchange identification command (XID\_CMD).

The period of the Timer T3 **shall** be computed by using a similar algorithm and parameters as Timer T1 with appropriate substitutions for T3min, T3max, T3multi and T3exp. T3min **shall** be separately negotiated. XID\_CMDs (except for ground station information frames) shall be retransmitted using the procedures defined in Section 3.2.2.4.3.1.

*Note:*

*1. There is one Timer T3 per DLE.*

*2. T3min must be greater than T1min to allow the responding entity time to coordinate the response and perform any additional initialization processing.*

3.2.2.4.3.4 Timer T4 (Maximum Delay Between Transmissions)

Timer T4 **shall** be set to the maximum delay between transmissions (T4). Timer T4 **shall** be started or restarted on queuing or requeuing a frame for transmission. Timer T4 **shall** never be canceled.

If a DLE does not receive a frame before Timer T4 expires, it **shall** send a command frame (P=1) to command a response from the peer DLE. When in the asynchronous balanced mode (ABM), the DLE **shall** send a receive ready frame (RR). When in the sent selective reject mode (SRM), the DLE **shall** send a selective reject frame (SREJ). When in the frame reject mode (FRM), the DLE **shall** send a frame reject frame (FRMR).

The value of Timer T4 **shall** be at least two minutes longer for a ground DLE than for the peer aircraft DLE. The command frame **shall** be transmitted using normal Timer T1 procedures up to N2 times. If no response is received, the DLE **shall** assume that the link is disconnected and invoke link recovery procedures.

*Note:*

*1. Timer T4 is used to verify the continued existence of the link.*

*2. There is one Timer T4 per DLE.*

*3. A DLE in the ABM or SRM should send any outstanding frames with the P bit of the last INFO frame set to 1.*

3.2.2.4.3.5 Parameter N1-Uplink, N1-Downlink (Maximum Number of Bits of any Frame)

Parameter N1-Uplink defines the maximum number of bits allowed in any uplink frame (excluding flags and zero bits inserted for transparency) that a ground DLS **shall** accept from the ground DLS User. Parameter N1-Uplink defines the maximum number of bits that a ground DLS **shall** encode in any uplink frame (excluding flags and zero bits inserted for transparency).

Parameter N1-Downlink defines the maximum number of bits allowed in any downlink frame (excluding flags and zero bits inserted for transparency) that a DLS **shall** accept from the aircraft DLS User. Parameter N1-Downlink defines the maximum number of bits that an aircraft DLS **shall** encode in any downlink frame (excluding flags and zero bits inserted for transparency).

3.2.2.4.3.6 Counter N2 (Maximum Number of Transmissions)

Counter N2 defines the maximum number of transmissions that the DLS performs for an outstanding AVLC frame that requires acknowledgement. Each AVLC frame that requires acknowledgement **shall** have its own instance of Counter N2. Counter N2 **shall** be set to zero when a new frame is ready for transmission. Counter N2 **shall** be incremented after each transmission of the frame until Counter N2 reaches the maximum number of attempts (value of parameter Counter N2). The counter **shall** be cleared after its associated frame is acknowledged or the maximum value is reached.

When Timer T1 expires, a DLE **shall** invoke the retransmission procedures of Section 3.2.2.4.3.1 up to N2 - 1 times.

When Timer T3 expires, a DLE **shall** invoke the retransmission procedures of Section 3.2.2.4.3.3 up to N2 - 1 times.

When Counter N2 reaches the maximum number of attempts (value of parameter N2) the LME **shall** be informed, and the transmission of the frame terminated.

*Note:*

*1. ~~There is one Counter N2 per an unacknowledged frame~~.*

*2. The value of the ground N2 parameter may be different from the value of the aircraft N2 parameter.*

3.2.2.4.3.7 Parameter k (VDL 2 Window Size)

Parameter k **shall** be set to the maximum number of outstanding sequentially numbered INFO frames that may be transmitted before an acknowledgment is required.

*Note: The value of the ground k parameter may be different from the value of the aircraft k parameter.*

3.2.2.4.4 Description of Procedures

Except as noted in Sections 3.2.2.4.5 through 3.2.2.4.10, the standard procedures described in ISO 4335 and ISO 7809 **shall** be followed.

3.2.2.4.5 Modes of Operation

The only modes of operation that a DLE **shall** support are detailed below.

3.2.2.4.5.1 Operational Mode

The operational mode **shall** be Asynchronous Balanced Mode (ABM).

3.2.2.4.5.2 Non-operational Mode

The non-operational mode **shall** be Asynchronous Disconnected Mode (ADM).

*Note: Among the reasons a DLE or LME enters the non-operational mode include issuing or receiving any of the following frames: DISC, XID\_CMD\_LCR, DM, or XID\_RSP\_LCR. Abbreviated frame names are defined in Tables 3-6 and 3-14.*

3.2.2.4.5.2.1 DISC Frame

If a DLE is unable to continue to receive, it **shall** transmit a DISC to terminate the current link. The P bit **shall** be set to 0 in DISC commands. A DLE **shall** treat all received DISCs (regardless of the P bit) as a DISC (P=0).

*Note 1: The use of a DISC command may result in the loss of unacknowledged data.*

An aircraft transmitting or receiving a DISC frame **shall** initiate either link establishment on one LME if no links remain or handoff.

*Note 2: If an LME is in the process of executing a handoff, it will retransmit the XID\_CMD\_HO (P=1) and wait for the Timer T3 to expire.*

3.2.2.4.5.2.2 DM Frame

If a DLS receives any valid unicast frame, except for an XID or TEST frame, from a DLS with which it does not have a link, it **shall** respond with a DM frame. All DM frames **shall** be transmitted with the F bit set to 0.

An aircraft transmitting or receiving a DM frame **shall** initiate link establishment on one LME if no links remain. A DLE **shall** treat all received DMs (regardless of the F bit) as a DM (F=0).

If an LME is in the process of executing a handoff, it shall retransmit the XID\_CMD\_HO (P=1) and wait for the Timer T3 to expire.

*Note:*

*1. ~~If an LME is in the process of executing a handoff, it will retransmit the XID\_CMD\_HO (P=1) and wait for the Timer T3 to expire.~~*

*2. A station receiving an invalid frame may choose to discard the frame instead of responding with a DM.*

*3. The procedures for an LME receiving a unicast XID from an LME with which it does not have a link are found in Section 3.2.2.5.4.*

3.2.2.4.5.2.3 Frame Reject Mode

When in ABM or SRM, and after transmitting a FRMR command, the DLE **shall** enter the frame reject mode (FRM). The DLE **shall** reenter the ABM or SRM only after it receives a UA (F=1) frame.

3.2.2.4.5.2.4 Sent Selective Reject Mode

When in ABM, and after transmitting a SREJ, the DLE **shall** enter the sent selective reject mode (SRM). The DLE **shall** re-enter the ABM only after it receives the missing INFO frames or a Handoff is completed.

3.2.2.4.6 Use of the P/F Bit

The use of the P/F bit **shall** follow the procedures detailed in ISO 4335, except as modified by Sections 3.2.2.4.6.1 through 3.2.2.4.6.3.

3.2.2.4.6.1 General

When a DLE receives a command frame with the P bit set to 1, the F bit **shall** be set to 1 in the corresponding response frame. The C/R bit in the address field **shall** be referenced to resolve the ambiguity between command and response frames.

3.2.2.4.6.2 INFO Frames

After receiving an INFO frame, a DLE **shall** generate an acknowledgment, within T2 seconds after detecting the end of transmission. If a valid INFO (P=1) is received, the response **shall** be either an RR (F=1) or SREJ (F=1). If a valid INFO (P=0) is received, the response **shall** be either a RR (F=0) or SREJ (F=0) or INFO (P=0).

*Note: The only time an RR or an SREJ frame should be transmitted with P = 1 is when T4 expires. The only time that an INFO frame should be transmitted with P=1 is either when T4 expires or the transmit window has closed.*

3.2.2.4.6.3 Unnumbered Frames

The P bit **shall** be set to 0 for UI and DISC frames. The F Bit **shall** be set to 0 for DM frames. Therefore, a response (e.g., UA) **shall** not be expected, and if received, **shall** be treated as an error.

3.2.2.4.7 Unnumbered Command Frame near simultaneous reception

When command frame near simultaneous reception occurs at two stations, the station that has precedence **shall** discard the received frame from its peer station. The peer station **shall** respond as if it had never sent the command frame.

3.2.2.4.7.1 DLE Procedures

While waiting for a response to an unnumbered command frame (i.e., FRMR), a DLE whose DLS address is lower than its peer DLE **shall** have precedence.

3.2.2.4.7.2 LME Procedures

An aircraft LME that supports optional Broadcast Handoff and receives a Broadcast Handoff **shall** process it regardless of what XID\_CMD it is waiting for a response. An aircraft LME that does not support optional Broadcast Handoff and receives a Broadcast Handoff, then the aircraft LME **shall** ignore the Broadcast Handoff without sending a response.

When XID\_CMD\_HO, except Broadcast handoff, is transmitted by both the ground and the airborne systems such that reception is nearly simultaneous, the hand-off command sent by the aircraft **shall** have precedence except as noted herein. A ground LME sending an XID\_CMD (P=1) **shall** have precedence over an aircraft LME sending an XID\_CMD (P=0). Otherwise, an LME whose DLS address is lower than its peer LME **shall** have precedence.

Proposal: When XID\_CMD\_HO, except Broadcast handoff, is transmitted by both the ground and the airborne systems such that reception is nearly simultaneous, then the hand-off command sent by the aircraft **shall** have precedence except when the hand-off command sent by the ground station is XID\_CMD (P=1) which has precedence over an aircraft LME sending an XID\_CMD (P=0). ~~Otherwise, an LME whose DLS address is lower than its peer LME~~ **~~shall~~** ~~have precedence~~.

*Note:*

1. *When the aircraft detects a ground station with coverage at its destination airport, then the destination airport ground station should be given preference when signal strength, flight path and other conditions indicate that a reliable link with the destination ground station is likely. Flight data shows that it is difficult to predict reliability of a link with a ground station. It should be noted that the aircraft can begin its descent near the RF boundary of the destination airport and care should be taken to prevent the handoff from occurring too early and the aircraft flying “under” the coverage of the destination airport.*

1. *Broadcast Handoff support is optional for aircraft.*

3.2.2.4.8 XID Frame

The XID frame **shall** be used for the LME to establish and maintain a link as defined in Section 3.2.2.5. The originator of an XID\_CMD (P = 1) frame **shall** retransmit the XID upon expiration of the Timer T3 whenever no response has been received. The receiving LME **shall** use the XID sequence number and retransmission field to differentiate a retransmission from a new XID; however, no meaning **shall** be attached to a missing XID sequence number. An LME **shall** send the exact **same** XID\_RSP to every retransmission of an XID\_CMD, unless it intends to change the link status via an XID\_CMD (\_HO, or \_LCR).

*Note: The procedures for retransmission for XID\_CMD (P=0) is a local ground system implementation matter.*

**3.2.2.4.8.1 Unrecognized parameters**

Receiving stations **shall** disregard any unrecognized XID parameters carried in an XID frame. Receiving stations **shall** process the remainder of the frame as if the unrecognized parameters had not been present. This provision is to facilitate introduction of additional XID parameters which may be needed in the future, without disruption to existing avionics or ground systems.

**3.2.2.4.8.2 Missing parameters**

Receiving stations **shall** continue to process an XID frame in the event that a parameter that is designated Mandatory, in accordance with Tables 3-48a, b and c, for a particular message is not present in the frame. This provision is to facilitate introduction of additional XID parameters which may be needed in the future, without disruption to existing avionics or ground systems.

*Note: It is recognized that the lack of key information in a parameter may limit the processing of an XID frame.*

3.2.2.4.9 Broadcast

Only XID\_CMDs or UIs **shall** be broadcast. The P/F bit **shall** be set to 0 (no acknowledgment) for broadcast frames.

3.2.2.4.10 Information Transfer

Except as noted below, the procedures for information transfer **shall** be specified by ISO 4335 and ISO 7809.

3.2.2.4.10.1 Transmission Queue Management

When the DLS sublayer has frames to transmit, it **shall** wait for the MAC sublayer to authorize transmission. Two transmit queues **shall** be maintained, one for supervisory and unnumbered (XID, FRMR, TEST, DISC, DM, RR, SREJ) frames and the other for information frames (INFO and UI). While waiting for authorization to transmit, the DLS sublayer **shall** update the transmit queues, eliminating certain frames as specified in Sections 3.2.2.4.10.1.1 through 3.2.2.4.10.1.2. If all of the frames on the DLS transmit queues are eliminated, then the authorization to transmit **shall** be ignored.

3.2.2.4.10.1.1 Eliminate Redundant Frames

At most, one RR, SREJ, DM, FRMR, or retransmitted INFO (of a given sequence number) **shall** be queued in response to a transmission. Superseded frames in the transmit queue **shall** be deleted (e.g., an INFO frame queued in response to a T1 timeout and then queued in response to receiving a SREJ).

If any INFO frame is received from the peer DLE, the DLS sublayer **shall** update the N(r) of all numbered frames addressed to that DLE in the transmit queue.

To eliminate unnecessary retransmission, if any numbered frame is received from the peer DLE, all frames in the transmit queue that it acknowledges shall be deleted. If an XID\_CMD from a peer LME with a lower-DLS address or an XID\_RSP is received from a peer LME, any XID\_CMDs in the transmit queue for that LME shall be deleted

*Note:*

*1. ~~To eliminate redundant frames, superseded frames in the transmit queue should be deleted (e.g., an INFO frame queued in response to a T1 timeout and then an SREJ).~~*

*2. ~~If any INFO frame is received from the peer DLE, the DLS sublayer should update the N(r) of all numbered frames addressed to that DLE in the transmit queue, thus improving the probability of the acknowledgment arriving~~.*

*3. ~~To eliminate unnecessary retransmission, if any numbered frame is received from the peer DLE, all frames in the transmit queue that it acknowledges should be deleted. If an XID\_CMD from a peer LME with a lower-DLS address or an XID\_RSP is received from a peer LME, any XID\_CMDs in the transmit queue for that LME should be deleted~~.*

3.2.2.4.10.1.2 Procedures for Transmission

Supervisory frames have higher priority than the information frames, so supervisory and unnumbered (XID, FRMR, TEST, DISC, DM) frames **shall** be transmitted in preference to information frames.

On transmission of an INFO frame, the DLE shall piggyback any queued RR and delete the RR so as to avoid transmitting the RR as a separate frame.

A station receiving a FRMR, DISC, or DM frame shall delete all outstanding traffic for the transmitting DLE as it would not be accepted if transmitted.

All unicast frames in the transmit queue shall be deleted after the radio supporting this transmit queue is retuned as the intended station cannot receive the transmission.

*~~Note:~~*

*~~1. On transmission of an INFO frame, the DLE should piggyback any queued RR so as to avoid transmitting the RR as a separate frame.~~*

*~~2. A station receiving an FRMR, DISC, or DM frame should delete all outstanding traffic for the transmitting DLE as it would not be accepted if transmitted.~~*

*~~3. All unicast frames in the transmit queue should be deleted after the radio supporting this transmit queue is retuned as the intended station cannot receive the transmission.~~*

3.2.2.4.10.2 SREJ Frame

The multi-selective reject option in ISO 4335 **shall** be used to request the retransmission of more than one INFO frame. The SREJ (F=0) frame **shall** be generated only after receipt of an out-of-order INFO (P=0) frame. The SREJ (F=1) shall be generated only after receipt of an INFO (P=1), RR (P=1) or SREJ (P=1). The SREJ (P=1) frame shall be generated only in accordance with the procedures of Section 3.2.2.4.3.4. A DLE **shall** acknowledge those frames which were received correctly but out of order by including in the SREJ information field an octet with bits 6-8 set to the INFO frame's sequence number and bit 1 set to 1. Although the F bit may be set to 0, the SREJ frame **shall** always acknowledge INFO frames up to N(r)-1 (where N(r) is the value in the control field).

*Note: AVLC has extended the standard ISO 4335 SREJ functionality to selectively acknowledge frames. In ISO 4335, the octets in the information field which were requesting retransmission of frames had bit position 1 set by default to 0.*

3.2.2.4.10.3 FRMR Frame

If a DLE receives an illegal frame (as defined by ISO 4335), it **shall** transmit a FRMR (P=1) to reset the link (e.g., state variables, timers and queues). A DLE, on receiving or transmitting a UA (F=1), **shall** reset the link (no XID exchange required). A DLE **shall** use the normal T1 and N2 procedures during the FRMR/UA exchange. A DLE transmitting the FRMR **shall** also retransmit the FRMR either upon expiration of Timer T4 or upon receipt of any frame other than a UA (F=1). A DLE receiving an illegal FRMR **shall** either discard the frame or treat it as a valid FRMR.

3.2.2.4.10.4 UA Frame

The UA frame **shall** be used only to acknowledge a FRMR.

3.2.2.4.10.5 UI Frame

UI frames **shall** be used solely to support connectionless data transfer required to provide broadcast services.

3.2.2.4.10.6 TEST Frame

The TEST command/response exchange is included in AVLC to allow a station to perform a loopback test using logic that is isolated from the normal frame processing. Initiating the exchange of Test frames is optional. If a TEST frame is received then a TEST frame **shall** be sent in response.

The TEST command can be used to cause the addressed station to respond at the

first response opportunity. An information field is optional with the TEST command. If the received TEST command contains an information field, the received information field **shall** be returned in the TEST response.

The TEST frame process can be executed by any station in any operational or non-operational state. For example, even if the aircraft has not executed a link establishment with a ground system, a ground station transmitting a TEST command will expect a response from that aircraft. The TEST command will have no effect on the mode or sequence variables maintained by the transmitting and responding stations.

*~~Note: The TEST command/response exchange has been included in AVLC to allow a station to perform a loopback test using logic that is isolated from the normal frame processing~~.*

3.2.2.5 VDL mode 2 Management Entity (VME)

3.2.2.5.1 VME Services

The services provided by VME are link provision and link change notifications.

3.2.2.5.1.1 Link Provision

A VME **shall** have an LME for each peer LME. Hence, a ground VME shall have an LME per aircraft and an aircraft VME shall have an LME per ground system. An LME **shall** establish a link between a local DLE and a remote DLE associated with its peer LME. A ground LME **shall** determine if an aircraft station is associated with its peer aircraft LME by comparing the aircraft address; two aircraft stations with identical aircraft addresses are associated with the same LME.

An aircraft LME **shall** determine if a ground station is associated with its peer ground LME by bit-wise logical ANDing the DLS address with the station ground system mask provided by the peer ground LME; two ground stations with identical masked DLS addresses are associated with the same LME.

Each aircraft and ground LME **shall** monitor all transmissions from its peer's station(s) to maintain a reliable link between some ground station and the aircraft while the aircraft is in coverage of a ground station.

*Note: If an aircraft receives a frame from a ground station, one and only one LME will process and react to that frame. Thus, the qualifying phrase "from a ground station associated with its peer LME" will not be included and should be understood to be implied.*

3.2.2.5.1.2 Link Change Notifications

The VME **shall** notify the intermediate-system system management entity (IS-SME) of changes in link connectivity by supplying information contained in the XID frames received.

3.2.2.5.2 Exchange Identity (XID) Parameter Formats

In the tables included in the subsections to this section, the following order is implied:

a. Bit order in each parameter value **is** indicated by subscript numbers. Bit 1 indicates the least significant bit.

b. Bits **shall** be transmitted octet by octet, starting with the parameter ID. Within each octet, the right most bit (as shown in the tables) **shall** be transmitted first.

*Note:*

*1. The tables are divided into three major columns that define the field name, the bit encoding and brief explanatory notes.*

*2. Requirements for the use of the parameters defined in the following sections are defined in Section 3.2.2.5.4.*

3.2.2.5.2.1 Parameter Encoding

The XID information field **shall** be encoded per ISO 8885 and may include the parameters described in Sections 3.2.2.5.2.2 to 3.2.2.5.2.7.

3.2.2.5.2.2 Public Parameters

XID parameters **shall** be encoded as defined in ISO 8885, with the addition of the private parameter data link layer subfield as defined in ISO 8885. The format identifier (hexadecimal 82) **shall** be used (per ISO 4335.2, Annex C) to identify the public parameter list identified in ISO 8885. The VDL mode 2 **shall** use the public parameter group ID of hexadecimal 80 to negotiate the common HDLC parameters. The public parameter set ID **shall** be included in XID frames if other public parameters are included. If other public parameters are not included then the public parameter set ID **shall** be excluded in XID frames.

*Note: ISO 8885 defines certain public parameters as receive and transmit which are referred to herein as uplink and downlink respectively.*

3.2.2.5.2.2.1 HDLC Public Parameter Set Identifier

The HDLC Public parameter set **is** identified by the ISO IA5 character string "8885:1993" and **shall** be encoded per Table 3-8 when sent. The HDLC parameter set **is** identified by the ISO IA5 character string "8885:1993" and **shall** be decoded per Table 3-8 when received. Parameter HDLC Public Parameter Set Identifier **shall** be included as the first public parameter whenever any other public parameter(s) are sent per ISO 8885.

Table 3-8: HDLC Public Parameter Set Identifier

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |  |
| Parameter length | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |  |
| Parameter value | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | character '8' |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | character '8' |
| 0 | 0 | l | l | 1 | 0 | 0 | 0 | character '8' |
| 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | character '5' |
| 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | character ':' |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | character '1' |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | character '9' |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | character '9' |
| 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | character '3' |

3.2.2.5.2.2.2 Timer T1 Parameter

Timer T1 parameter defines the values that **shall** be used in the calculation of downlink Timer T1 performed by the aircraft DLE. The values **shall** be defined in units of milliseconds for T1min and T1max and in hundredths of seconds for T1mult and T1exp. The timer values **shall** be encoded as 4 unsigned 16-bit integers per Table 3-9:

*Note: Refer to Table 3-9 for more information on Timer T1 parameters.*

Table 3-9:  Timer T1 Parameter

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |  |
| Parameter length | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |  |
| Parameter value | l16 | l15 | l14 | l13 | l12 | l11 | l10 | l9 | (T1min) |
| l8 | l7 | l6 | l5 | l4 | l3 | l2 | l1 |  |
| u16 | u15 | u14 | u13 | u12 | u11 | u10 | u9 | (T1max) |
| u8 | u7 | u6 | u5 | u4 | u3 | u2 | u1 |  |
| m16 | m15 | m14 | m13 | m12 | m11 | m10 | m9 | (T1mult) |
| m8 | m7 | m6 | m5 | m4 | m3 | m2 | m1 |  |
| e16 | e15 | e14 | e13 | e12 | e11 | e10 | e9 | (T1exp) |
| e8 | e7 | e6 | e5 | e4 | e3 | e2 | e1 |  |

3.2.2.5.2.3 VDL mode 2 Private Parameters

The parameter identifier fields **shall** allow simple identification of the purpose of the parameter as defined in Table 3-10:

Table 3-10: VDL mode 2 Private Parameter Identification

|  |  |  |
| --- | --- | --- |
| **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 |

3.2.2.5.2.4 General Purpose Information Private Parameters

Both aircraft and ground LMEs use general purpose information private parameters to transfer basic information to each other.

*Note: ISO 8885 defines the group identifier of the private parameter function to be the hexadecimal value F0.*

3.2.2.5.2.4.1 VDL mode 2 Private Parameter Set Identifier

The VDL mode 2 Private Parameter set identifier **shall** be by the ISO IA5 character capital 'V' encoded per Table 3-11. The VDL mode 2 Private Parameter set identifier parameter **shall** be included as the first private parameter sent per ISO 8885 whenever any of the private parameters are to be sent.

Table 3-11: Private Parameter Set Identification

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |  |
| Parameter value | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | Character V |

3.2.2.5.2.4.2 Connection Management Parameter

The Connection Management parameter defines the type of XID sent and the connection options negotiated for that particular link. The Connection Management parameter **shall** be included in XID frames sent during link establishment and ground initiated ground station handoff per Tables 3-12, 3-13, and 3-14. An LME **shall** set the reserved bits to 0 on transmission. An LME **shall** ignore the value of the reserved bits on receipt.

Table 3-12: Connection Management Parameter

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Parameter value | 0 | 0 | 0 | 0 | v | x | r | h |

Table 3-13: Connection Management Parameter Values

| **Bit** | **Name** | **Encoding** | |
| --- | --- | --- | --- |
| 1 | h | h = 0 | No link currently established. |
|  |  | h = 1 | Link currently established. |
| 2 | r | r = 0 | Link connection accepted. |
|  |  | r = 1 | Link connection refused. |
| 3 | x | x = 0 | Only VDL-specific ground DTE addresses. |
|  |  | x = 1 | Ground network DTE addresses accepted. |
| 4 | v | v = 0 | Expedited subnetwork connection not supported |
|  |  | v = 1 | Expedited subnetwork connection supported. |
| 5-8 | Reserved | Set to 0 |  |

Table 3-14: Abbreviated XID Names

| **Name** | **C/R** | **P/F** | **h** | **r** | **x** | **v** | **Notes** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| GSIF | 0 | 0 | - | - | - | - | Ground Station Identification Frame |
| XID\_CMD\_LE | 0 | 1 | 0 | 0 | x | x | Link Establishment |
| XID\_CMD\_LCR | 0 | 0 | 0 | 1 | x | x | Link Connection Refused |
| XID\_CMD\_LPM | 0 | 1 | - | - | - | - | Link Parameter Modification |
| XID\_CMD\_HO | 0 | 1 | 1 | 0 | x | x | If P=1, then initiating handoff. |
| XID\_CMD\_HO | 0 | 0 | 1 | 0 | x | x | If broadcast and P=0, then commanding a Broadcast Handoff.  If unicast and P=0, then Requesting Handoff. |
| XID\_RSP\_LE | 1 | 1 | 0 | 0 | x | x |  |
| XID\_RSP\_LCR | 1 | 1 | 0 | 1 | x | x |  |
| XID\_RSP\_LPM | 1 | 1 | - | - | - | - |  |
| XID\_RSP\_HO | 1 | 1 | 1 | 0 | x | x |  |

x = not applicable

- = connection management parameter not included

3.2.2.5.2.4.3 Signal Quality Parameter (SQP)

This parameter defines the received signal quality value of the last received transmission from the destination of the XID. It **shall** be encoded as a 4-bit integer per Table 3-15. There are two SCP scales defined in the VDL mode 2 MOPS Section 2.4.5.3.3.3.1 and Section 2.4.5.3.3.3.2 and are referred to as the Original SQP scale and Supplement 4 SQP scale respectively.

The sending station **shall** encode SQP using the Original SQP scale as defined in VDL mode 2 MOPS as a 4-bit integer per Table 3-15 bits q4-q1 and when the optional Supplement 4 SQP is provided by the VDR then it is encoded as a 4-bit integer per Table 3-15 bits p4-p1. If the Supplement 4 SQP is not available then the p bits are set to zero.

The receiving station **shall** decode SQP per Table 3-15.

Table 3-15: Signal Quality Parameter

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Parameter value | p4 | p3 | p2 | p1 | q4 | q3 | q2 | q1 |

If the transmitting LME included the SQP parameter in the XID\_CMD (P=1) frame, then the responding LME **shall** also include it in the respective XID\_RSP (F=1) frame.

3.2.2.5.2.4.4 XID Sequencing Parameter

This parameter defines the XID sequence number (s s s) and an XID retransmission number (r r r r). It **shall** be encoded per Table 3-16. An LME **shall** increment the sequence number for every new XID (setting the retransmission field to 0 on the first transmission) and **shall** increment the retransmission field after every retransmission. In an XID\_RSP, the sequence number **shall** be set to the value of the XID\_CMD sequence number generating the response (the retransmission field **shall** be ignored).

The XID Sequencing parameter defines the XID sequence number (s s s) and XID retransmission number (r r r r). The XID transmission number should increment for each new XID transmitted until the maximum value is reached then the next value should be 0, The XID retransmission number is 0 for the first transmission of an XID frame and 1 in the first retransmission and 2 in the second retransmission and so on until the maximum number of retransmissions is reached.

The transmitting LME **shall:**

* encode the XID Sequencing Parameter per Table 3-16 and
* increment the sequence number field (s s s) for every new XID frame, except XID RSP, and
* set the retransmission field (r r r r) to 0 on the first transmission of the XID and
* increment the retransmission field after every retransmission of that XID.

In an XID\_RSP, the LME **shall** set the sequence number in the XID RSP to the value of the sequence number in the XID CMD that caused the response to be sent and set the retransmission field to zero

Table 3-16: XID Sequence Parameter

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Parameter value | r4 | r3 | r2 | r1 | 0 | s3 | s2 | s1 |

3.2.2.5.2.4.5 AVLC Specific Options Parameter

The AVLC Specific Options parameter defines which AVLC protocol options are supported by the transmitting station. When both the AVLC Specific Options parameter and the Connection Management parameter are included in an XID, then the bit values for those options which are included in both parameters **shall** be determined by the Connection Management parameter.

A transmitting station **shall** encode the AVLC Specific Options parameter per Tables 3-17 and 3-18.

A receiving station **shall** decode the AVLC Specific Options parameter per Tables 3-17 and 3-18.

Table 3-17: AVLC Specific Options Parameter Format

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Parameter value | ips | gnd | a | bs | bl | i | v | x |

Table 3-18: AVLC Specific Options Parameter Bit Definitions

| **BIT** | **Name** | **Value** | **Description** |
| --- | --- | --- | --- |
| 1 | x | x = 0 | Only VDL-specific DTE addresses |
| x = 1 | Ground network DTE address accepted |
| 2 | v | v = 0 | Expedited subnetwork connection not supported |
| v = 1 | Expedited subnetwork connection is supported |
| 3 | i | i = 0 | Does not support initiated handoff |
| i = 1 | Supports initiated handoff |
| 4 | bl | bl = 0 | Broadcast link handoff not supported |
| bl = 1 | Broadcast link handoff supported |
| 5 | bs | bs = 0 | Broadcast subnetwork connection not supported |
| bs = 1 | Broadcast subnetwork connection supported |
| 6 | a | a = 0 | No AOA service supported and/or requested (see text below) |
| a = 1 | AOA service supported and/or requested (see text below) |
| 7 | gnd | gnd = 0 | FSL contains airborne frequencies (see text below) |
| gnd = 1 | FSL contains ground frequencies |
| 8 | ips | ips = 0 | No ATN/IPS packets in INFO (IOA) frames service supported and/or requested (see text below) |
| ips = 1 | ATN/IPS packets in INFO (IOA) frames service supported and/or requested (see text below) |

The AVLC Specific Options parameter, bits 6 and 8, and the ATN/OSI Router NET parameter advertise the services offered by the ground station. The aircraft has to connect with a ground station in order to see whether the ground station provides a valid ATN/IPS Address which is required to determine whether ATN/IPS service is available. Possible states for available services are shown in Table 3-18a.

Table 3-18a: Ground Station Service Status States

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bit 6, a** | **Bit 8, ips** | **ATN/OSI Router NET parameter** | **ATN/IPS Address parameter** | **Ground station Service Status** |
| 0 | 0 | Contains zeros | Don’t care because bit 8 is zero | No services offered by ground station. Avionics should consider switching ground stations |
| 1 | 0 | Contains zeros | Don’t care because bit 8 is zero | ACARS AOA only service offered |
| 0 | 1 | Contains zeros | available and valid value | ATN/IPS only service offered |
| 0 | 1 | Contains zeros | Unavailable or invalid value | No services offered by ground station. |
| 1 | 1 | Contains zeros | available and valid value | ACARS AOA and ATN/IPS services offered |
| 1 | 1 | Contains zeros | Unavailable or invalid value | ACARS AOA services offered |
| 0 | 0 | Non-zero value | Don’t care because bit 8 is zero | ATN/OSI VDL mode 2 ISO 8208 only service offered |
| 1 | 0 | Non-zero value | Don’t care because bit 8 is zero | ACARS AOA and ATN/OSI VDL mode 2 ISO 8208 services offered |
| 0 | 1 | Non-zero value | available and valid value | ATN/IPS and ATN/OSI VDL mode 2 ISO 8208 services offered |
| 0 | 1 | Non-zero value | Unavailable or invalid value | ATN/OSI VDL mode 2 ISO 8208 services offered |
| 1 | 1 | Non-zero value | available and valid value | ACARS AOA and ATN/IPS and ATN/OSI VDL mode 2 ISO 8208 services offered |
| 1 | 1 | Non-zero value | Unavailable or invalid value | ACARS AOA and ATN/OSI VDL mode 2 ISO 8208 services offered |

*Note: Aircraft implementations may include any combination of the three services mentioned herein (AOA, ATN/OSI, ATN/IPS). Ground implementations may include any combination of the three services.*

Ground station support for ATN/OSI VDL mode 2 ISO 8208 **shall** be indicated by encoding at least one non-zero value in the ATN/OSI Router NETs parameter in the GSIF.

If a ground station does not support ATN/OSI VDL mode 2 ISO 8208 then it **shall** be indicated by encoding the ATN/OSI Router NETs parameter with the value zero in the GSIF.

Ground station support for ACARS AOA **shall** be indicated by setting bit 6 (“a” bit) of the AVLC Specific Options parameter to one.

If ground station does not support ACARS AOA then it **shall** be indicated by setting bit 6 (“a” bit) of the AVLC Specific Options parameter to zero. If the AOA ground station does not also support ATN/OSI then the VSDA parameter value **shall** be zero.

Aircraft support for ACARS AOA **shall** be indicated by setting bit 6 (“a” bit) of the AVLC Specific Options parameter to one.

If an aircraft does not support ACARS AOA then it **shall** be indicated by setting bit 6 (“a” bit) of the AVLC Specific Options parameter to zero.

If the ground station sets bit 7 (“gnd” bit) of the AVLC Specific Options parameter to one in its GSIF, it indicates that the frequency support list defined in the GSIF **shall** be used only by aircraft which are on the ground at the airport identified by the airport coverage parameter in the GSIF.

If the ground station sets bit 7 (“gnd” bit) of the AVLC Specific Options parameter to zero in its GSIF, it indicates that the frequency support list defined in the GSIF **shall** be used when the aircraft is airborne.

*Note: Avionics designed prior to the introduction of the “gnd” bit may use the FSL when airborne or on the ground regardless of the value of the “gnd” bit. It is recommended that the DSP not accept connection on the ground frequency by aircraft that are airborne*.

Ground station support for ATN/IPS **shall** be indicated by setting bit 8 (“ips” bit) of the AVLC Specific Options parameter to one in the GSIF and other XIDs. If the IPS ground station does not also support ATN/OSI then the VSDA parameter value **shall** be xero.

A ground station that does not support ATN/IPS **shall** set bit 8 (“ips” bit) of the AVLC Specific Options parameter to zero.

If an aircraft wants to use ATN/IPS then it **shall** set bit 8 (“ips” bit) of the AVLC Specific Options parameter to one.

An aircraft that does not support ATN/IPS **shall** set bit 8 (“ips” bit) of the AVLC Specific Options parameter to zero.

mode . The aircraft must also receive a valid ATN/IPS Address in order for the aircraft to use the ATN/IPS service. If bit 8 is zero or the ATN/IPS Address parameter is not available or the ATN/IPS Address parameter available but its value is not valid then ATN/IPS is un-usable.

The GSIF may offer any combination of the three services defined herein (ACARS AOA, ATN/OSI, ATN/IPS).

The service status provided in the GSIF can change dynamically based on the status of the ground networks.

Therefore, avionics **shall** monitor the network status provided in the GSIF and initiate VDL mode 2 handoffs and/or link establishments in order to access the desired services.

The CMU **shall** not attempt to connect with a ground station indicating that its current service status is No Service.

For example, if the ground station sets bit 6 of the AVLC specific options parameter to zero in its GSIF, it indicates that the ground station does not support ACARS AOA protocol over the VDL mode 2 link. If the aircraft responds (via an XID frame), then ACARS AOA service is not available over the established link regardless of the value of bit 6 in the AVLC specific options parameter in the XID transmitted by the aircraft.

*Note: Avionics designed prior to the introduction of the “ips” bit in the* AVLC specific options parameter *will ignore bit 8 (“ips” bit) in GSIF and XID frames because bit 8 was defined as Reserved in the previous version of MASPS. Avionics designed to this version of MASPS but do not support ATN/IPS should ignore bit 8 “ips” in the AVLC Specific options parameter.*

*Note: A ground station designed prior to the introduction of the “ips” bit in the* AVLC specific options parameter *will ignore bit 8 (“ips” bit) in received XID frames because bit 8 was defined as Reserved in the previous version of MASPS. A ground station that does not support ATN/IPS should ignore bit 8 (“ips” bit) in received XID frames.*

3.2.2.5.2.4.6 Expedited Subnetwork Connection Parameter

The expedited subnetwork connection parameter defines the expedited packets that the current XID contains.

The expedited subnetwork connection parameter, which may be repeated in the XID, **shall** contain one and only one of the following ISO 8208 subnetwork packets: CALL REQUEST, CALL ACCEPTED, or a CLEAR REQUEST.

The sending station **shall** encode the Expedited Subnetwork Connection parameter per Table 3-19 with a parameter length value of 3 to 255 inclusive, which should be the length of the ISO 8208 packet in the parameter.

If a station receives an XID containing the Expedited Subnetwork Connection parameter then it **shall** be decoded per Table 3-19 and invoke the expedited subnetwork connection procedures.

If, during a ground station handoff, an aircraft LME has not received a ground station information frame (GSIF) from the ground LME, it may assume expedited subnetwork connection is supported.

Table 3-19: Expedited Subnetwork Connection

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |  |
| Parameter length | n8 | n7 | n6 | n5 | n4 | n3 | n2 | n1 |  |
| Parameter value | p8 | p7 | p6 | p5 | p4 | p3 | p2 | p1 | one ISO 8208 |
|  | … |  |  |  |  |  |  |  | subnetwork |
|  | p8 | p7 | … |  |  |  |  |  | packet |

3.2.2.5.2.4.7 LCR Cause Parameter

The LCR parameter defines the reason why the link connection request was refused.

The parameter, which may be repeated, **shall** be encode per Tables 3-20 and 3-21 and consist of a rejection cause code (c bits), backoff delay time in seconds (d bits), and additional data (a bits), when indicated by Table 3-21.

Cause codes 00 hex to 7F hex apply to the responding station; cause codes 80 hex to FF hex apply to the responding system.

If the r bit in the Connection Management parameter is set to 1 then at least one copy of this parameter **shall** be included in the XID response else (the r bit in the Connection Management parameter is set to zero) this parameter isexcluded.

An LME receiving an LCR Cause parameter less than 80 hex **shall** not transmit another XID\_CMD to that peer station for the duration of time designated in the LCR Cause parameter.

An LME receiving an LCR Cause parameter greater than 7F hex shall not transmit another XID\_CMD to that peer system for the duration of time designated in the LCR Cause parameter.

*Note: An aircraft LME receiving a station-based cause code from one ground station may immediately transmit the same XID\_CMD to another ground station of the same ground system.*

Table 3-20: LCR Cause Parameter

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |  |
| Parameter length | n8 | n7 | n6 | n5 | n4 | n3 | n2 | n1 |  |
| Parameter value | c8 | c7 | c6 | c5 | c4 | c3 | c2 | c1 | cause |
| d16 | d15 | d14 | d13 | d12 | d11 | d10 | d9 | Delay time |
| d8 | d7 | d6 | d5 | d4 | d3 | d2 | d1 |  |
| a8 | a7 | a6 | a5 | a4 | a3 | a2 | a1 | additional data when required,  see Table 3-21 |
|  | a16 | a15 | a14 | a13 | a12 | a11 | a10 | a9 | 2nd byte of additional data when required, see Table 3-21. |

The value in the parameter length field is variable to allow for the inclusion of additional data for some of the cause codes as indicated by Table 3-21. Valid values for parameter length **shall** be 3 or greater depending on whether the cause code requires additional data per Table 3-21.

Table 3-21: Cause Code Table

| **Cause** | **Function** | **Additional Data Encoding** | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 00h | Bad local parameter.  The additional data block, which may be repeated, contains the GI and PI of a parameter which cannot be satisfied by this ground station. This cause will not be sent for an illegal Connection Management parameter. | g8  p8 | g7  p7 | g6  p6 | g5  p5 | g4  p4 | g3  p3 | g2  p2 | g1  p1 |
| 01h | Out of link layer resources. |  | | | | | | | |
| 02h | Out of packet layer resources. |  | | | | | | | |
| 03h | Terrestrial network not available. |  | | | | | | | |
| 04h | Terrestrial network congestion. | undefined | | | | | | | |
| 05h | Cannot support autotune. |  | | | | | | | |
| 06h | Station cannot support initiating handoff. |  | | | | | | | |
| 07h | Autotune rejected – service required from multiple providers |  | | | | | | | |
| 08h | Autotune rejected – not preferred provider |  | | | | | | | |
| 09h | Attempting to connect to Ground frequency while still indicating Airborne |  | | | | | | | |
| 0A-7Eh | Reserved |  | | | | | | | |
| 7Fh | Other unspecified local reason. |  | | | | | | | |
| 80h | Bad global parameter.  The additional data block, which may be repeated, contains the GI and PI of a parameter which cannot be satisfied by any ground station in the system. This cause will not be sent for an illegal Connection Management parameter. | identical to cause code 00 | | | | | | | |
| 81h | Protocol Violation.  The first octet of the additional data block contains:  1- C/R bit (c bit) of the received XID;  2- P/F bit (p bit) of the received XID;  3- Disconnected bit (d bit) shall be set to 1 if the LME has no links with the remote LME (the unexpected bit shall also be set to 1);  4- Illegal bit (i bit) shall be set to 1 if the LME receives an illegal XID (i.e., not listed in Table 3-50 and described in Section 3.2.2.5.4);  5- Unexpected bit (u bit) shall be set to 1 if the LME receives a legal XID which is not legal in the context in which it was received.  The second octet contains the parameter value of the Connection Management parameter (m bits) if included in the illegal XID. After transmitting or receiving an LCR with this cause code, an LME shall delete all of its links. | 0  m8 | 0  m7 | 0  m6 | u  m5 | i  m4 | d  m3 | p  m2 | c  m1 |
| 82h | Ground system out of resources. |  | | | | | | | |
| 83h | IPS address mismatch/inconsistency |  | | | | | | | |
| 84h | IPS address missing or invalid in received XID |  | | | | | | | |
| 85-FEh | Reserved |  | | | | | | | |
| FFh | Other unspecified system reason. |  | | | | | | | |

*Note: See GI and PI definitions in the key below Table 3-48c.*

3.2.2.5.2.4.8 ATN/IPS Address Parameter

The ATN/IPS Address parameter provides the IPv6 address of the ATN/IPS router reachable via the ground station that provided the information. The ground station is required to provide the ATN/IPS Address parameter when the ground station offers ATN/IPS service

If a ground station provides ATN/IPS service then it **shall** encode a valid IPv6 address in the ATN/IPS Address parameter per Table 3-123.

If the aircraft is configured to use ATN/IPS and receives the ATN/IPS Address parameter then the aircraft **shall** decode the ATN/IPS Address parameter per Table 3-123 and validate the IPv6 address per section 3-TBD herein.

If the ground station does not support ATN/IPS, then the ground station **shall** omit the ATN/IPS Available parameter.

*Note: at this time, it is expected that the ATN/IPS Address parameter will be delivered in RSP\_LE and RSP\_HO frames.*

Table 3-TBD: ATN/IPS Address Parameter

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | ATN/IPS Address |
| Parameter length | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |  |
| Parameter value | a8 | a7 | a6 | a5 | a4 | a3 | a2 | a1 | ATN/IPS IPv6 Router Address |
| a16 | a15 | a14 | a13 | a12 | a11 | a10 | a9 |
| … |  |  |  |  |  |  |  |
| a120 | a119 | a118 | a117 | a116 | a115 | a114 | a113 |  |
| a128 | a127 | a126 | a125 | a124 | a123 | a122 | a121 |

3.2.2.5.2.5 Aircraft-Initiated Information Private Parameters

An aircraft LME uses aircraft-initiated information parameters to inform the ground about that aircraft's capabilities or desires..

3.2.2.5.2.5.1 Modulation Support Parameter

The Modulation Support parameter indicates the modulation schemes supported by the station. Note that the Modulation Support parameter is also used in uplinked XIDs

The sending station **shall** encode the Modulation Support parameter as shown in Tables 3-22 and 3-23.

The Modulation Support parameter **shall** be decoded as shown in Tables 3-22 and 3-23 by the receiving station.

Table 3-22: Modulation Support

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Parameter value | 0 | 0 | 0 | 0 | m4 | m3 | m2 | m1 |

Table 3-23: Modulation Scheme and Bit Rate

|  |  |  |  |
| --- | --- | --- | --- |
| **Bit** | **Name** | **Encoding** | |
|  |  |  |  |
| 1 | AM-MSK | 0 | (not mode A) |
|  |  | 1 | Mode A, 2400 bits/s MSK |
| 2 | D8PSK | 0 | (Not Mode 2) |
| 1 | Mode 2, 31 500 bits/s |
| 3 | D8PSK | 0 | (Not Mode 3) |
| 1 | Mode 3, 31 500 bits/s |
| 4 | Reserved | Set to 0 |  |
|  |  |  |  |
| *Note: More than one modulation scheme may be supported by an aircraft*. | | | |

3.2.2.5.2.5.2  Acceptable Alternate Ground Station Parameter

This parameter defines a list of up to eight ground stations in order of preference by the aircraft.

The aircraft **shall** use this parameter to encode a list of up to eight DLS addresses in 32-bit fields as per Table 3-24.

The ground station **shall** decode the Acceptable Ground Station parameter per Table 3-24.

Table 3-24: Acceptable Alternative Ground Station Parameter

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |  |
| Parameter length | n8 | n7 | n6 | n5 | n4 | n3 | 0 | 0 |  |
| Parameter value | g22 | g23 | g24 | g25 | g26 | g27 | 0 | 0 | DLS address |
| g15 | g16 | g17 | g18 | g19 | g20 | g21 | 0 |  |
| g8 | g9 | g10 | g11 | g12 | g13 | g14 | 0 |  |
| g1 | g2 | g3 | g4 | g5 | g6 | g7 | 0 |  |

The value in the parameter length field is variable to allow for multiple (up to 8) ground stations to be listed. The parameter length value shall be a multiple of 4 and a maximum of 32 (4x8).

3.2.2.5.2.5.3 Destination Airport Parameter

The Destination Airport parameter provides the aircraft's destination airport for the current flight.

The aircraft **shall** encode the destination airport ICAO airport code as four, 8-bit ISO IA5 upper case, alpha characters (A-Z) per Table 3-25.

*Note: the aircraft should provide a valid ICAO airport code to the VDL mode 2 avionics.*

If Destination Airport data is not available then the Destination Airport parameter **shall** be omitted as stated in Tables 3-48.

The ground station **shall** decode the destination airport as four, 8-bit ISO IA5 characters per Table 3-25.

Table 3-25: Destination Airport Parameter

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |  |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |  |
| Parameter value | a8 | a7 | a6 | a5 | a4 | a3 | a2 | a1 | first character |
| b8 | b7 | b6 | b5 | b4 | b3 | b2 | b1 |  |
| c8 | c7 | c6 | c5 | c4 | c3 | c2 | c1 |  |
| d8 | d7 | d6 | d5 | d4 | d3 | d2 | d1 | fourth character |

3.2.2.5.2.5.4 Aircraft Location Parameter

The Aircraft Location parameter defines the current position of the aircraft. The Aircraft Location parameter data is considered valid when it contains current latitude and longitude values. Altitude data is highly desirable but not required in order to include the parameter in an XID frame.

*Note: the aircraft should provide current, valid latitude, longitude and altitude data to the VDL mode 2 avionics.*

When latitude and longitude data is available, then the aircraft **shall** encode the data as shown in Tables 3-26 and 3-27 and set the altitude field as follows:

* Mean Sea Level (feet)/1000 rounded off to an integer (e.g. parameter value for an aircraft altitude of 19,900 feet would be 20) when the aircraft is airborne and altitude data is available or
* set the altitude to 0 when the aircraft is on the ground or
* set the altitude to 255 (FFh) when altitude data is unavailable.

The ground **shall** decode the data as shown in Tables 3-26 and 3-27 and interpret the data as follows:

* when altitude value is 0 then aircraft is on ground
* when altitude value is 255 then altitude data is unavailable
* when altitude data is not 0 and not 255 then aircraft is airborne and altitude data is available.
* Mean Sea Level (feet)/1000 when the aircraft is airborne and altitude data is available

Table 3-26: Aircraft Location

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |  |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |  |
| Parameter value | v12 | v11 | v10 | v9 | v8 | v7 | v6 | v5 | Latitude (v) |
| v4 | v3 | v2 | v1 | h12 | h11 | h10 | h9 |  |
| h8 | h7 | h6 | h5 | h4 | h3 | h2 | h1 | Longitude (h) |
| a8 | a7 | a6 | a5 | a4 | a3 | a2 | a1 | Altitude (a) |

Table 3-27: Aircraft Location Subfield Description

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Subfield** | **Range** | **Encoding** | **Notes** | **Abbreviation** |
| Latitude | + 90 to -90 | Integer [degrees\*10] | positive = north,  negative = south,  coded as two's complement. Note 1 | v bits |
| Longitude | +180 to - 180 | Integer [degrees\*10] | positive = east,  negative = west,  coded as two's complement. Note 1 | h bits |
| Altitude | 0 to 255 | Integer [MSL altitude (ft)/1000] | See notes 2 and 3 | a bits |

*Note 1: For example, 100 degrees 18 minutes west equals 100.3 degrees west, which is expressed as -1003, the two's complement of which is encoded as C15 hexadecimal.*

*Note 2: Altitude data should be Mean Sea Level (MSL) while the aircraft is airborne and 0 when the aircraft is on the ground which means that an aircraft on the ground at Denver will report an altitude of 0 until it takes off, then the altitude will change to 5 (5000 ft/1000).*

*Note 3: When altitude data is not available then the altitude field value is set to 255 (FFh).*

3.2.2.5.2.5.5 Channel Utilization Parameter

The Channel Utilization parameter provides a means an aircraft using VDL Mode 2 to report the channel utilization information, as well as a flag bit to declare the occurrence of one or more TM2 (channel congestion) events, to the ground network. The aircraft CMU is expected to retain, for one minute duration, the Channel Utilization data periodically reported by the onboard VDR, as described in ARINC Characteristic 750. The CMU should average the values received for a one minute duration and then report the computed value by including the Channel Utilization parameter in any downlink XID frame such as XID\_CMD\_LE, XID\_CMD\_HO, XID\_RSP\_HO, or XID\_RSP\_LCR.

When provided by the aircraft, this information allows the VDL network operators to have an accurate status of the RF environment experienced by the aircraft and use that information for the purpose of capacity monitoring and frequency management.

When the aircraft creates an XID frame for transmission and has calculated the average CU value for a complete one minute time interval then the aircraft **shall** encode the Channel Utilization parameter as shown in Table 3-122 else (partial or incomplete CU calculations, that is those that do not span a complete one minute time interval), exclude the Channel Utilization parameter.

The ground **shall** decode the Channel Utilization parameter as shown in Table 3-122.

Table 3-122 – Channel Utilization

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |  |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |  |
| Parameter value | TM | U7 | U6 | U5 | U4 | U3 | U2 | U1 | U7 - U1 = average CU during most recent complete 1 minute interval  TM = 0 to indicate that no TM2 events were detected since the previous XID was sent.  TM = 1 to indicate that at least one TM2 event was detected since the previous XID was sent. |

The calculation of the CU value **shall** be initialized after initiation of VDL mode 2 operation (for example, after a transition from POA to VDL mode 2) or after a transition to a different VDL mode 2 operating frequency.

If the CMU receives a TM2 channel congestion indication from the VDR after the previous XID transmission and while its link with that ground station is in the data transfer state then the TM bit **shall** be set to 1 until it is sent in an XID and reset else its set to 0.

The TM bit is initialized to 0 at CMU power-up, CMU reset, initiation of VDL mode 2 operation (for example, after a transition from POA to VDL mode 2), transition to a different operating frequency, VDL mode 2 hand off or downlinked in an XID frame.

3.2.2.5.2.6 Ground-Initiated Modification Private Parameters

A ground LME **shall** use the ground-initiated modification parameters to change the value of various parameters in one or more aircraft. Aircraft LMEs **shall** not send an XID with these parameters.

3.2.2.5.2.6.1 Autotune Frequency Parameter

The ground uses the Autotune Frequency parameter to command the aircraft LME to use a different frequency. In it used in conjunction with the Replacement Ground Station parameter.

The ground station **shall** encode the Autotune Frequency parameter as follows:

* as a 16-bit field per Table 3-28 and
* the modulation subfield (m bits) per Tables 3-23 and 3-24 and.
* the frequency subfield (f bits) is encoded as:   
  Integer [(frequency in MHz \* 100) - 10000]

The aircraft **shall** decode the Autotune Frequency parameter as follows:

* a 16-bit field per Table 3-28 and
* the modulation subfield (m bits) per Tables 3-23 and 3-24 and.
* the frequency subfield (f bits) is decoded as:   
  Integer [(frequency in MHz \* 100) - 10000

The aircraft **shall** validate the modulation subfield value indicates that VDL mode 2 is supported by the frequency. The aircraft **shall** validate the frequency subfield contains a value of 118.00 to 138.97 inclusive.

*Note: As an example, for a frequency of 131.725 MHz, the encoded value is decimal 3172 or hexadecimal C64.*

Table 3-28: Autotune Frequency Parameter

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Parameter value | m4 | m3 | m2 | m1 | f12 | f11 | f10 | f9 |
| f8 | f7 | f6 | f5 | f4 | f3 | f2 | f1 |

3.2.2.5.2.6.2 Replacement Ground Station List (RGSL)

This parameter defines a list of ground stations in order of ground LME preference. These addresses **shall** be used by the aircraft LME during handoffs as possible alternate ground stations if the proposed ground station is not acceptable to the LME.

The ground station **shall** encode a list of up to eight ground station DLS addresses in 32-bit fields per Table 3-29.

The aircraft **shall** decode the list of up to eight ground station DLS addresses in 32-bit fields per Table 3-29 and used by the aircraft LME during handoffs as possible alternate ground stations if the proposed ground station is not acceptable to the LME.

Table 3-29: Replacement Ground Station List

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Parameter length | n8 | n7 | n6 | n5 | n4 | n3 | 0 | 0 |
| Parameter value | g22 | g23 | g24 | g25 | g26 | g27 | 0 | 0 |
| g15 | g16 | g17 | g18 | g19 | g20 | g21 | 0 |
| g8 | g9 | g10 | g11 | g12 | g13 | g14 | 0 |
| g1 | g2 | g3 | g4 | g5 | g6 | g7 | 0 |

The value in the parameter length field is variable to allow for multiple ground stations to be listed*.* The parameter length value **shall** be a multiple of 4 and a maximum of 32 (8x4).

3.2.2.5.2.6.3 Timer T4 Parameter

The Timer T4 parameter provides a means for the ground to command the aircraft DLE to use a different value for Timer T4 (in minutes) than the default value.

If the aircraft receives this parameter then it **shall** decode it as an unsigned 16-bit integer per Table 3-30 and the decoded value used for the aircraft DLE Timer T4 value (in minutes), instead of the default value.

The ground **shall** encode the Timer T4 value (in minutes) as an unsigned 16-bit integer per Table 3-30:

Table 3-30: Timer T4 Parameter

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Parameter value | n16 | n15 | n14 | n13 | n12 | n11 | n10 | n9 |
| n8 | n7 | n6 | n5 | n4 | n3 | n2 | n1 |

3.2.2.5.2.6.4 MAC Persistence Parameter

The MAC Persistence parameter provides a means for the ground to command the aircraft to use a different value for the p in the MAC p-persistent CSMA algorithm than the default value.

The ground **shall** encode the 8-bit unsigned integer as Hexadecimal 00 (= Decimal 1/256) to Hexadecimal FF (= Decimal 1) per Table 3-31.

When the aircraft receives the MAC Persistence parameter then it **shall** decode the 8-bit unsigned integer as Hexadecimal 00 (= Decimal 1/256) to Hexadecimal FF (= Decimal 1) per Table 3-31 and use this value for p in the MAC p-persistent CSMA algorithm instead of the default value

Table 3-31: MAC Persistence Parameter

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Parameter value | n8 | n7 | n6 | n5 | n4 | n3 | n2 | n1 |

3.2.2.5.2.6.5 Counter M1 Parameter

This parameter defines a means for the ground to command the aircraft to use a different value for M1 in the MAC than the default value.

When the aircraft receives this parameter then it **shall** decode the 16-bit unsigned integer per Table 3-32 and use this value for M1 in the MAC instead of the default value.

The ground station **shall** encode the M1 value as a 16-bit unsigned integer per Table 3-32.

Table 3-32: Counter M1 Parameter

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Parameter value | n16 | n15 | n14 | n13 | n12 | n11 | n10 | n9 |
| n8 | n7 | n6 | n5 | n4 | n3 | n2 | n1 |

3.2.2.5.2.6.6 Timer TM2 Parameter

This parameter provides a means for the ground to command the aircraft to use a different value for Timer TM2 (in seconds) in the aircraft than the default value.

The ground station **shall** encode the TM2 value (in seconds) as an 8-bit integer per Table 3-33.

When the aircraft receives the TM2 parameter then it **shall** decode the 8-bit unsigned integer per Table 3-33 and use this value for TM2 (in seconds) in the aircraft MAC instead of the default value.

Table 3-33: Timer TM2 Parameter

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Parameter value | n8 | n7 | n6 | n5 | n4 | n3 | n2 | n1 |

3.2.2.5.2.6.7 Timer TG5 Parameter

The Timer TG5 parameter provides a means for the ground to command the aircraft to use different values for the TG5 timers (in seconds) in the initiating and responding LME than the default TG5 timer values.

The ground station **shall** encode the initiating and responding TG5 values (in seconds) as two 8-bit unsigned integers per Table 3-34.

When the aircraft receives the Timer TG5 parameter then it **shall** decode the two 8-bit unsigned integers per Table 3-34 and use these values (in seconds) for TG5 for the initiating and responding LME instead of the default values.

Table 3-34: Timer TG5 Parameter

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 |  |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |  |
| Parameter value | i8 | i7 | i6 | i5 | i4 | i3 | i2 | i1 | initiating |
| r8 | r7 | r6 | r5 | r4 | r3 | r2 | r1 | responding |

3.2.2.5.2.6.8 T3min Parameter

The TG3min parameter provides a means for the ground to command the aircraft DLE to use a different value for Timer T3min (in milliseconds) than the default value.

The ground station **shall** encode the Timer T3min (in milliseconds) value as a 16-bit unsigned integer per Table 3-35.

When the aircraft receives the T3min parameter then it **shall** decode the 16-bit unsigned integer per Table 3-35 and use this value for T3min (in milliseconds) in the aircraft DLE instead of the default value.

Table 3-35: T3min Parameter

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Parameter value | n16 | n15 | n14 | n13 | n12 | n11 | n10 | n9 |
| n8 | n7 | n6 | n5 | n4 | n3 | n2 | n1 |

3.2.2.5.2.6.9 Ground Station Address Filter Parameter

The Ground Station Address Filter parameter defines the DLS address of the ground station from which links are handed off.

The ground station **shall** encode the ground station address filter parameter in a 32-bit field per Table 3-36 and send it in an XID\_CMD.

If the receiving aircraft LME has a link with the identified ground station then the aircraft **shall** process the XID\_CMD and decode the ground station address filter parameter in the 32-bit field per Table 3-36.

Table 3-36: Ground Station Address Filter Parameter

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Parameter value | g22 | g23 | g24 | g25 | g26 | g27 | 0 | 0 |
| g15 | g16 | g17 | g18 | g19 | g20 | g21 | 0 |
| g8 | g9 | g10 | g11 | g12 | g13 | g14 | 0 |
| g1 | g2 | g3 | g4 | g5 | g6 | g7 | 0 |

3.2.2.5.2.6.10 Broadcast Connection Parameter

This parameter defines a single aircraft's link attributes for a new link, i.e.:

* aircraft address whose link was successfully established on the new link (minimum information);
* an optional list of one or more subnetwork connections maintained for that aircraft;
* and for each subnetwork connection listed, an indication of whether its subnetwork dependent convergence facility (SNDCF) context was maintained.

Per Table 3-37 and 3-38, the ground station **shall**:

* enter the aircraft address in the aircraft ID subfield (a bits) and
* set the optional M/I subfield (m bit) as the SNDCF M/I bit in the CALL ACCEPTED Call User Data field; and
* set the optional LCI subfield (l bits) to the logical channel identifier of the subnetwork connection of the old link which is to be maintained on the new link.

Any particular aircraft **shall** not appear in more than one broadcast parameter block.

*Note 1: Refer to Section 3.2.2.5.4.10.2 for more discussion of the M/I and LCI subfields.*

Table 3-37: Broadcast Connection (Link Only) Parameter

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |  |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |  |
| Parameter value | a24 | a23 | a22 | a21 | a20 | a19 | a18 | a17 | Aircraft ID |
| a16 | a15 | a14 | a13 | a12 | a11 | a10 | a9 |  |
| a8 | a7 | a6 | a5 | a4 | a3 | a2 | a1 |  |

*Note 2: Table 3-37 shows the case of a successful link handoff, with no switched virtual circuits (SVCs) maintained.*

Table 3-38: Broadcast Connection (Link and Subnetwork) Parameter

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |  |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |  |
| Parameter value | a24 | a23 | a22 | a21 | a20 | a19 | a18 | a17 | Aircraft ID |
| a16 | a15 | a14 | a13 | a12 | a11 | a10 | a9 |  |
| a8 | a7 | a6 | a5 | a4 | a3 | a2 | a1 |  |
| 0 | 0 | 0 | m | 112 | 111 | 110 | 19 | M/I bit and LCI |
| 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 |  |

*Note 3: Table 3-38 shows the case of a successful link handoff, as well as one SVC having been maintained.*

3.2.2.5.2.7 Ground-Initiated Information Private Parameters

A ground LME uses ground-initiated information parameters to inform one or more aircraft LMEs about that ground system's capabilities. Aircraft LMEs do not send these parameters.

3.2.2.5.2.7.1 Frequency Support List (FSL)

The Frequency Support List parameter defines the list of frequencies, modulation schemes and associated ground stations supported in the coverage area of the originating ground station.

The ground station **shall** format the Frequency Support List parameter as follows

* consist of a list of up to eight 48-bit entries per Table 3-39 and
* with the modulation subfield (m bits) encoded per Table 3-23 and
* with the frequency subfield (f bits) encoded per Section 3.2.2.5.2.6.1 and
* the ground station address (g bits) subfield contains a DLS address encoded as a 32-bit field per Table 3-39 and
* the ground DLS address is a DLS address of a ground station which can provide services using the specified frequency and modulation scheme.

The aircraft **shall**:

* decode the modulation subfield (m bits) per Table 3-23 and
* decode the frequency subfield (f bits) per Section 3.2.2.5.2.6.1 and
* decode the ground station address subfield (g bits) 32-bit subfield per Table 3-39.

The aircraft **shall** validate that the modulation subfield value indicates VDL mode 2 is supported by the frequency. The aircraft **shall** validate the frequency subfield contains a value of 118.00 to 138.97 inclusive. A viable FSL is one that passes the validation criteria specified herein. If a modulation subfield value omits support for VDL mode 2 then the FSL is considered not viable. If a frequency subfield value is less than 118.00 or greater than 136.97 then the FSL is considered not viable.

Ground stations advertised in the FSL **shall** use the same operating parameters as the transmitting station.

During frequency recovery the aircraft LME **shall** randomly choose a frequency from the list to re-acquire service.

Table 3-39: Frequency Support List

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Parameter length | n8 | n7 | n6 | n5 | n4 | n3 | n2 | 0 |
| Parameter value | m4 | m3 | m2 | m1 | f12 | f11 | f10 | f9 |
| f8 | f7 | f6 | f5 | f4 | f3 | f2 | f1 |
| g22 | g23 | g24 | g25 | g26 | g27 | 0 | 0 |
| g15 | g16 | g17 | g18 | g19 | g20 | g21 | 0 |
| g8 | g9 | g10 | g11 | g12 | g13 | g14 | 0 |
| g1 | g2 | g3 | g4 | g5 | g6 | g7 | 0 |

The value in the parameter length field is variable to allow for multiple data values to be listed, all with the parameter value format shown in Table 3-39.

The parameter length value **shall** be a multiple of 6 and a maximum of 48 (6x8).

3.2.2.5.2.7.2 Airport Coverage Indication Parameter

The Airport Coverage Indication parameter defines a list of up to eight four-character ICAO airport identifiers for which the ground station can support communication with aircraft on the ground. Each airport is identified by its 4 character ICAO identifier.

The ground station **shall** encode the ICAO airport code using four, upper case, alpha (e.g. A to Z) 8-bit ISO IA5 characters per Table 3-40.

The aircraft **shall** decode and validate the ICAO airport code as four, upper case, alpha (e.g. A to Z) 8-bit ISO IA5 characters per Table 3-40.

Table 3-40: Airport Coverage Indication Parameter

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |  |
| Parameter length | n8 | n7 | n6 | n5 | n4 | n3 | 0 | 0 |  |
| Parameter value | a8 | a7 | a6 | a5 | a4 | a3 | a2 | a1 | first character |
| b8 | b7 | b6 | b5 | b4 | b3 | b2 | b1 |  |
| c8 | c7 | c6 | c5 | c4 | c3 | c2 | c1 |  |
| d8 | d7 | d6 | d5 | d4 | d3 | d2 | d1 | fourth character |

The value in the parameter length field is variable to allow for multiple data values to be listed, all with the parameter value format shown in Table 3-40. The parameter length value **shall** be a multiple of 4 and not exceed 32 (4x8).

3.2.2.5.2.7.3 Nearest Airport Parameter

The ground uses the Nearest Airport parameter to inform aircraft which airport is nearest the ground station. The airport is identified by its four-character ICAO airport identifier.

The ground station **shall** encode the ICAO four-character airport identifier as four, upper case, alpha (e.g. A to Z) 8-bit ISO IA5 characters per Table 3-41.

The aircraft **shall** decode and validate the data as four, upper case, alpha (e.g. A to Z) 8-bit ISO IA5 characters per Table 3-41.

The Nearest Airport parameter **shall** not be included in an XID if the Airport Coverage Identification parameter is included and vice versa.

Table 3-41: Nearest Airport Parameter

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |  |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |  |
| Parameter value | a8 | a7 | a6 | a5 | a4 | a3 | a2 | a1 | first character |
| b8 | b7 | b6 | b5 | b4 | b3 | b2 | b1 |  |
| c8 | c7 | c6 | c5 | c4 | c3 | c2 | c1 |  |
| d8 | d7 | d6 | d5 | d4 | d3 | d2 | d1 | fourth character |

3.2.2.5.2.7.4 ATN Router NETs Parameter

The ATN Router NET parameter defines one ATN/OSI air-ground router identified by the “administration identifier” (ADM) and a Three Octet User Defined subfield of the network entity titles (NETs).

If the ground station offers ATN/OSI services then the ground **shall** encode the ATN Router Net parameter per Table 3-42 with the “administration identifier” (ADM) and a Three Octet User Defined subfield of the network entity titles (NETs of the ATN/OSI air-ground router, else (ground station does not support ATN/OSI operations), the ATN Router NETs parameter is filled with all-zeros in accordance with section 3.2.2.5.2.4.5.

The aircraft **shall** decode the ATN Router NETs parameter per Table 3-42

Table 3-42: ATN Router NETs Parameter

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | ATN RTR Nets |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |  |
| Parameter value | a24 | a23 | a22 | a21 | a20 | a19 | a18 | a17 | ADM Subfield |
| a16 | a15 | a14 | a13 | a12 | a11 | a10 | a9 |
| a8 | a7 | a6 | a5 | a4 | a3 | a2 | a1 |
| u24 | u23 | u22 | u21 | u20 | u19 | u18 | u17 | User Defined |
| u16 | u15 | u14 | u13 | u12 | u11 | u10 | u9 |
| u8 | u7 | u6 | u5 | u4 | u3 | u2 | u1 |

3.2.2.5.2.7.4.1 Recommendation

The ATN Router NET parameter should contain a single VSDA (See Section 3.2.3.3.2.2.2) reachable from the ground station broadcasting the GSIF.

*Note: ICAO VDL* mode 2 *standards permit the advertisement of multiple VSDAs within a single GSIF. There are a range of scenarios supporting end-to-end connectivity for ATN/OSI ATS applications; however, the current favored approach is to use ground-ground networking to support connectivity between adjacent ATS Providers, and consequently that advertisement of only a single VSDA per Ground Station (GS) is necessary to support current requirements. This strategy avoids the necessity for selection logic in avionics, and ensures interoperability. In the event that it is desired to implement a future ground network architecture that cannot be supported by a single VSDA then it will be necessary to ensure that appropriate industry standards are in place to specify criteria by which avionics should select the VSDAs through which connections are required. At this time, no circumstances are foreseen that would require advertisement of more than one VSDA address*

3.2.2.5.2.7.5 Station Operator Mask Parameter

The Station Operator Mask parameter defines the station operator mask.

The ground station **shall** encode the Station Operator Mask as a 27-bit mask in a 32-bit field per Table 3-43.

The aircraft **shall** decode the data as a 27-bit mask in a 32-bit field per Table 3-43.

Table 3-43: Station Operator Mask Parameter

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Parameter value | g22 | g23 | g24 | g25 | g26 | g27 | 0 | 0 |
| g15 | g16 | g17 | g18 | g19 | g20 | g21 | 0 |
| g8 | g9 | g10 | g11 | g12 | g13 | g14 | 0 |
| g1 | g2 | g3 | g4 | g5 | g6 | g7 | 0 |

3.2.2.5.2.7.6 Timer TG3 Parameter

The Timer TG3 parameter can be used by the ground to inform the aircraft of the values (lower bound and upper bound) of the Timer TG3 (in half seconds) that the ground LME is using.

The ground station **shall** encode the timer TG3 value (in half-seconds), as a pair of unsigned 16-bit integers per Table 3-44 by the ground station.

The aircraft **shall** decode the Timer TG3 data (in half-seconds), as a pair of unsigned 16-bit integers per Table 3-44.

Table 3-44:  Timer TG3 Parameter

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 |  |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |  |
| Parameter value | l16 | l15 | l14 | l13 | l12 | l11 | l10 | l9 | lower bound |
| l8 | l7 | l6 | l5 | l4 | l3 | l2 | l1 |  |
| u16 | u15 | u14 | u13 | u12 | u11 | u10 | u9 | upper bound |
| u8 | u7 | u6 | u5 | u4 | u3 | u2 | u1 |  |

3.2.2.5.2.7.7 Timer TG4 Parameter

The Timer TG4 parameter can be used by the ground to inform the aircraft of the value of the Timer TG4, (in seconds), that the ground LME is using.

The ground station **shall** encode the Timer TG4 value (in seconds) as an unsigned 16-bit integer per Table 3-45.

The aircraft **shall** decode the Timer TG4 value (in seconds), as an unsigned 16-bit integer per Table 3-45.

Table 3-45: Timer TG4 Parameter

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Parameter value | v16 | v15 | v14 | v13 | v12 | v11 | v10 | v9 |
| v8 | v7 | v6 | v5 | v4 | v3 | v2 | v1 |

3.2.2.5.2.7.8 Ground Station Location Parameter

The Ground Station Location parameter defines the position of the ground station.

The ground station **shall** encode the Ground Station Location parameter per Tables 3-27 and 3-46.

The aircraft **shall** decode the Ground Station Location parameter per Tables 3-27 and 3-46.

.

Table 3-46: Ground Station Location Parameter

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |  |
| Parameter length | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |  |
| Parameter value | v12 | v11 | v10 | v9 | v8 | v7 | v6 | v5 | latitude (v) |
| v4 | v3 | v2 | v1 | h12 | h11 | h10 | h9 |  |
| h8 | h7 | h6 | h5 | h4 | h3 | h2 | h1 | longitude (h) |

*Note: Section 3.2.2.5.2.5.4 provides an example of encoding scheme used.*

3.2.2.5.3 VME Service System Parameters

The VME service **shall** implement the system parameters per Table 3-47 and detailed in Sections 3.2.2.5.3.1 through 3.2.2.5.3.5.

Table 3-47: VDL mode 2 Management Entity System Parameters

| **Symbol** | **Parameter name** | | **Minimum** | **Maximum** | **VDL mode 2 Default** | **Increment** |
| --- | --- | --- | --- | --- | --- | --- |
| TG1 (air only) | frequency dwell time | | 20 s | 600 s | 240 s | 1 s |
| TG2 | Maximum idle activity time | aircraft | 120 s | 360 s | 240 s | 1 s |
|  |  | ground | 10 min | 4320 min | 60 min | 1 min |
| TG3 (ground only) | Maximum time between transmissions | | 100 s | 120 s | Uniform between 100-120 s | 0.5 s |
| TG4 (ground only) | Maximum time between GSIFs | | 100 s | 120 s | None | 1 s |
| TG5 | Maximum link overlap time | initiating | 0 s | 255 s | 20 s | 1 s |
|  |  | responding | 0 s | 255 s | 60 s | 1 s |

3.2.2.5.3.1 Timer TG1 (Frequency Dwell Time)

Timer TG1 is the time an aircraft LME dwells on a frequency while attempting to establish a link (e.g. in order to receive a valid uplink from at least one ground station).

The timer TG1 **shall** be started by an aircraft LME when an aircraft tunes to a new frequency during a frequency search.

Timer TG1 **may** be canceled when a valid uplink is received from the preferred ground station or the aircraft station may wait until Timer TG1 expires.

Upon expiration of Timer TG1 timer the aircraft station **shall**:

a. establish a link with one of the ground systems from which it has received a valid uplink; or

b. continue searching; or

c. if an aircraft did not detect any uplink traffic within TG1 seconds, it **shall** tune to the next frequency in the search table.

*Note:*

*1. The duration of Timer* *TG1 should be chosen to maximize the probability*  *a valid uplink is received from at least one ground system before Timer TG1 expires.*

*2. There is one Timer TG1 per LME.*

*3. In order to allow an aircraft station an opportunity to link to its most preferred ground system, Timer TG1 should not be canceled unless a valid uplink is received from its most preferred ground system.*

3.2.2.5.3.2 Timer TG2 (Maximum Idle Activity Time)

Timer TG2 is set to the maximum time that an LME **shall** retain information on another station without receiving a transmission from it.

Aircraft Timer TG2 is set to the maximum time that an aircraft LME retains information on a ground station without receiving a transmission from it.

Ground Station Timer TG2 is set to the maximum time that a ground LME retains information on an aircraft station without receiving a transmission from it.

*Note: Timer TG2 in the aircraft and ground LMEs can have different values. The default values are significantly different.*

Timer TG2 **shall** be started when a valid transmission is first received from a station and restarted on each reception of a subsequent valid transmission from that station.

If Timer TG2 expires, then the LME **shall** assume that the station is no longer reachable.

If Timer TG2 expires, then an aircraft LME **shall** delete the station from the Peer Entity Connection (PEC) table.

If Timer TG2 expires and a link existed with that station, then link recovery **shall** be invoked.

*Note 1: Link recovery is very different for ground stations and aircraft stations.*

*Note 2: There is one TG2 Timer for each station being monitored.*

3.2.2.5.3.3 Timer TG3 (Maximum Time Between Transmissions)

Timer TG3 **shall** be used at the ground station only. TG3 timer is set to the maximum time between transmissions from that ground station. Timer TG3 **shall** be started when the ground station becomes operational and restarted on the transmission of any frame. On expiration, if the ground station is still operational and there is no other frame to transmit, then the ground station **shall** transmit a GSIF; and restart Timer TG3. Timer TG3 is never canceled

The value to set the TG3 timer to **shall** consist of a fixed value equal to the minimum value plus a random value uniformly distributed between 0 and 20 seconds.

*Note: There is one Timer TG3 per ground station.*

3.2.2.5.3.4 Timer TG4 (Maximum Time Between GSIFs)

Timer TG4 **is** implemented at the ground station only. Timer TG4 is set to the maximum time (TG4) between transmissions of a GSIF from that ground station.

Timer TG4 **shall** be started when the ground station becomes operational and restarted on the transmission of a GSIF. On expiration of TG4, if the ground station is operational, then the ground station **shall** transmit a GSIF and restart timer TG4.

The value to set Timer TG4 to **shall** consist of a fixed value equal to the minimum value plus a random value uniformly distributed between 0 and 20 seconds.

*Note: There is one Timer TG4 per ground station. TG4 is never canceled*

3.2.2.5.3.5 Timer TG5 (Maximum Link Overlap Time)

The TG5 Timers, in the initiating and responding LMEs are set to the maximum time that the respective LMEs maintain the old link during handoffs.

The LME initiating the handoff **shall** start its Timer TG5 when it receives an XID\_RSP\_HO.

The LME responding to the handoff **shall** start its Timer TG5 when it transmits its XID\_RSP\_HO.

The initiating LME does not ever restart its Timer TG5.

The responding LME **shall** restart its Timer TG5 if it retransmits an XID\_RSP\_HO.

Timer TG5 **shall** be canceled if either the old or new link is prematurely disconnected.

After TG5 expires, each LME **shall** silently disconnect its half of the old link.

Example: When TG5 expires in the initiating LME then the initiating LME **shall** silently disconnect its half of the old link. When TG5 expires in the responding LME then the responding LME **shall** silently disconnect its half of the old link

*Note: There is one Timer TG5 per LME.*

*Note: The Timer TG5 values for initiating and responding LMEs can be different.*

3.2.2.5.4 Description of LME Procedures

The aircraft and ground LMEs **shall** use the XID frame types listed in Tables 3-48a, b, and c and the procedures described in the text below to provide a reliable connection between the aircraft and ground system. Frame near simultaneous reception (see Section 3.2.2.4.7) **shall** be applied before determining if a frame is illegal or unexpected (see Section 3.2.2.5.2.4.7). If an LME receives any valid XID\_HO or XID\_LPM frame from a system with which it does not have a link, it **shall** respond with an XID\_LCR with the 'd' bit set to 1 in the Protocol Violation Cause Code.

3.2.2.5.4.1 Frequency Management Procedures

The aircraft LME **shall** use the following procedures to acquire a frequency on which reliable VDL mode 2 services are available.

3.2.2.5.4.1.1 Frequency Search

On avionics initialization, the aircraft LME **shall** initiate frequency search using the Common signaling Channel (CSC).

~~After link disconnection, if the aircraft LME can no longer detect uplink VDL mode 2 frames on the current frequency, then the aircraft LME~~ **~~shall~~** ~~initiate the frequency search procedure.~~ The aircraft LME **shall** attempt to identify a frequency on which VDL mode 2 service is available by using TG1 (see section 3.2.2.5.3.1) and tuning the radio to the common signaling channel (CSC) and to other frequencies on which it knows firsthand that VDL mode 2 service is available.

The aircraft LME **shall** monitor the frequency until a valid uplink VDL mode 2 frame with an acceptable source address is received and a link established or until Timer TG1 timer expires. If Timer TG1 expires without receiving a valid uplink VDL mode 2 frame with an acceptable source address and there is another frequency to monitor then the aircraft LME **shall** tune the radio to another frequency and re-start TG1 timer.

3.2.2.5.4.1.2 Frequency Recovery Procedure

If the LME can no longer maintain or establish a link on the current frequency or if the MAC entity indicates that the current frequency is congested then the LME **shall** tune the radio to the CSC or an alternate frequency using the data in the Frequency Support List previously received.

3.2.2.5.4.2 Link Maintenance Procedures

The aircraft and ground LMEs **shall** use the following procedures to maintain the VDL mode 2 link:

a) ground station identification;

b) initial link establishment;

c) link parameter modification;

d) aircraft-initiated handoff;

e) ground-initiated handoff;

f) ground-requested aircraft-initiated handoff;

g) ground-requested broadcast handoff;

h) autotune; and

i) FSL-assisted frequency management.

3.2.2.5.4.3 Ground Station Identification

A ground station **shall** send a GSIF by broadcasting an XID\_CMD (P = 0) with parameters per Tables 3-48a, ~~b, and c~~ if its Timer TG3 expires (meaning that it has not transmitted any frame in TG3 seconds) or if its Timer TG4 expires (meaning that it has not sent a GSIF in TG4 seconds). If the GSIF provides a Frequency Support List (See Section 3.2.2.5.2.7.1) which **shall** only be used by aircraft on the ground then the AVLC specific options “gnd” bit is set to one. If the ground station offers VDL mode 2 service, the operator of that ground station **shall** ensure that, besides transmitting GSIFs on the service frequency, GSIFs are transmitted on the CSC. The ground system operator will ensure that only current and up-to-date information is contained in the GSIF. Each ground station that supports ATN/OSI **shall** broadcast the VSDA of the ATN/OSI air/ground router reachable through it via the ATN Router NET parameter of the GSIF. If the ground station does not support ATN/OSI then the VSDA parameter value **shall** be zero. Aircraft LMEs receiving a GSIF **shall** process its content to identify the functionality of the ground station as well as the correct operational parameters to be used when communicating with it.

~~Each ground station that supports AOA~~ **~~shall~~** ~~set bit 6 (“a”) of the AVLC Specific Options parameter. If the AOA ground station does not also support ATN/OSI then the VSDA parameter value~~ **~~shall~~** ~~be zero.~~

~~Each ground station that supports IPS~~ **~~shall~~** ~~set bit 8 of the AVLC Specific Options parameter. If the IPS ground station does not also support ATN/OSI then the VSDA parameter value~~ **~~shall~~** ~~be xero.~~

Aircraft LMEs which have a connection with the transmitting ground station **shall** process only informational parameters and those parameters specified for an XID\_CMD\_LPM (Link Parameter Modification) per Tables 3-48a, b, and c. Unrecognized parameters are handled in accordance with Section 3.2.2.4.8.1.

Missing mandatory parameters are handled in accordance with Section 3.2.2.4.8.2.

Table 3-48a: XID Parameters

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | **GSIF** | **Air initiated link establishment** | | **Link parameter modification** | |
| **Source**  **address** | | Ground station | Aircraft | New ground station | Current Ground station | Aircraft |
| **Destination**  **address** | | All aircraft | Proposed  ground station | Aircraft | Aircraft | Current  ground station |
| **XID parameters** | **GI** | **PI** | **GSIF**  **(P=0)** | **XID\_CMD\_LE (P=1)** | **XID\_RSP\_LE (F=1)** | **XID\_CMD\_LPM (P=1)** | **XID\_RSP\_LPM (F=1)** |
| **Public parameters** |  |  |  |  |  |  |  |
| Parameter set ID | 80h | 01h | M | M | M | N/A | N/A |
| Procedure classes | 80h | 02h | M | M | M | N/A | N/A |
| HDLC options | 80h | 03h | M | M | M | N/A | N/A |
| N1-downlink | 80h | 05h | O | N/A | O | N/A | N/A |
| N1-uplink | 80h | 06h | O | N/A | O | N/A | N/A |
| k-downlink | 80h | 07h | O | N/A | O | N/A | N/A |
| k-uplink | 80h | 08h | O | N/A | O | N/A | N/A |
| Timer T1 – downlink | 80h | 09h | O | N/A | O | N/A | N/A |
| Counter N2 | 80h | 0Ah | O | N/A | O | N/A | N/A |
| Timer T2 | 80h | 0Bh | O | N/A | O | N/A | N/A |
| **Private parameters** |  |  |  |  |  |  |  |
| Parameter set ID | F0h | 00h | M | M | M | M | M |
| Connection management | F0h | 01h | N/A | M | M | N/A | N/A |
| SQP | F0h | 02h | N/A | O | O | O | O |
| XID sequencing | F0h | 03h | N/A | M | M | M | M |
| AVLC specific options | F0h | 04h | M | M | M | N/A | N/A |
| Expedited SN connection | F0h | 05h | N/A | O | O | N/A | N/A |
| LCR cause | F0h | 06h | N/A | N/A | N/A | N/A | N/A |
| Modulation support | F0h | 81h | N/A | M | N/A | N/A | N/A |
| Alternate ground stations | F0h | 82h | N/A | O | N/A | N/A | N/A |
| Destination airport | F0h | 83h | N/A | M3 | N/A | N/A | M3 |
| Aircraft location | F0h | 84h | N/A | M3 | N/A | N/A | M3 |
| Channel Utilization | F0h | 8Ch | N/A | O | N/A | N/A | O |
| Autotune frequency | F0h | 40h | N/A | N/A | O | N/A | N/A |
| Repl. ground station | F0h | 41h | N/A | N/A | O | N/A | N/A |
| Timer T4 | F0h | 42h | O | N/A | O | O | N/A |
| MAC persistence | F0h | 43h | O | N/A | O | O | N/A |
| Counter M1 | F0h | 44h | O | N/A | O | O | N/A |
| Timer TM2 | F0h | 45h | O | N/A | O | O | N/A |
| Timer TG5 | F0h | 46h | O | N/A | O | O | N/A |
| Timer T3min | F0h | 47h | O | N/A | O | N/A | N/A |
| Address filter | F0h | 48h | N/A | N/A | N/A | N/A | N/A |
| Broadcast connection | F0h | 49h | N/A | N/A | N/A | N/A | N/A |
| Frequency support | F0h | C0h | O | N/A | O | N/A | N/A |
| Airport coverage | F0h | C1h | M 1,2 | N/A | M 1,2 | N/A | N/A |
| Nearest airport ID | F0h | C3h | M 1,2 | N/A | M 1,2 | N/A | N/A |
| ATN router NETs | F0h | C4h | M | N/A | M | N/A | N/A |
| System mask | F0h | C5h | M | N/A | M | N/A | N/A |
| TG3 | F0h | C6h | O | N/A | O | N/A | N/A |
| TG4 | F0h | C7h | O | N/A | O | N/A | N/A |
| Ground station location | F0h | C8h | M | N/A | O | N/A | N/A |

*Note: See Key at the end of Table 3-48c.*

Table 3-48b: XID Parameters

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **Ground initiated handoff** | | **Air initiated handoff** | |
| **Source**  **address** | | Proposed  ground station | Aircraft | Aircraft | New ground Station |
| **Destination**  **address** | | Aircraft | New Ground station | Proposed  ground station | Aircraft |
| **XID parameters** | **GI** | **PI** | **XID\_CMD\_HO (P=1)** | **XID\_RSP\_HO**  **(F=1)** | **XID\_CMD\_HO (P=1)** | **XID\_RSP\_HO (F=1)** |
| **Public parameters** |  |  |  |  |  |  |
| Parameter set ID | 80h | 01h | M | M | M | M |
| Procedure classes | 80h | 02h | M | M | M | M |
| HDLC options | 80h | 03h | M | M | M | M |
| N1-downlink | 80h | 05h | O | N/A | N/A | O |
| N1-uplink | 80h | 06h | O | N/A | N/A | O |
| k-downlink | 80h | 07h | O | N/A | N/A | O |
| k-uplink | 80h | 08h | O | N/A | N/A | O |
| Timer T1 – downlink | 80h | 09h | O | N/A | N/A | O |
| Counter N2 | 80h | 0Ah | O | N/A | N/A | O |
| Timer T2 | 80h | 0Bh | O | N/A | N/A | O |
| **Private parameters** |  |  |  |  |  |  |
| Parameter set ID | F0h | 00h | M | M | M | M |
| Connection management | F0h | 01h | M | M | M | M |
| SQP | F0h | 02h | O | O | O | O |
| XID sequencing | F0h | 03h | M | M | M | M |
| AVLC specific options | F0h | 04h | M | M | O | O |
| Expedited SN connection | F0h | 05h | X | X | O | O |
| LCR cause | F0h | 06h | N/A | N/A | N/A | N/A |
| Modulation support | F0h | 81h | N/A | N/A | N/A | N/A |
| Alternate ground stations | F0h | 82h | N/A | N/A | O | N/A |
| Destination airport | F0h | 83h | N/A | M3 | M3 | N/A |
| Aircraft location | F0h | 84h | N/A | M3 | M3 | N/A |
| Channel Utilization | F0h | 8Ch | N/A | O | O | N/A |
| Autotune frequency | F0h | 40h | N/A | N/A | N/A | O |
| Repl. ground station | F0h | 41h | O | N/A | N/A | O |
| Timer T4 | F0h | 42h | O | N/A | N/A | O |
| Mac persistence | F0h | 43h | O | N/A | N/A | O |
| Counter M1 | F0h | 44h | O | N/A | N/A | O |
| Timer TM2 | F0h | 45h | O | N/A | N/A | O |
| Timer TG5 | F0h | 46h | O | N/A | N/A | O |
| Timer T3min | F0h | 47h | O | N/A | N/A | O |
| Address filter | F0h | 48h | N/A | N/A | N/A | N/A |
| Broadcast connection | F0h | 49h | N/A | N/A | N/A | N/A |
| Frequency support | F0h | C0h | O | N/A | N/A | O |
| Airport coverage | F0h | C1h | M 1,2 | N/A | N/A | M 1,2 |
| Nearest airport ID | F0h | C3h | M 1,2 | N/A | N/A | M 1,2 |
| ATN router NETs | F0h | C4h | M | N/A | N/A | M |
| System mask | F0h | C5h | M | N/A | N/A | M |
| TG3 | F0h | C6h | O | N/A | N/A | O |
| TG4 | F0h | C7h | O | N/A | N/A | O |
| Ground station location | F0h | C8h | O | N/A | N/A | O |

*Note: See Key at the end of Table 3-48c.*

Table 3-48c: XID Parameters

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | | **Ground requested handoff** | **Ground requested broadcast** | **Link connection rejection** |
| **Source**  **address** | | Current  ground station | New ground station | Any station |
| **Destination**  **address** | | Aircraft | All aircraft | Any station |
| **XID parameters** | **GI** | **PI** | **XID\_CMD\_HO (P=0)** | **XID\_CMD\_HO (P=0)** | **XID\_RSP\_LCR**  **XID\_CMD\_LCR** |
| **Public parameter** |  |  |  |  |  |
| Parameter set ID | 80h | 01h | M | M | N/A |
| Procedure classes | 80h | 02h | M | M | N/A |
| HDLC options | 80h | 03h | M | M | N/A |
| N1-downlink | 80h | 05h | O | O | N/A |
| N1-uplink | 80h | 06h | O | O | N/A |
| k-downlink | 80h | 07h | O | O | N/A |
| k-uplink | 80h | 08h | O | O | N/A |
| Timer T1 – downlink | 80h | 09h | O | O | N/A |
| Counter N2 | 80h | 0Ah | O | O | N/A |
| Timer T2 | 80h | 0Bh | O | O | N/A |
| **Private parameters** |  |  |  |  |  |
| Parameter set ID | F0h | 00h | M | M | M |
| Connection management | F0h | 01h | M | M | M |
| SQP | F0h | 02h | N/A | N/A | N/A |
| XID sequencing | F0h | 03h | M | M | M |
| AVLC specific options | F0h | 04h | O | O | N/A |
| Expedited SN connection | F0h | 05h | N/A | N/A | N/A |
| LCR cause | F0h | 06h | N/A | N/A | M |
| Modulation support | F0h | 81h | N/A | N/A | N/A |
| Alternate ground stations | F0h | 82h | N/A | N/A | N/A |
| Destination airport | F0h | 83h | N/A | N/A | N/A |
| Aircraft location | F0h | 84h | N/A | N/A | N/A |
| Channel Utilization | F0h | 8Ch | N/A | N/A | O |
| Autotune frequency | F0h | 40h | M | N/A | N/A |
| Repl. ground station | F0h | 41h | M | N/A | N/A |
| Timer T4 | F0h | 42h | O | O | N/A |
| MAC persistence | F0h | 43h | O | O | N/A |
| Counter M1 | F0h | 44h | O | O | N/A |
| Timer TM2 | F0h | 45h | O | O | N/A |
| Timer TG5 | F0h | 46h | O | O | N/A |
| Timer T3min | F0h | 47h | O | O | N/A |
| Address filter | F0h | 48h | N/A | M | N/A |
| Broadcast connection | F0h | 49h | N/A | M | N/A |
| Frequency support | F0h | C0h | O | O | N/A |
| Airport coverage | F0h | C1h | N/A | M 1,2 | N/A |
| Nearest airport ID | F0h | C3h | N/A | M 1,2 | N/A |
| ATN router NETs | F0h | C4h | M | M | N/A |
| System mask | F0h | C5h | M | M | N/A |
| TG3 | F0h | C6h | O | O | N/A |
| TG4 | F0h | C7h | O | O | N/A |
| Ground station location | F0h | C8h | O | O | N/A |

Key for Tables 3-48a, b, and c above:

Abbreviations used:

GI= ISO 8885 Group identifier, O= Optional,

PI= ISO 8885 Parameter identifier N/A= Not applicable,

M= Mandatory, h= hexadecimal

X = Prohibited

*Notes for Tables 3-48a, b, and c:*

1. *In a GSIF XID frame it is mandatory to include either the Airport Coverage Indication parameter or the Nearest Airport Identifier parameter but not both (see Section 3.2.2.5.2.7.3).*
2. *Where the Airport Coverage Indication parameter and the Nearest Airport Identifier parameter are marked as mandatory, either parameter shall be included in the frame but not both.*

1. *Presence of this parameter is mandated when valid data is available. An aircraft should provide valid data to the CMU. In the case when valid data is not available, such as equipment failure or broken wires or misconfiguration, then the corresponding parameter should be omitted from the XID.*

3.2.2.5.4.4 Link Establishment

The aircraft LME **shall** initiate the link establishment procedure with a ground station to establish the initial link with the ground system. An aircraft transmitting or receiving a DM frame **shall** initiate link establishment if no link remains.

3.2.2.5.4.4.1 Aircraft Initiation

The aircraft LME **shall** choose a ground station with which it wishes to establish a link based on the signal quality of all received uplink frames and on information in any received GSIFs. It **shall** then attempt to establish a link with the chosen ground station by sending an XID\_CMD\_LE (P=1) frame. This frame **shall** include the mandatory parameters per Tables 3-48a, b, and c and also any optional parameters for which the aircraft does not wish to use the default value. If the aircraft LME has received a GSIF from the ground station to which it is transmitting the XID\_CMD\_LE (P=1), then it **shall** use the parameters as declared; otherwise, it **shall** use the default parameters.

Once the aircraft LME has established a link to a ground station, it **shall** monitor the VHF signal quality on the link and the transmissions of the other ground stations. The aircraft LME **shall** initiate a link establishment to a new ground station in a different ground system if any of the following events occur:

1. the VHF signal quality on the current link is poor and the signal quality of all the ground stations of the current ground system is poor and the signal quality of a ground station belonging to a different ground system is significantly better;

2. the Counter N2 is exceeded on any frame sent to the current ground station and the signal quality of all the ground stations of the current ground system is poor and the signal quality of a ground station belonging to a different ground system is significantly better;;

3. the ISO 8208 flow control window of the ISO 8208 subnetwork SVC on the link remains closed for greater than 1 minute and the signal quality of all the ground stations of the current ground system is poor and the signal quality of a ground station belonging to a different ground system is significantly better. (See Section 3.2.3.2.4.1).

3.2.2.5.4.4.2 General Ground Response

If the ground LME receives the XID\_CMD\_LE (P=1), it **shall** confirm link establishment by sending an XID\_RSP\_LE (F=1) frame containing the parameters per Tables 3-48a, b, and c. The ground LME **shall** include in the XID\_RSP\_LE (F=1) any optional parameters for which it is not using the default values. If the XID\_RSP\_LE (F=1) includes the Autotune parameter, then the Replacement Ground Station List parameter **shall** be included indicating the ground stations on the new frequency with which the aircraft LME can establish a new link using the operating parameters specified in the XID\_RSP\_LE (F=1). If the XID\_RSP\_LE (F=1) does not include the Autotune parameter, the ground LME **can** include the Replacement Ground Station List parameter if it wishes to indicate the ground stations that can be reached on the current frequency using the **same** operating parameters as the transmitting station. If the ground station supports IOA then it shall include the IPS address parameter in the XID\_RSP\_LE (F=1) frame

3.2.2.5.4.4.3 Exceptional Cases

If an LME receiving the XID\_CMD\_LE (P=1) cannot establish the link with the sending LME, then it **shall** transmit an XID\_RSP\_LCR (F=1) instead of an XID\_RSP\_LE (F=1).

If the parameters in the XID\_RSP\_LE (F=1) from the ground LME are not acceptable to the aircraft LME, then the aircraft LME **shall** transmit a DISC to the ground.

If the Autotune parameter is included in the XID\_RSP\_LE (F=1) and the aircraft LME is unable to perform the autotune, then the aircraft **shall** respond with an XID\_CMD\_LCR (P = 0); the link established on the current frequency **shall** not be affected.

While waiting for a response to an XID\_CMD\_LE (P=1), an aircraft LME receiving any unicast frame other than a TEST or an XID **shall** retransmit the XID\_CMD\_LE (P=1) instead of transmitting a DM.

*Note: See Section 3.2.2.4.8 on the processing of an XID\_CMD.*

3.2.2.5.4.5 Link Parameter Modification (LPM)

3.2.2.5.4.5.1 Ground Initiation

The ground LME **shall** request a modification of an existing link connection's parameters by sending an XID\_CMD\_LPM (P=1) to the aircraft LME containing the parameters per Tables 3-48a, b, and c.

3.2.2.5.4.5.2 General Aircraft Response

The aircraft LME **shall** acknowledge with an XID\_RSP\_LPM (F=1) containing the parameters per Tables 3-48a, b, and c.

*Note: If Counter N2 is exceeded for the XID\_CMD\_LPM (P=1), the ground LME should attempt to handoff via another station before disconnecting the link to the aircraft.*

3.2.2.5.4.6 Aircraft-Initiated Handoff (AIHO)

The aircraft LME **shall** implement Aircraft-Initiated Handoff. The aircraft LME **shall** always set the “i” bit in the AVLC Specific Options to 1.

3.2.2.5.4.6.1 Aircraft Handoff

Once the aircraft LME has established a link to a ground station, it **shall** monitor the VHF signal quality on the link and the transmissions of the other ground stations. The aircraft LME **shall** initiate a handoff to a new ground station if any of the following events occur:

1. the VHF signal quality on the current link is poor and the signal quality of another ground station is significantly better;

2. the Counter N2 is exceeded on any frame sent to the current ground station;

3. the Timer TG2 expires for the current link;

4. the Timer TM2 expires. In this case, the aircraft **shall** autonomously tune to an alternate frequency (provided in a frequency support list) before initiating the handoff;

5. the ISO 8208 flow control window of the ISO 8208 subnetwork SVC on the link remains closed for greater than 1 minute. (See Section 3.2.3.2.4.1)

6. the aircraft is on a frequency acquired from a GSIF with the ‘gnd’ bit set to one and becomes airborne; or

7. the aircraft lands and has received a viable Frequency Support List (see section 3.2.2.5.2.7.1) within a GSIF with the ‘gnd’ bit set to one.

3.2.2.5.4.6.2 Site Selection Preference

When the aircraft is using ATN services, then the aircraft LME **shall** prefer to handoff to a ground station which indicates (in the GSIF) accessibility to the ATN air-ground router(s) with which the aircraft DTE has subnetwork connections and has acceptable link quality.

When the aircraft is using ATN services and there are no ground stations with acceptable link quality that offer access to the ATN air-ground router(s) with which the aircraft DTE has subnetwork connections and there is a ground station with better link quality that provides access to a different ATN air-ground router then the aircraft **shall** initiate a handoff to that ground station.

*Note: “Acceptable link quality” means that there is a reasonable expectation to be able to maintain the link and exchange messages.*

When the aircraft is using ATN services and there are no ground stations with acceptable link quality with access to any ATN air-ground router(s) then the aircraft **may** initiate a handoff to a ground station that does not offer ATN service.

*Note: If an aircraft has commenced approach to its destination airport and its current link is with a ground station whose Airport Coverage Indication parameter indicates that it does not provide coverage at the destination airport, then the aircraft should handoff to a ground station whose Airport Coverage Indication parameter indicates that it offers coverage at the destination airport when the aircraft is close enough to the destination ground station to establish and maintain a reliable connection.*

3.2.2.5.4.6.3 Interaction of LMEs

When an aircraft VME decides to switch from a ground station in one ground system (and thus associated with one LME) to a ground station in another ground system (and thus associated with a different LME in the aircraft), the new LME **shall** use the link establishment procedures and the old LME **shall** send a DISC when directed by the VME.

*Note: Optimally the old link should not be disconnected until after the new link is capable of carrying application data.*

3.2.2.5.4.6.4 General Ground Response

If the ground LME receives the XID\_CMD\_HO (P=1), it **shall** confirm the link handoff by sending an XID\_RSP\_HO (F=1) frame containing the parameters per Tables 3-48a, b, and c. The ground LME **shall** include in the XID\_RSP\_HO (F=1) the optional parameters for which it is not using the default values. If the XID\_RSP\_HO (F=1) includes the Autotune parameter then the Replacement Ground Station List parameter **shall** be included indicating the ground stations with which the aircraft LME can establish a new link on the new frequency, using the operating parameters specified in the XID\_RSP\_HO (F=1). If the XID\_RSP\_HO (F=1) does not include the Autotune parameter, the ground LME **shall** include the Replacement Ground Station List parameter if it wishes to indicate the ground stations which can be reached on the current frequency using the **same** operating parameters as the transmitting station.

3.2.2.5.4.6.5 Disconnecting Old Link

If the new and old ground stations are associated with different systems, the procedures of 3.2.2.5.4.6.3 **shall** be followed.

Otherwise, the aircraft LME **shall** set Timer TG5 when it receives the XID\_RSP\_HO (F=1) and has validated the received parameters. The ground LME **shall** set Timer TG5 after it transmits the XID\_RSP\_HO (F=1). In the event that a further handoff is performed while a TG5 timer is still running, the TG5 timer **shall** be expired and the previous link silently disconnected, prior to restarting TG5.

3.2.2.5.4.6.5.1 Disconnecting Old Link (Autotune Parameter Not Used)

Both stations **shall** preferentially use the new link once it has been created.Both stations **shall** continue to maintain the old link until their respective Timer TG5 expires, after which each will consider the link disconnected without sending or receiving a DISC.

3.2.2.5.4.6.5.2 Disconnecting Old Link (Autotune Parameter Used)

Both stations **shall** disconnect any remaining old link after TG5 expiration without sending or receiving a DISC.

3.2.2.5.4.6.6 Exceptional Cases

If the ground LME cannot satisfy the XID\_CMD\_HO, then it **shall** transmit an XID\_RSP\_LCR instead of an XID\_RSP\_HO; and the current link **is** not be affected.

While waiting for a response to an XID\_CMD\_HO, an aircraft LME receiving any unicast frame other than a TEST or an XID from any ground station other than the current station **shall** retransmit the XID\_CMD\_HO.

If the Counter N2 is exceeded on the XID\_CMD\_HO, the aircraft LME **shall** attempt to handoff to another ground station; the current link **shall** not be affected.

If the aircraft LME cannot perform the autotune, it **shall** transmit an XID\_CMD\_LCR (P=0); the current connection **shall** not be affected.

If the parameters in the XID\_RSP\_HO are not acceptable to the aircraft LME, then the aircraft LME **shall** transmit a DISC to the ground on the new link.

*Note: See Section 3.2.2.4.8 on the processing of an XID\_CMD.*

3.2.2.5.4.7 RESERVED

3.2.2.5.4.8 Ground-Initiated Handoff (GIHO)

If a ground LME implements this section, then it **shall** set the i bit in the AVLC Specific Options parameter to 1; otherwise, it shall set the i bit to 0.

3.2.2.5.4.8.1 Ground Action

To command an aircraft to establish a new link to a proposed ground station on the same frequency, the ground LME **shall** send via the proposed ground station an XID\_CMD\_HO (P=1) to the aircraft with parameters per Tables 3-48a, b, and c. If the ground LME will accept a handoff to other ground stations, the XID\_CMD\_HO (P=1) **shall** include the Replacement Ground Station List parameter specifying the link layer address of those other stations. Any operating parameters in the XID\_CMD\_HO (P=1) (either modification or informational) **shall** be valid for the transmitting station and for all ground stations listed in the Replacement Ground Station List parameter, except the Airport Coverage Indication parameter, Ground station Location and Nearest Airport ID parameter which are only valid for the transmitting ground station.

3.2.2.5.4.8.2 General Aircraft Response

The aircraft LME **shall** respond by sending an XID\_RSP\_HO (F=1) with parameters per Tables 3-48a, b, and c to either the proposed ground station or to the aircraft LME’s preferred ground station from the RGSL if the XID\_CMD\_HO (P=1) included the Replacement Ground Station List parameter.

3.2.2.5.4.8.3 Disconnecting Old Link

The aircraft LME **shall** set the Timer TG5 after it transmits the XID\_RSP\_HO (F=1). The ground LME **shall** set the Timer TG5 when it receives the XID\_RSP\_HO (F=1). Although new traffic will be sent over the new link, the old link **shall** not be disconnected immediately to allow any old traffic to be delivered.

3.2.2.5.4.8.4 Exceptional Cases

If the aircraft LME cannot accept the handoff request, it **shall** respond with an XID\_RSP\_LCR; the old link **shall** not be affected.

While waiting for a response to an XID\_CMD\_HO (P=1), a ground LME receiving any unicast frame other than a TEST or an XID from the aircraft **shall** retransmit the XID\_CMD\_HO (P=1).

If the parameters in the XID\_RSP\_HO (F=1) are not acceptable to the ground LME, then the ground LME **shall** transmit a DISC to the aircraft on the new link.

*Note:*

*1. See Section 3.2.2.4.8 on the processing of an XID\_CMD.*

*2. If Counter N2 is exceeded for the XID\_CMD\_HO, the ground LME should attempt to handoff via another station before deleting all links to the aircraft.*

3.2.2.5.4.9 Ground-Requested Aircraft-Initiated Handoff (GRAIHO)

~~A ground LME~~ **~~shall~~** ~~not perform this function with aircraft that do not support Ground-Requested Aircraft-Initiated Handoffs as indicated in the AVLC Specific Options parameter bit 3 “i”.~~

Aircraft **shall** support GRAIHO uplinks.

3.2.2.5.4.9.1 Ground Action

For the ground LME to request an aircraft to initiate a handoff to an alternate frequency, it **shall** send an XID\_CMD\_HO (P=0) on the current link with parameters per Tables 3-48a, b, and c, including the mandatory Autotune parameter. The parameters in the XID (both modification and informational) are valid for all ground stations listed in the Replacement Ground Station List. The Replacement Ground Station List parameter applies to the new frequency.

3.2.2.5.4.9.2 General Aircraft Response

If the aircraft LME receives the XID\_CMD\_HO (P=0), it **shall** commence an aircraft-initiated handoff XID\_CMD\_HO (P=1) to a ground station, preferably one listed in the Replacement Ground Station List parameter.

*Note: See Section 3.2.2.4.8 on the processing of an XID\_CMD.*

3.2.2.5.4.9.3 Exceptional Cases

If the aircraft LME cannot initiate the handoff, it **shall** send an XID\_CMD\_LCR (P=0); and maintain the current link. If the aircraft LME cannot perform the autotune, it **shall** transmit an XID\_CMD\_LCR (P=0); and maintain the current link. The aircraft LME **shall** retransmit on the new frequency the XID\_CMD\_HO (P=1) using the normal retransmission procedures. If the aircraft station fails to connect to a ground station after the aircraft retunes, the aircraft LME **shall** retune to the CSC and attempt link establishment.

*Note:*

1. *If Counter N2 is exceeded for the XID\_CMD\_HO (P=0), the ground LME should send a Ground Initiated Handoff ~~attempt to request a~~ ~~ground-based requested air-initiated handoff~~ (XID\_CMD\_HO (P=1)) via another station before disconnecting all links to the aircraft.*

*2. If an aircraft station fails to establish the requested connection on the new frequency, it may use information available on the new frequency to determine alternate viable ground stations before reverting to the CSC.*

3.2.2.5.4.10 Ground-Requested Broadcast Handoff

If the ground LME broadcasts link handoffs then it **shall** set the b1 bit in the AVLC Specific Options parameter to 1; otherwise, it **shall** set the b1 bit to 0. If the ground LME supports broadcast 8208 subnetwork connection handoff, the ground LME **shall** also support broadcast link handoffs and **shall** set the b1 and bs bits in the AVLC Specific Options parameter to 1; otherwise, it **shall** set the bs bit to 0.

*Note:*

1. *See Table 3-18 for definition of b1 and b2 bits.*

*2. This is an optional aircraft capability*.

3.2.2.5.4.10.1 Ground Action

If the ground LME supports broadcast link handoffs, for each aircraft that indicates it supports broadcast link handoff, the ground LME **shall** confirm the link handoff by including the Broadcast Connection parameter per Tables 3-48a, b, and c. If the ground LME supports broadcast subnetwork connection management, for each aircraft that indicates it supports broadcast subnetwork connection management, the ground LME **shall** confirm the link handoff and the subnetwork connection maintenance by including the Broadcast Connection parameter per Tables 3-48a, b, and c.

3.2.2.5.4.10.2 Aircraft Response

The LME in each aircraft **shall** process received broadcast XID\_CMD\_HO (P=0) and determine if the ground LME had performed a broadcast link recovery (and possibly an expedited subnetwork recovery) for it. It **shall** do this by verifying that the Ground Station Address Filter parameter contains the DLS address of the ground station that it is connected to and that a Broadcast Connection parameter exists containing its aircraft address. Aircraft LMEs supporting broadcast recovery **shall** consider that a link handoff has occurred with the new link having the same parameters as the old link (as modified by the parameters in the broadcast XID). The old link **shall** be disconnected immediately.

The Broadcast Connection parameter **shall** include the 8208 subnetwork connection information (i.e., the M/I and LCI subfields) for only those 8208 subnetwork connections between the aircraft DTE and the peer ground DTEs that the ground LME maintained. Aircraft LMEs supporting broadcast subnetwork connection management **shall** process the remainder of the Broadcast Connection parameter to determine which subnetwork connections the ground LME maintained. For those subnetwork connections associated with the logical channels on the old link that the ground LME maintained, the aircraft DTE **shall** consider as if the CALL REQUEST and CALL ACCEPTED sent on the old link were resent on the new link (except that the M/I bit in the Broadcast Connection parameter **shall** supersede the value in the previous CALL ACCEPTED). At this point the aircraft DTE, ground DCE, and ground DTE **shall** be initialized. If the Broadcast Connection parameter indicates that the ground was not able to maintain a subnetwork connection (i.e., a particular LCI is not mentioned in the Broadcast Connection parameter), the aircraft **shall** explicitly establish this subnetwork connection per Section 3.2.3.6.3.3.1.

3.2.2.5.4.10.3 Exceptional Cases

If the aircraft LME does not support broadcast recovery, but the ground LME performed a broadcast link recovery for it, then the aircraft LME **shall** perform ~~either~~ an air-initiated link handoff. ~~(if the aircraft LME supports same) or request a ground-initiated link handoff.~~

If the aircraft LME finds the new ground station unacceptable, it **shall** perform an air-initiated handoff ~~(if the aircraft LME supports same) or request a link handoff~~.

If the Ground Station Address Filter parameter does not equal the DLS address of a link that the aircraft LME has or if no aircraft identifier subfield in a Broadcast Connection parameter equals its aircraft address, the aircraft LME **shall** not process the ground requested broadcast handoff.

If the aircraft LME supports broadcast link handoffs but does not support broadcast subnetwork connection management and the Broadcast Connection field is implemented per Tables 3-48a, b, and c, the aircraft **shall** explicitly establish its subnetwork connections.

If the Broadcast Connection parameter indicates that a subnetwork connection was maintained, but the aircraft LME does not recognize that subnetwork connection, then the aircraft DTE **shall** transmit a CLEAR REQUEST for each unrecognized subnetwork connection.

3.2.2.5.4.11 Ground-Requested Autotune

This section summarizes the autotune details found in Sections 3.2.2.5.4.4 (AILE), 3.2.2.5.4.6 (AIHO), and 3.2.2.5.4.9 (GRAIHO).

3.2.2.5.4.11.1 Ground Action

To request an aircraft LME to handoff to a ground station on a different frequency, the ground LME **shall** include the Autotune and Replacement Ground Station List parameters in an XID it sends during a link establishment (XID\_RSP\_LE (F=1)) or handoff procedure (GRAIHO XID\_CMD\_HO (P=0) or AIHO XID\_RSP\_HO (F=1)).

*Note: Ground service providers should be aware that if the Replacement Ground Station List contains a large number of ground stations, the aircraft may take a significant period of time to attempt each ground station in turn, during which time the aircraft will remain out of communication*.

3.2.2.5.4.11.2 General Response

‘Silently disconnect’ refers to the disconnection of an existing link without sending of a DISC. Typically, this is performed when the peer entity can be assumed to have also disconnected the link by procedural means, such as expiration of a timer.

3.2.2.5.4.11.2.1 Aircraft Response

On receipt of an XID containing an autotune parameter and when permitted by the aircraft preferences for the ground service provider, the aircraft LME **shall** silently disconnect any existing AVLC link it has with the same ground service provider and then retune the aircraft radio to the new frequency indicated in the Autotune parameter and commence an aircraft-initiated handoff to the chosen ground station selected from the Replacement Ground Station List parameter. When attempting an air-initiated handoff in accordance with an Autotune request, the aircraft LME **shall** retransmit the XID\_CMD\_HO (P=1) on the new frequency using the normal retransmission procedures, until either counter N2 is exceeded, or else an XID\_RSP\_HO (F=1) has been received. If counter N2 is exceeded, the aircraft **shall** attempt a handoff to another ground station from the Replacement Ground Station List. If all stations in the RGSL have been attempted, then the aircraft **shall** switch to the CSC to perform link establishment.

3.2.2.5.4.11.2.2 Ground Response

When the ground service provider receives a request to establish a new link on a new frequency by means of an XID\_CMD\_HO (P=1), it **shall** silently disconnect any existing link with the aircraft station through any of its ground stations and respond to the request.

3.2.2.5.4.11.3 Exceptional Cases

If the aircraft LME cannot perform the autotune, it **shall** transmit an XID\_CMD\_LCR (P = 0); the current link **shall** not be affected.

*~~Note:~~*

*~~1. When the ground system requests an autotune, the parameters and the VSDA reachable through the original ground station (if applicable) should be maintained for each station in the Replacement Ground Station List associated with the autotune.~~*

*~~2. This provision eliminates the potential complication of the ground maintaining an IDRP Route that is incapable of reaching the aircraft during an autotune.~~*

3.2.2.5.4.12 Frequency Support List-assisted Frequency Management

If an FSL is provided in an uplink XID (GSIF or other XID) and the aircraft station determines the need to change frequency, the aircraft station **shall** attempt the available frequencies advertised in the FSL to connect and maintain communications with peer ground systems. When the aircraft is airborne it should use the FSL in accordance with Section 3.2.2.5.4.12.1 below and when on the ground in accordance with Section 3.2.2.5.4.12.2.

The first frequency/ground station selection **shall** be made at random from the FSL, so as to give an equal probability of selecting any entry. If the handoff is not successful and there is another frequency/ground station entry in the FSL, then another handoff attempt **shall** be made until each frequency/ground station entry is tried once using normal retransmission logic. If the resulting new link is disconnected by the ground station while the aircraft’s TG5 timer is running, the aircraft station cannot assume that the previous link is still valid. In such a case, the aircraft station **shall** consider the handoff to have failed and attempt a handoff to another frequency/ground station as described above. If all of the handoff attempts fail, then the aircraft station **shall** switch to the CSC and collect ground station information for a possible link establishment.

Ground stations advertised in the FSL **shall** use the same operating parameter values as the FSL transmitting station, with the possible exception of the following parameters: ATN Router NET, AVLC Specific Options, Airport Coverage Indication and Nearest Airport and Ground Station Location. (similar to Replacement Ground Station List used in the Autotune procedure). However, the AVLC Specific Options parameter shall include the services (AOA, ATN AND/OR IOA) currently used by the aircraft.

*Note: The CSC is always considered available regardless of its inclusion or exclusion from air or ground FSL.*

3.2.2.5.4.12.1 Frequency Support List for Aircraft in the Air

If the “gnd” bit in the AVLC Specific Options parameter of a GSIF is set to zero, then the FSL **shall** be used by aircraft which are airborne. When airborne, the aircraft station **shall** use the FSL either:

1. following transition from the ground to air as described in Section 3.2.2.5.4.12.2, or else
2. to perform the frequency recovery, per Section 3.2.2.5.4.1.2, whenever it is unable to establish or maintain a link on the current frequency or when Timer TM2 expires.

An airborne aircraft station **shall** not change to a frequency from the FSL under any other circumstances. The GSIFs on a ground frequency **shall** contain an FSL and the AVLC options parameter with the “gnd” bit set to zero.

Aircraft in the air **shall** not use an FSL carried in a GSIF with the “gnd” bit set to one.

3.2.2.5.4.12.2 Frequency Support List for Aircraft on the Ground

If the “gnd” bit in the AVLC options parameter of a GSIF is set to one, then the FSL **shall** be used by aircraft stations which are on the ground at the airport identified by the Airport Coverage Indication parameter in the GSIF. Aircraft stations which support the “gnd” bit and which are on the ground **shall** attempt a handoff to a frequency and associated ground station(s) in the Frequency Support List. When the aircraft station is on the ground, it **shall** only use ground stations that advertise coverage for the airport at which the aircraft is located.

*Note 1****:*** *It is recognized that the aircraft may receive an FSL for use in the air without receiving an FSL for use on the ground. In that case, if the aircraft lands it should remain on its current frequency. It is up to the ground system to determine if an alternate frequency is desirable and use a GRAIHO to attempt to rectify the frequency used.*

In the event that all handoffs on the ground frequency fail, the aircraft station **shall** then revert to, and remain on, the CSC (no more attempts to use the ground FSL) until the aircraft takes off. The aircraft is still obligated to change frequency if it receives an autotune.

Once an aircraft station on a ground frequency leaves the ground, its LME **shall** handoff to a frequency and associated ground station received from the FSL of a GSIF with the “gnd” bit set to zero. If there is no non-ground FSL frequency known by the aircraft station, the aircraft station **shall** tune to the CSC.

Aircraft stations which are unable to determine whether the aircraft is on the ground or in the air **shall** not attempt to use a ground frequency.

*Note 2****:*** *The ground system should examine the A/G bit of any downlink AVLC XID frame attempting to establish a link or perform a handoff to a ground station on a ground frequency. In the event that the A/G bit indicates that the aircraft is not on the ground, the link should not be established, and the ground should respond with an XID\_RSP\_LCR (LCR Cause code 09h).*

3.2.2.5.4.13 Expedited Subnetwork Connection Management

If an LME implements this function, then it **shall** set the v bit in the AVLC Specific Options and in the Connection Management parameters to 1; otherwise it **shall** set them to 0. This function **shall** only be applicable for the link establishment and air-initiated handoff processes.

*Note: See Table 3-18 for definition of v bit.* *The Expedited Subnetwork establishment procedure can only be used when connecting with a ground station that supports ATN/OSI. Expedited Subnetwork establishment cannot be used with a VDL mode* *2 ground station that only supports AOA or ATN/IPS services.*

3.2.2.5.4.13.1 Initiating Station of Subnetwork Connection Management

To perform an expedited subnetwork connection establishment or maintenance, the initiating LME **shall** include in the XID\_CMD the Expedited Network Connection parameter for each subnetwork connection that needs to be established or maintained. The procedures for an expedited link establishment and maintenance **shall** be the same as outlined in Sections 3.2.2.5.4.4, 3.2.2.5.4.6, and 3.2.2.5.4.8.

3.2.2.5.4.13.2 General Responder Action

If the responding LME receives an XID\_CMD with one or more Expedited Network Connection parameters, it **shall** confirm subnetwork connection establishment or maintenance by sending an XID\_RSP containing the parameters per Tables 3-48a, b, and c. The responding LME **shall** attempt to establish or maintain the specified subnetwork connections as outlined in Section 3.2.3.6.3. The responding LME **shall** include in the XID\_RSP the CALL ACCEPTED or CLEAR REQUEST responses (i.e. in the Expedited Network Connection parameter) and any optional parameters for which it is not using the default values. The ground LME **shall** not process the Expedited Network Connection parameters if it includes the Autotune parameter in the XID\_RSP.

3.2.2.5.4.13.3 Exceptional Cases

If the responding LME cannot support the Expedited Network Connection establishment or maintenance but can support the link establishment or handoff, it **shall** respond with XID\_RSP with the connection management v bit set to 0 and **shall** not include the Expedited Network Connection parameters in the XID\_RSP.

If T3min expires, the responding LME **shall** include all responses (i.e. CALL ACCEPTED or CLEAR REQUEST) that it has received up to that point in the XID\_RSP. Any late responses from respective DTE(s) **shall** be sent to the initiating LME in INFO frames.

*Note: All XID\_CMD retransmissions will cause the responding LME to respond with the same XID\_RSP without further processing. All late subnetwork connection responses from ground DTEs will not be included in the retransmitted XID\_RSP.*

3.2.2.5.4.14 Ground Base Recovery When N2 Uplink Occurs

For various reasons, the ground station may send N2 uplink transmissions without receiving any response from the aircraft. From the aircraft perspective, the link may appear available (i.e., until there is a downlink transmission that may test the link). It is recommended that the ground system initiates a Ground Initiated Hand Off (GIHO) or a Ground Requested Air Initiated Hand Off (GRAIHO) as soon as the N2 uplink transmissions are completed (last expiration of T1) without receiving a response from the aircraft.

*Note 1: It is recommended that a GIHO is sent in preference to a GRAIHO, since the GIHO is sent via a new GS selected by the ground service provider, and is more likely to succeed. A GRAIHO is required by ICAO standards to be sent over the existing link via the current GS, which is already experiencing a dysfunctional uplink.*

*The aircraft may receive the GIHO or GRAIHO command and perform a hand-off. That would minimize the undetected loss of communication.*

*Immediate disconnection of the AVLC link (e.g., by a DISC sent by the ground station) is not considered as viable as it implies the disconnection of the ATN air-ground link, requiring reestablishment of the IDRP A/G Adjacency, involving additional overhead and delay.*

After the N2 failed uplinks, if the ground station receives any downlinks in sequence, the ground system should convey the downlinks to the layer above VDL mode 2 (AOA or ISO 8208 or ATN/IPS) as well as following the recommendation of initiating a GIHO or a GRAIHO.

*Note 2: The downlink may not be acknowledged successfully by the ground station, but will be delivered. The GIHO or GRAIHO should lead to a link with a new ground station, and once that new link is in place, the previous dysfunctional link should be silently disconnected by the established TG5 procedure.*

If the Ground Station (GS) that transmitted the GIHO does not receive a HO\_RSP or LCR then the GS should retransmit the GIHO according to the established procedures (N2-T3).

If the aircraft receives a GIHO while an aircraft initiated handoff is in progress, then the aircraft **shall** ignore the GIHO or send an LCR response per section 3.2.2.5.4.8.4.

If the ground station receives an AIHO while a ground station GIHO initiated handoff is in progress, then the ground station **shall** cease sending the GIHO and respond to the AIHO.

If the aircraft receives a GRAIHO while an aircraft initiated handoff is in progress, then the aircraft **shall** ignore the GRAIHO or downlink an LCR per section 3.2.2.5.4.9.3.

If the ground station receives an AIHO while a ground station GRAIHO initiated handoff is in progress, then the ground station **shall** cease sending the GRAIHO and respond to the AIHO

3.2.3 Subnetwork Layer Protocols and Services

This version of MASPS defines three subnetwork layer protocols and services:

1. ISO 8208 to support ATN (MASPS original subnetwork protocol and service)
2. ACARS Over AVLC (AOA) see section 3.2.5.
3. IPS Over AVLC (IOA) see section 3.2.4.
4. FIS?

3.2.3.1 Architecture

The subnetwork layer protocol used across the VHF A/G subnetwork is referred to formally as a subnetwork access protocol (SNAcP). The SNAcP is referred to within this document as the subnetwork protocol. If there are any differences between this document and the cited specifications, this document **shall** have precedence.

The VDL Mode 2 system is capable of supporting multiple network protocols over AVLC (link layer) at the same time, enabling AOA and ATN and IOA services to co-exist over the VDL Mode 2 media. The data link layer frame can carry either packet type, with a signature component for the host to differentiate between the different types of frames. The signature component identifier is the ISO/IEC 9577 header, see the specific subnetwork sections for the details for a particular subnetwork.

When ISO 8208 is the subnetwork used by the aircraft then the aircraft entity **shall** act as a DTE and the ground subnetwork entity acts as a DCE.

*Note: Refer to ISO 8208 for information on the DTE-DCE or DTE-DTE relationships.*

3.2.3.1.1 ISO 8208 Access Points for ATN

The Subnetwork Service Access Point (SNSAP) **shall** be uniquely identified by the subnetwork Data Terminal Equipment (DTE) address. SNSAPs **shall** define the Subnetwork Point of Attachment (SNPA) used by the service primitives that define the subnetwork service to the subnetwork dependence convergence protocol.

3.2.3.1.2 ACARS Over AVLC (AOA)

AOA is a service that encapsulates ACARS messages within an AVLC frame for transmission over the VDL Mode 2 system. See section 3.2.6 herein for AOA specification. AOA is provided as a service to the users of the datalink services to support AOC messages/applications and FANS 1/A.~~.~~

The ISO 9577 Initial Protocol Identifier (IPI) byte encoding of all-ones (0xFF) is reserved by ISO/IEC TR 9577 to allow for the specification of additional subnetwork protocols beyond those explicitly defined in the ISO document. When this form of IPI encoding is employed, a second octet (the Extended Initial Protocol Identifier (EIPI)) is used to specify the actual subnetwork protocol in use. The "ACARS Over AVLC" (AOA) subnetwork protocol (used to provide backwards compatibility for ACARS applications to operate over VDL Mode 2) currently specifies the EIPI encoding of 0xFF.

The IPI and EIPI **shall** be set in the first two octets of the uplink and downlink Information frame containing an AOA message as illustrated in Table 3-49. The IPI set to “1111 1111” indicates that the IPI is extended by one octet. The second octet, EIPI set to “1111 1111” indicates the payload, or user data, is an ACARS 618/620 block aka AOA message.

*Note: The values for the IPI and EIPI are the same for both uplink and downlink frames.*

Table 3-49: AOA Message Format within the AVLC frame

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | |  | BIT NUMBER | | | | | | | | | | | | | | | |
| DESCRIPTION | | | | Octet No. | 8 | | 7 | 6 | | | 5 | | 4 | | | 3 | | 2 | | 1 |
| FLAG | | | | 0 | 0 | | 1 | 1 | | | 1 | | 1 | | | 1 | | 1 | | 0 |
| ISO 3309:1996(E) [3] | | Destination Address Field | 1 | d22 | d23 | | | d24 | d25 | | d26 | | | d27 | | A/G | | | 0 |
| 2 | d15 | d16 | | | d17 | d18 | | d19 | | | d20 | | d21 | | | 0 |
| 3 | d8 | d9 | | | d10 | d11 | | d12 | | | d13 | | d14 | | | 0 |
| 4 | d1 | d2 | | | d3 | d4 | | d5 | | | d6 | | d7 | | | 0 |
| Source Address Field | 5 | s22 | s23 | | | s24 | s25 | | s26 | | | s27 | | C/R | | | 0 |
| 6 | s15 | s16 | | | s17 | s18 | | s19 | | | s20 | | s21 | | | 0 |
| 7 | s8 | s9 | | | s10 | s11 | | s12 | | | s13 | | s14 | | | 0 |
| 8 | s1 | s2 | | | s3 | s4 | | s5 | | | s6 | | s7 | | | 1 |
| Link Control Field | | | 9 |  | |  |  | | | P/F | |  |  | | | |  | |  |
| Information  Field | Initial Protocol Identifier (IPI) | | 10 | 1 | | 1 | 1 | | | 1 | | 1 | 1 | | | | 1 | | 1 |
| Extended IPI | | 11 | 1 | | 1 | 1 | | | 1 | | 1 | 1 | | | | 1 | | 1 |
| User Data | | 12.. N-2 | ARINC 618/620 Message | | | | | | | | | | | | | | | |
| Frame Check Sequence Field | | | N-1 | fcs9 | | fcs10 | MOST SIGNIFICANT OCTET | | | | | | | | | | | fcs15 | fcs16 |
| N | fcs1 | | fcs2 | LEAST SIGNIFICANT OCTET | | | | | | | | | | | fcs7 | fcs8 |
| Flag | | | N+1 | 0 | | 1 | 1 | | | 1 | | 1 | 1 | | | | | 1 | 0 |
| Reference VDL mode 2 SARPs, Figure 6-2, VDL mode 2 Technical Manual Figure 5-1 | | | | | | | | | | | | | | | | | | | |

3.2.3.1.3 Flight Information Services-Broadcast (FIS-B)

RTCA SC-195 has developed Minimum Aviation System Performance Standards (MASPS) for Flight Information Services-Broadcast (FIS-B), an automated, media-independent digital data link system. The system will provide non-control, advisory information needed by pilots to operate more safely and efficiently in the National Airspace System and in international airspace.

FIS provides to pilots the necessary weather graphics and text, Special Use Airspace (SUA) information, Notices to Airmen (NOTAMs), and other information.

This broadcast data provides connectionless unacknowledged protocol services. This broadcast data link service supports efficiency in spectrum use since there is no need to separately transmit the same information to multiple receivers.

One of the FIS-B media is the VDL Mode 2 subnetwork; consequently, there is a need to uniquely identify this service from other services that are or might be carried by VDL Mode 2, such as ATN, AOA and future applications. The FIS-B MASPS specify a field from within a VDL Mode 2 UI frame to uniquely identify a FIS-B message in accordance with the recommendations of ISO/IEC TR 9577. This field facilitates subnetwork access protocol identification in the event of multiple concurrent subnetwork use. The IPI is set to the 0xFF and, FIS-B has selected the EIPI encoding of 0xFE (11111110) as a frame type identifier.

The IPI and EIPI **shall** be set in the first two octets of the uplink Un-numbered Information broadcast frame as illustrated in Table 3-50. The IPI set to “1111 1111” indicates that the IPI is extended by one octet. The second octet, EIPI set to “1111 1110” indicates the payload, or user data, is a FIS-B block.

Table 3-50: FIS-B Message Format

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | | | | | | | | | | | | | | | | | | | | | | |
|  | | |  | BIT NUMBER | | | | | | | | | | | | | | | | | | | | |
| DESCRIPTION | | | Octet No. | 8 | 7 | | | 6 | | | 5 | | | 4 | | | 3 | | | 2 | | | 1 | |
| FLAG | | | 0 | 0 | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | 0 | |
| ISO 3309:1996(E) [3] | Destination Address Field | | 1 | d22 | | d23 | | | | d24 | | d25 | | | d26 | | | d27 | | | A/G | | 0 | |
| 2 | d15 | | d16 | | | | d17 | | d18 | | | d19 | | | d20 | | | d21 | | 0 | |
| 3 | d8 | | d9 | | | | d10 | | d11 | | | d12 | | | d13 | | | d14 | | 0 | |
| 4 | d1 | | d2 | | | | d3 | | d4 | | | d5 | | | d6 | | | d7 | | 0 | |
| Source Address Field | | 5 | s22 | | s23 | | | | s24 | | s25 | | | s26 | | | s27 | | | C/R | | 0 | |
| 6 | s15 | | s16 | | | | s17 | | s18 | | | s19 | | | s20 | | | s21 | | 0 | |
| 7 | s8 | | s9 | | | | s10 | | s11 | | | s12 | | | s13 | | | s14 | | 0 | |
| 8 | s1 | | s2 | | | | s3 | | s4 | | | s5 | | | s6 | | | s7 | | 1 | |
| Link Control Field | | | 9 |  | | |  | |  | | | | P/F | | |  | | |  | | |  | |  | |
| Un-numbered  Information  Field | | Initial Protocol Identifier (IPI) | 10 | 1 | | | 1 | | 1 | | | | 1 | | | 1 | | | 1 | | | 1 | | 1 | |
| Extended IPI | 11 | 1 | | | 1 | | 1 | | | | 1 | | | 1 | | | 1 | | | 1 | | 0 | |
| User Data | 12..N-2 | FIS-B | | | | | | | | | | | | | | | | | | | | | |
| Frame Check Sequence Field | | | N-1 | fcs9 | | | fcs10 | | MOST SIGNIFICANT OCTET | | | | | | | | | | | | | fcs15 | | fcs16 | |
| N | fcs1 | | | fcs2 | | LEAST SIGNIFICANT OCTET | | | | | | | | | | | | | fcs7 | | fcs8 | |
| Flag | | | N+1 | 0 | | | 1 | | 1 | | | | 1 | | | 1 | | | 1 | | | 1 | | 0 | |
| Reference VDL mode 2 SARPs, Figure 6-2, VDL mode 2 Technical Manual Figure 5-1 | | | | | | | | | | | | | | | | | | | | | | | | | |

3.2.3.2 ISO 8208 Services

This section specifies the ISO 8208 services offered by the subnetwork sublayer. The ISO 8208 services are described in an abstract manner and do not imply any particular implementations. The ISO 8208 services provided by the subnetwork to the subnetwork service user **shall** include the functions described in Sections 3.2.3.2.1 through 3.2.3.2.4.

3.2.3.2.1 ISO 8208 Subnetwork Connection Management

A variety of ISO 8208 packet types, procedures, and facilities **are** used to establish, terminate, and manage the 8208 connections across the VDL mode 2 subnetwork. Connection status information **is** maintained at both ends of the 8208 connection. Connection status information **should** be maximized to minimize amount of information passed with each data transfer phase transmission and that ground system operational control of the subnetwork is maximized.

3.2.3.2.2 ISO 8208 Packet Fragmentation and Reassembly

This ISO 8208 subnetwork capability **shall** perform the fragmenting of large data units passed from the subnetwork user for transmission across the A/G portion of the subnetwork. Reassembly **shall** be performed at the receiving end of the subnetwork.

Note: the fragment size supported by the A/G portion of the subnetwork is variable and can be different for uplinks and downlinks.

3.2.3.2.3 ISO 8208 Error Recovery

REJECT packet types **shall** be used for subnetwork-level error recovery. These packets **shall** be sent between subnetwork entities to cause retransmission of DATA packets and to recover from error response time-out states. Under no circumstances **shall** RESET or RESTART be used to recover from an error that can be handled by REJECT as described above. Aircraft DTEs **shall** accept REJECT packets and should retransmit the specified packets.

*Note: The ground DCE with which an aircraft has a VDL link should not clear subnetwork connections on receipt of REJECT packets but should retransmit the specified packet(s).*

3.2.3.2.4 ISO 8208 Connection Flow Control

ISO 8208 DATA packet sequence numbering combined with the use of the ISO 8208 sliding window **shall** be used for passive flow control.

*Note:*

*1. 8208 Receive Not Ready (RNR) packets should not be used for explicit flow control.*

*2. The use of explicit 8208 RNRs requires a subsequent packet to clear the f2 (DXE RECEIVE NOT READY) state. The 8208 RNRs and subsequent 8208 RR frames will cause more RF utilization than would be caused by merely delaying the acknowledgment.*

3.2.3.2.4.1 ISO 8208 Flow Control Window Closure

A complication is known to exist by which disruption on the VDL mode 2 uplink may cause the downlink VDL mode 2 ISO 8208 flow control window to close, followed by loss of AVLC at the ground station. The closure of the ISO 8208 downlink flow control window then prevents the aircraft from discovering the loss of the AVLC link, leading to a sustained loss of ATN end-to-end communication.

In order to recover from this condition, an aircraft **shall** detect whenever the SVC flow control window becomes closed. Closure of the flow control window is indicated when

P(S) = P(R) + W - 1 under modulo 8,

where

P(S) is the send sequence number of the last packet sent,

P(R) is the last receive sequence number, and

W is the window size.

In the event that closure of the flow control window persists for greater than 1 minute, the aircraft **shall** consider the underlying AVLC link to have been lost and commence an air-initiated handoff to another ground station.

3.2.3.3 ISO 8208 Packet Format

Except as qualified below, the packet format **shall** be as specified in ISO 8208, Section 12. During call setup, VDL mode 2 **shall** use the extended format in conjunction with the fast select facility.

3.2.3.3.1 ISO 8208 General Format Identifier

The Qualifier bit (Q-bit) in DATA packets **shall** be set to 0 in VDL mode 2. Modulo 8 sequencing **shall** be used in the VDL.

*Note: A subnetwork entity may receive a CLEAR CONFIRMATION with the appropriate cause code if the peer subnetwork entity wants to use modulo 128 sequencing.*

3.2.3.3.2 ISO 8208 Calling and Called DTE Addresses

Calling and called DTE addresses **shall** be as detailed in Sections 3.2.3.3.2.1 through 3.2.3.3.2.2.3.

3.2.3.3.2.1 ISO 8208 Encoding

Octet 4 **shall** consist of the address lengths, encoded as follows:

a) 4 least significant bits: called DTE address length; and

b) 4 most significant bits: calling DTE address length

Octet 5 and consecutive octets **shall** consist of the following address fields, in order:

a) called DTE address field

b) calling DTE address field

The A-bit in the General Format Identifier **shall** be set to 0 to indicate the use of this Address Block format.

3.2.3.3.2.2 ISO 8208 Address Field

The address length **shall** indicate the field length for the calling and called DTE addresses. The variable length field is known informally as the address field. The address field **shall** be encoded in BCD form. When the calling and called DTE address fields together occupy an odd number of BCD characters, the address field shall be padded to occupy an integer number of octets.

3.2.3.3.2.2.1 ISO 8208 Aircraft DTE Address

The aircraft DTE address **shall** be the BCD encoding of the octal representation of the 24-bit ICAO binary address.

3.2.3.3.2.2.2 ISO 8208 Ground DTE Address

The VDL mode 2 SARPs supports two ATN/OSI addressing options at the subnetwork layer. The default addressing is called VDL mode 2 Specific DTE Addressing (VSDA) and should be supported by all VDL mode 2 entities. Optionally, VDL mode 2 SARPs supports X.121 addressing. The VSDA address consists of six octets. When the ground station offers ATN/OSI services, then the first three octets of VSDA should be the same as the ATN Administration Domain Identifier (ADM) field as defined in the ATN SARPs. The service provider assigns the second three octets of VSDA. The service provider may use these three octets to uniquely address an air/ground ATN/OSI router or may use them as a routing area identifier (same as the ATN Administration Region Selector (ARS) field specified in the ATN SARPs ICAO Document 9880, Part 3, Section 3.4)). If the VSDA assigned by the ground service provider does not uniquely identify a specific air/ground router, then the ground system should support X.121 addressing option.

When the ground station does not offer ATN/OSI services and only offers AOA and/or ATN/IPS services then the VSDA value **shall** be all zeros.

3.2.3.3.2.2.2.1 ISO 8208 Ground VDL mode 2 Specific DTE Addressing (VSDA)

The VDL subnetwork specific ground DTE address **shall** be the binary representation of the NET (the facility is to convey the called address that was received from the ground station GSIF). ~~This default addressing is called VDL Specific DTE Addressing (VSDA). The VSDA consists of six octets. The first three octets of VSDA should be the same as the ATN Administration Domain Identifier (ADM) field as defined in the ATN SARPs. The air/ground router is assigned the second three octets of VSDA. The ground system may use these three octets to uniquely address an air/ground router or may use them as a routing area identifier (same as the ATN ARS field specified in the ATN SARPs ICAO Document 9880, Part 3, Section 3.4). If the VSDA assigned to a router does not uniquely identify a specific air/ground router, then the ground system should support X.121addressing option~~.

The VSDA **shall** be sent in the Called Address Extension facility. Bit 8 of the first octet after the facility code **shall** set to 1 and bit 7 shall be set to 0. The Called Address **shall** not be included when using VDL mode 2 subnetwork-specific ground DTE address.

3.2.3.3.2.2.2.2 ISO 8208 Ground Network DTE Addresses

If the ground LME indicates support of ground network DTE addresses during link establishment, it **shall** accept and process addresses which follow the format used in the ground network. All CALL REQUESTs from the ground **shall** use, as the Calling Address, the ground DTE's X.121 address.

*Note: This facility allows addressing of ground DTEs other than those associated with the ATN/OSI routers in the list of ATN router NETs. It requires, however, that the aircraft system management entity (SME) know or be informed via an application exchange of the address of the DTE in the ground network.*

3.2.3.3.3 ISO 8208 Call User Data Field

The fast select facility **shall** be used to carry VDL mode 2 mobile SNDCF Call User Data, including the intermediate system hello (ISH) PDU.

*Note: This reduces the number of transmissions required to set up the various layers. Refer to the ICAO Doc 9880, Part III, Section 3.7.6.2.1.4 and Doc 9739, Part IV, Sections 3.4.10.3 and 3.6.4.*

3.2.3.3.4 ISO 8208 Packet Types

Packet encoding **shall** be as specified in ISO 8208. VDL mode 2 **shall** not support the following ISO 8208 packet types: Interrupt, Interrupt Confirmation, and Receiver Not Ready.

3.2.3.4 ISO 8208 Subnetwork Layer Service System Parameters

The parameters listed in Table 3-51 **shall** be used in the subnetwork protocol. Except as noted in Section 3.2.3.6, the description of function and procedures **shall** be as documented in ISO 8208. For all parameters, Table 3-51 **shall** indicate the configured or negotiated values that **shall** be used by the aircraft DTE and the ground DCE. T21, T23, and R23 **shall** also apply to the ground DTE.

3.2.3.4.1 ISO 8208 Packet Size

The Packet Size **shall** be negotiated via the flow control parameter negotiation facility or Non-standard Default Packet Size facility to be the value in Table 3-51 appropriate to the mode for both directions.

3.2.3.4.2 ISO 8208 Parameter W (Transmit Window Size)

The parameter, W, **shall** be the maximum number of outstanding sequentially numbered data packets that may be transmitted before an acknowledgment is required. In the absence of negotiations via the nonstandard default packet size facility or the flow control parameter negotiation facility, this parameter **shall** be set per Table 3-51. W **shall** be negotiated to the same value in both directions.

Table 3-51: ISO 8208 Subnetwork Layer Service System Parameter

| **Symbol** | **Name** | **Minimum** | **Maximum** | **VDL Mode 2 Default** |
| --- | --- | --- | --- | --- |
| T20 | RESTART REQUEST response timer | 1 s | 300 s | 180 s |
| T21 | CALL REQUEST response timer | 1 s | 300 s | 90 s |
| T22 | RESET REQUEST response timer | 1 s | 300 s | 180 s |
| T23 | CLEAR REQUEST response timer | 1 s | 300 s | 180 s |
| T27 | REJECT response timer | 1 s | 300 s | 180 s |
| R20 | RESTART REQUEST retransmission count | 0 | 7 | 1 |
| R22 | RESET REQUEST retransmission count | 0 | 7 | 1 |
| R23 | CLEAR REQUEST retransmission count | 0 | 7 | 1 |
| P | Packet size | 128 octets | 2048 octets | 1024 octets |
| W | Transmit window size | 1 packet | 7 packets | 7 packets |
| A | Acknowledgment window size | 1 packet | 4 packets | 4 packets |
| LTC | Lowest two-way channel | 0 | 4095 | 1024 |
| HTC | Highest two-way channel | 0 | 4095 | 3071 |

*Note:*

*1. Parameter W is identical to the standard ISO 8208 parameter W.*

*2. Packet size (P) and Window sizes (W and A) define defaults and may be negotiated during call setup. Other parameter values are preset and are not negotiated.*

3.2.3.4.3 ISO 8208 Parameter A (Acknowledgment Window Size)

This parameter, A, **shall** be the minimum number of frames the receiver **shall** receive before it generates an ISO 8208 RR packet. Parameter A **shall** not be separately negotiated, but **shall** be set equal to the ceiling of half of W.

*Note: 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.*

3.2.3.5 ISO 8208 Effects of Layers 1 and 2 on the Subnetwork Layer

The subnetwork layer virtual circuit **shall** be valid only on the underlying link layer connection over which it was established.

3.2.3.6 ISO 8208 Description of Procedures

Except as noted in Sections 3.2.3.6.1 through 3.2.3.6.5, the provisions of ISO 8208 **shall** apply between the aircraft DTE and the ground DCE. If a ground DCE receives an unsupported packet layer facility, it either **shall** process the CALL REQUEST without altering the facilities or **shall** send a CLEAR CONFIRMATION.

3.2.3.6.1 ISO 8208 Supported Facilities

Table 3-52 lists options and facilities, documented in ISO 8208, that **shall** be supported by VDL.

Table 3-52:  ISO 8208 Facilities Supported by VDL Mode 2

| **Facility** | **ISO 8208 Section** |
| --- | --- |
| Packet Retransmission | 13.4 |
| Reject response timer (T27 timer) | 13.4.1 |
| Nonstandard Default Packet Sizes | 13.9 |
| Nonstandard Default Window Sizes | 13.10 |
| Flow Control Param. Negotiation | 13.12 |
| Fast Select | 13.16 |
| Fast Select Acceptance | 13.17 |
| Call redirection | 13.25 |
| Called line address modified notification | 13.26 |
| Called address extension | 14.2 |

3.2.3.6.2 ISO 8208 Unsupported Facilities

Table 3-53 lists the facilities, documented in ISO 8208, that **shall** not be supported by VDL Mode 2.

3.2.3.6.3 ISO 8208 Subnetwork Establishment and Connection Management

The subnetwork establishment and connection management options used **shall** be chosen as required by the operational conditions.

Table 3-53:  ISO 8208 Facilities Not Supported

| **Facility** | **ISO 8208 Section** |
| --- | --- |
| Q-bit | 6.6 |
| Non-receipt of window rotation information | 11.2 |
| Window status transmission timer (T24 timer) | 11.2.2 |
| On line facility registration | 13.1 |
| Extended packet sequence numbering | 13.2 |
| D‑bit modification | 13.3 |
| Incoming calls barred | 13.5 |
| Outgoing calls barred | 13.6 |
| One-way logical channel outgoing | 13.7 |
| One-way logical channel incoming | 13.8 |
| Default throughput classes assignment | 13.11 |
| Throughput class negotiation | 13.13 |
| Closed user group related facilities | 13.14 |
| Bilateral closed user group related facilities | 13.15 |
| Reverse charging | 13.18 |
| Reverse charging acceptance | 13.19 |
| Local charging prevention | 13.20 |
| Network user identification | 13.21 |
| Charging information | 13.22 |
| RPOA selection | 13.23 |
| Hunt group | 13.24 |
|  |  |
|  |  |
| Transit delay selection and indication | 13.27 |
| Calling address extension | 14.1 |
| Minimum throughput class negotiation | 14.3 |
| End-to-end transit delay negotiation | 14.4 |
| Expedited data negotiation | 14.5 |

3.2.3.6.3.1 ISO 8208 Subnetwork Entity Initialization

The ground DCE **shall** initialize on receipt of a valid XID\_CMD\_LE.

*Note: Only the subnetwork layer entities corresponding to the link on which the XID\_CMD\_LE/XID\_RSP\_LE is received will be initialized. The entities assigned to other links will not be affected.*

3.2.3.6.3.2 ISO 8208 Subnetwork Connection Establishment

Only aircraft DTEs **shall** request subnetwork connection establishment in the VDL mode 2 subnetwork.

3.2.3.6.3.2.1 ISO 8208 Explicit Subnetwork Connection Establishment

Immediately after link establishment, the aircraft DTE **shall** attempt to establish a subnetwork connection to at least one ground DTE. The aircraft DTE **shall** request a single subnetwork connection per ground DTE by the transmission of a CALL REQUEST packet specifying the ground DTE address. On receipt of the CALL REQUEST, the ground DCE **shall** attempt to establish a subnetwork connection to the aircraft DTE by responding with a CALL ACCEPTED packet; otherwise the ground DCE **shall** send a CLEAR REQUEST packet including the clearing cause and diagnostic code of the failure. If Ground Network X.121DTE addressing is implemented, then the ground DCE **shall** use the Called Line Address Modification Notification facility to inform the aircraft DTE of the ground DTE's X.121 address. Else, if the default Ground DTE addressing is implemented the ground DCE **shall** use the Called Address Extension facility to inform the aircraft of the ground DTE’s VSDA address that was delivered in the CALL REQUEST.

3.2.3.6.3.2.2 ISO 8208 Expedited Network Connection Establishment

An aircraft LME initiating expedited subnetwork connection establishment **shall** implement this section. The aircraft LME **shall** invoke the procedures described in 3.2.2.5.4.13 when connecting to a ground LME indicating support for expedited subnetwork connection procedures. The aircraft DTE **shall** reissue CALL REQUESTs for those logical channels for which responses (i.e. either a CALL ACCEPTED or a CLEAR REQUEST) were not included in the XID\_RSP\_LE. If Ground Network X.121 DTE addressing is implemented, then the ground DCE **shall** use the Called Line Address Modification Notification facility to inform the aircraft DTE of the ground DTE's X.121 address. Else, if the default Ground DTE addressing is implemented then the ground DCE **shall** use the Called Address Extension facility to inform the aircraft of the ground’s VSDA address that was delivered in the CALL REQUEST.

*Note: The CLEAR CONFIRMATION, if required, will be transferred in an INFO frame.*

3.2.3.6.3.3 ISO 8208 Subnetwork Connection Maintenance

During link establishment a ground DCE **shall** indicate its available routers in the ATN Router NETs parameter and the aircraft LME **shall** then attempt to maintain all subnetwork connections.

*Note: For subnetwork connections to be maintained across ground station changes, the LME gives preference in choosing a new ground station to ground stations indicating accessibility to the DTEs to which subnetwork connections already exist.*

3.2.3.6.3.3.1 ISO 8208 Explicit Subnetwork Connection Maintenance

To explicitly request subnetwork connection maintenance to a ground DTE, an aircraft DTE **shall** send a CALL REQUEST packet to the ground DTE with the fast select facility set containing a VDL mode 2 mobile SNDCF Call User Data Field indicating a request to maintain SNDCF context. If the ground DTE can accept the call, it **shall** respond with a CALL ACCEPTED packet with the fast select facility set containing a VDL mode 2 mobile SNDCF Call User Data field indicating whether the SNDCF context was maintained. If the Ground DTE or a DCE is unable to accept the call, it **shall** send a CLEAR REQUEST packet to the aircraft DTE including the clearing cause and diagnostic code of failure. If Ground Network X.121 DTE addressing is implemented, then the ground DTE **shall** use the Called Line Address Modification Notification facility to inform the aircraft DTE of the ground DTE's X.121 address. Else if the default Ground DTE addressing is implemented then the ground DCE **shall** use the Called Address Extension facility to inform the aircraft of the ground’s VSDA address that was delivered in the CALL REQUEST.

3.2.3.6.3.3.2 ISO 8208 Expedited Subnetwork Connection Maintenance

An LME initiating expedited subnetwork connection maintenance **shall** implement this section. If both the aircraft and ground LMEs support expedited subnetwork procedures, then the procedures described in Section 3.2.2.5.4.13 **shall** be invoked. The initiating DTE **shall** reissue CALL REQUESTs for those logical channels for which responses (i.e. a CALL ACCEPTED or a CLEAR REQUEST) were not included in the XID\_RSP\_HO. A ground DTE **shall** include its Calling Address in the appropriate field. If Ground Network DTE addressing is implemented, then the ground DTE **shall** use the Called Line Address Modification Notification facility to inform the aircraft DTE of the ground DTE's X.121 address. Else, if the default Ground DTE addressing is implemented then the ground DCE **shall** use the Called Address Extension facility to inform the aircraft of the ground’s VSDA address that was delivered in the CALL REQUEST.

*Note: The CLEAR CONFIRMATION, if required, will be transferred in an INFO frame. How the ground LME obtains the CALL REQUEST packet(s) (in ground-initiated handoffs) is outside the scope of this document.*

3.2.3.6.3.3.3 ISO 8208 Broadcast Subnetwork Connection Maintenance

An LME **shall** set the bs bit in the XID AVLC Specific Options parameter to 1 if it supports broadcast subnetwork connections. The procedures per Section 3.2.2.5.4.10 **shall** be invoked for each aircraft that indicates support for broadcast subnetwork procedures. The ground DTE and DCE and aircraft DTE **shall** assume those subnetwork connections have been created per Section 3.2.2.5.4.10. If an aircraft DTE cannot accept a call, it **shall** send a CLEAR REQUEST. If the ground DTE indicated that it maintained the SNDCF context but the aircraft DTE cannot maintain the SNDCF context, it **shall** send a CALL REQUEST indicating that the SNDCF context is not to be maintained.

*Note: The CLEAR CONFIRMATION, if required, will be transferred in an INFO frame. How the ground and aircraft LME know how to create the calls with their associated negotiated facilities is outside the scope of this document.*

3.2.3.6.3.4 ISO 8208 Call Redirection for X.121-based Networks

Even if the ground network supports X.121 addressing, the aircraft **shall** generate the new Call Request with the VSDA address of the specific air-ground router in the address extension field of the Called Address Extension facility. For JOIN and HANDOFF operations, the aircraft station **shall** always generate a Call Request using a VSDA address in the Called Address Extension facility

If the addressed air-ground router is not reachable from the ground station, the ground system **shall** redirect the call to a different air-ground router DTE and inform the aircraft about the call redirection using the Called Line Address Modification Notification (CLAMN) facility specified in Section 3.2.3.6.3.3.

*Note: A CLAMN facility can be used to modify the address for reasons other than redirection*.

Call redirection **shall** only be used in case of faults related to the air-ground router. The ground system **shall** only redirect a call to another address within the same routing domain (i.e., same Air-Ground Router).

3.2.3.6.4 ISO 8208 Error Handling

An aircraft DTE or ground DCE **shall** send a CLEAR REQUEST or RESTART REQUEST packet only for recovery from a DTE failure. When an aircraft DTE or ground DCE receives a DATA packet with a bad sequence number, it **shall** transmit a REJECT, as specified in ISO 8208, Section 13.4.

When an aircraft DTE receives a CLEAR REQUEST, it **shall** follow the ISO 8208 procedure for receiving an indication of virtual call clearing and attempt to re-establish the virtual circuit by sending a CALL REQUEST 60 seconds +/- 10 seconds after it received the CLEAR REQUEST.

***Note: If a CLEAR REQUEST is received that indicates that the reject reason is due to an offered service not being supported, then the CALL REQUEST may be reattempted once immediately removing the offering for the rejected service.***

When the CALL RESPONSE timer (T21) of an aircraft DTE expires, it **shall** attempt to establish another virtual circuit by sending a CALL REQUEST.

*Note: Following expiration of T21, the aircraft DTE will also clear the unsuccessful call following the ISO 8208 procedure.*

3.2.3.6.5 ISO 8208 RESET Handling

3.2.3.6.5.1 RESET events on a VDL mode 2 subnetwork virtual circuit shall be processed in accordance with ISO 8208, subject to the following additional requirements.

*Note: VDL mode 2 subnetwork RESET events may be originated either by the SNDCF (in accordance with ICAO Document 9880 Ed2, Section 3.7.4.3.4.5.2) or else by the Packet Layer (due to a protocol error such as an erroneous sequence number). In the case of an SNDCF (i.e. DTE user) originated RESET, the LREF table must be cleared on both air and ground sides, whereas in the case of a Packet Layer originated RESET, the LREF table is maintained on both sides. The Cause and Diagnostic codes in the RESET REQUEST packet are used to distinguish between these two cases.*

3.2.3.6.5.2 An aircraft or ground system generating an ISO 8208 RESET originated by the SNDCF in accordance with ICAO Document 9880 Ed2, Section 3.7.4.3.4.5.2 shall set the Cause code to 0x00 and the Diagnostic code to 0xFA in the RESET REQUEST packet.

*Note 1: Specification of a single Cause and Diagnostic code combination to represent an SNDCF originated RESET event is intended to promote interoperability between CSPs and avionics.*

*Note 2: The Cause and Diagnostic codes specified above have the meaning prescribed by ISO 8208 of “DTE originated reset – user resynchronization” which corresponds most closely to the circumstances of an SNDCF originated RESET.*

*Note 3: The referenced section of ICAO Document 9880 also requires the originator’s LREF table associated with the virtual circuit to be cleared under these circumstances.*

3.2.3.6.5.3 An aircraft or ground system generating an ISO 8208 RESET originated by the Packet Layer as a result of a protocol error shall set the Cause and Diagnostic codes in the RESET REQUEST packet in accordance with ISO 8208, avoiding use of the Cause and Diagnostic code combinations appearing in Table 3-54, and notify the local SNDCF to maintain the LREF table associated with the virtual circuit in the state that existed prior to the RESET.

3.2.3.6.5.4 An aircraft or ground system receiving a RESET INDICATION packet shall inspect the Cause and Diagnostic codes to establish whether it is an SNDCF originated or Packet Layer originated RESET.

3.2.3.6.5.5 An aircraft shall interpret a RESET INDICATION packet received with the Cause and Diagnostic codes specified in Section 3.2.3.6.5.2 as SNDCF originated, and notify the local SNDCF to clear the LREF table associated with the virtual circuit, as required by ICAO Document 9880 Ed2, Section 3.7.4.3.7.2.

3.2.3.6.5.6 Ground systems shall interpret a RESET INDICATION packet received with any Cause and Diagnostic code combination appearing in Table 3-54 as SNDCF originated, and notify the local SNDCF to clear the LREF table associated with the virtual circuit.

*Note 1: This measure is intended to provide backward compatibility with legacy avionics which set a range of different Cause and Diagnostic codes to indicate an SNDCF originated RESET (listed in Table 3-54) and which may remain in service for some time.*

*Note 2: It is strongly recommended that this measure should be implemented in the form of a configurable table, to facilitate adaptation to avionic behavior which may not have previously been recognized.*

3.2.3.6.5.7 An aircraft or ground system receiving a RESET INDICATION packet that is not in accordance with either of Sections 3.2.3.6.5.5 or 3.2.3.6.5.6 shall notify the local SNDCF to maintain the LREF table associated with the virtual circuit in the state that existed prior to the RESET.

Table 3-54: Cause and Diagnostic Codes Indicating Aircraft SNDCF Originated RESETs

|  |  |  |
| --- | --- | --- |
| Cause (hex) | Diagnostic (hex) | ISO 8208 Definition |
| 00 | FA | DTE originated – user resynchronization |
| 00 | E9 | DTE originated – reason unspecified |
| 00 | 00 | DTE originated – no additional information |
| 80 | 80 | DTE originated – specific diagnostic |
|  |  |  |
|  |  |  |

3.2.3.6.6 ISO 8208 Acknowledgments

An ISO 8208 RR packet **shall** be generated only when a DATA packet with a valid P(s) and P(r) is received, which closes the acknowledgment window. The aircraft DTE or ground DCE **shall** transmit an ISO 8208 RR packet acknowledging the outstanding packets as soon as it is able.

3.2.4 ISO 8208 VDL mode 2 Mobile SNDCF

3.2.4.1 ISO 8208 VDL mode 2 Mobile SNDCF Introduction

The VDL Mode 2 mobile SNDCF **shall** be the standard ISO 8208 mobile SNDCF specified in the ICAO Document 9880, Part 3, Section 3.7.6, except as described below.

3.2.4.2 RESERVED

3.2.4.3 ISO 8208 Call User Data Encoding

The Call User Data field of the CALL REQUEST and CALL ACCEPTED packets **shall** be used to carry SNDCF information, and is detailed below.

3.2.4.3.1 ISO 8208 ISH PDU

The ISH PDU **shall** be included in both the CALL REQUEST and CALL ACCEPTED packets user data fields.

3.2.4.3.2 ISO 8208 Maintained/Initialized (M/I) Status Bit

The fifth bit of the compression technique octet (i.e., the sixth octet of the Call User Data field) **shall** be the Maintained/Initialized (M/I) status bit which is used to indicate whether the SNDCF context (e.g., the compression state) was maintained from an old SVC to a new SVC.

3.2.4.3.3 ISO 8208 CALL REQUEST

If the calling SNDCF is requesting that the SNDCF context be maintained from an existing call to the new call being established, it **shall** set the M/I bit to 1; otherwise, the M/I bit is set to 0.

3.2.4.3.4 ISO 8208 CALL ACCEPTED

If the called SNDCF has successfully maintained the entire SNDCF context to the new call being established, it **shall** set the M/I bit to 1; otherwise, the M/I bit is set to 0.

3.2.5 ATN/IPS (IOA) Subnetwork Layer

To be provided by Collins, Stephane Pelleschi

3.2.6 ACARS AOA Subnetwork Layer

To be provided by Boeing, Tom McGuffin

APPENDIX M MASP’s to SARPs MATRIX

This Appendix provides correlation between the MASPS and each of three other documents; the Core SARPs, the Tech Manual for VDL-2 and the Tech Manual for VDL-3. The column on the right is for designation of an item as being relevant to aircraft (A) or ground (G) radios or both (B).

| **Table M-1 Correlation Matrix: DO-224D to Core SARPs** | | | |
| --- | --- | --- | --- |
| MASPS Section ID | MASPS Section Title | SARPs Section ID | Applicability Code |
| 1.1.2 | Definitions of Terms | 6.1.1 | B |
| 1.1.3 | Aeronautical VHF Communications Frequencies | 6.1.4.1 | B |
| 1.2 | VHF Voice and Data System Elements and Principles of Operation | 6.1 | B |
| 1.3 | General Applications | 6.1.3 | B |
| 1.3.1 | Introduction | 6.1.3 | B |
| 2.5.1 | Provision of Digital Voice and Data Link | 6.1, 6.1.3.2 | B |
| 3 | Technical Characteristics | 6.3 | B |
| 3.1 | Modes of Operation | 6.4.2 | B |
| 3.2 | VDL Mode 2 | 6.4 -6.4.3.4.1.1 | B |
| 3.2.1 | Physical Layer Protocols and Services | 6.4 | B |
| 3.2.1.1 | Functions | 6.4.1-6.4.1.1 | B |
| 3.2.1.1.1 | Transceiver Frequency Control | 6.4.1.1.1 | B |
| 3.2.1.1.2 | Data Reception by the Transceiver or Receiver | 6.4.1.1.2 | B |
| 3.2.1.1.3 | Data Transmission by the Transceiver or Transmitter | 6.4.1.1.3 | B |
| 3.2.1.1.4 | Notification Services | 6.4.1.1.(d) | B |
| 3.2.1.2 | Modulation Scheme | 6.4.2.1 | B |
| 3.2.1.2.1 | Data Encoding | 6.4.2.1.1 | B |
| 3.2.1.2.2 | Transmitted Signal Form | 6.4.2.1.2 | B |
| 3.2.1.2.3 | Modulation Rate | 6.4.2.2 | B |
| 3.2.1.3 | Training Sequence | 6.4.3.1.1 | B |
| 3.2.1.3.1 | Transmitter Ramp-up and Power Stabilization | 6.4.3.1.1.1 | B |
| 3.2.1.3.2 | Transmitter Power Ramp- Down | 6.4.3.3.2 | B |
| 3.2.1.3.3 | Synchronization and Ambiguity Resolution | 6.4.3.1.1.2 | B |
| 3.2.1.3.4 | Reserved Symbol | 6.4.3.1.1.3 | B |
| 3.2.1.3.5 | Transmission Length | 6.4.3.1.1.4 | B |
| 3.2.1.3.6 | Header FEC | 6.4.3.1.1.5 | B |
| 3.2.1.3.7 | Bit Transmission Order | 6.4.3.1.1.6 | B |
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1. ARINC Characteristics 597, 597A, 724, 724B, 758. ARINC Specifications 618, 619, 620. [↑](#footnote-ref-1)
2. See RTCA SC-172 WG-1 Report on VHF Air-Ground Communications System Improvements Alternatives Study and Selection of Proposals for Future Action: DO-225, Chap. 3-AM(R)S, ATS and AOC Requirements. [↑](#footnote-ref-2)
3. See RTCA SC-172 WG-1 Report on VHF Air-Ground Communications System Improvements Alternatives Study and Selection of Proposals for Future Action: DO-225, Chap. 3-AM(R)S, ATS and AOC Requirements. [↑](#footnote-ref-3)