AIR/GROUND CHARACTER-ORIENTED PROTOCOL SPECIFICATION

ARINC SPECIFICATION 618-6

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Specification 618-1	October 19, 1994	December 30, 1994
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Specification 618-5	June 26, 2000	August 31, 2000
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A description of the changes introduced by each supplement is included on Goldenrod paper at the end of this document.

FOREWORD

Aeronautical Radio, Inc., the AEEC, and ARINC Standards

Aeronautical Radio, Inc. (ARINC) was incorporated in 1929 by four fledgling airlines in the United States as a privately-owned company dedicated to serving the communications needs of the air transport industry. Today, the major U.S. airlines remain the Company's principal shareholders. Other shareholders include a number of non-U.S. airlines and other aircraft operators.

ARINC sponsors aviation industry committees and participates in related industry activities that benefit aviation at large by providing technical leadership and guidance and frequency management. These activities directly support airline goals: promote safety, efficiency, regularity, and cost-effectiveness in aircraft operations.

The Airlines Electronic Engineering Committee (AEEC) is an international body of airline technical professionals that leads the development of technical standards for airborne electronic equipment-including avionics and in-flight entertainment equipment-used in commercial, military, and business aviation. The AEEC establishes consensus-based, voluntary form, fit, function, and interface standards that are published by ARINC and are known as ARINC Standards. The use of ARINC Standards results in substantial benefits to airlines by allowing avionics interchangeability and commonality and reducing avionics cost by promoting competition.

There are three classes of ARINC Standards:

a) ARINC Characteristics – Define the form, fit, function, and interfaces of avionics and other airline electronic equipment. ARINC Characteristics indicate to prospective manufacturers of airline electronic equipment the considered and coordinated opinion of the airline technical community concerning the requisites of new equipment including standardized physical and electrical characteristics to foster interchangeability and competition.

b) ARINC Specifications – Are principally used to define either the physical packaging or mounting of avionics equipment, data communication standards, or a high-level computer language.

c) ARINC Reports – Provide guidelines or general information found by the airlines to be good practices, often related to avionics maintenance and support.

The release of an ARINC Standard does not obligate any airline or ARINC to purchase equipment so described, nor does it establish or indicate recognition or the existence of an operational requirement for such equipment, nor does it constitute endorsement of any manufacturer's product designed or built to meet the ARINC Standard.

In order to facilitate the continuous product improvement of this ARINC Standard, two items are included in the back of this volume:

An Errata Report solicits any corrections to the text or diagrams in this ARINC Standard.

An ARINC IA Project Initiation/Modification (APIM) form solicits any recommendations for addition of substantive material to this volume which would be the subject of a new supplement.

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1.0 AIR/GROUND COMMUNICATION

1.1 Introduction

The Aircraft Communications Addressing and Reporting System, known by the acronym 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 the airline's command, control, and management system.

The Aircraft Communications Addressing and Reporting System (ACARS) was introduced as an air/ground communications network utilizing the VHF aeronautical radio band. Later, ACARS was extended to use satellite communications system (SATCOM) as well. The ACARS consists of an airborne subsystem and a ground station network. The ground network is attached to the networks of subscriber airlines and other users such as aviation authorities.

With the support of the ground based service providers network, the airborne part of this air/ground data link enables equipment onboard an aircraft to function as a mobile communications terminal and, therefore, as if it were an integral part of an airlines internal data communications system.

This standard describes an optional functionality for existing ACARS air-to-ground communications protocols to function over the VHF Digital Link (VDL) Mode 2 Data Link Layer, referred to as ACARS Over AVLC (AOA). The Data Link Layer of VDL Mode 2 is called Aviation VHF Link Control (AVLC).

1.2 Purpose of This Document

This specification contains a compendium of provisions previously defined in ARINC Characteristics 546, 566, 716, 597, 724, and 724B. These characteristics contained redundant material which, when updated at various times, created contradictions and confusion as to which text was correct.

The purpose of this specification is to bring this redundant material into one document which should serve as the description of operation within the ACARS air/ground environment. This specification also serves to clarify contradictions in the above-mentioned documents and present new material which will bring the overall ACARS documentation into the current state which it has evolved over many years. The provisions listed herein are included by reference in the originating documents as appropriate and, therefore continue to apply as provisions of systems described in the originating documents.

In this document a reference to ARINC Characteristic 724/B refers to both ARINC Characteristic 724 and ARINC Characteristic 724B.

1.3 Document Organization

This Section provides an overview of ACARS and introduces the elements necessary for the communications function.

Section 2 outlines the air/ground block format in its entirety. Each of the fields of the message is introduced followed by a definition of the range of characters from the ISO-5 character set that are authorized for use in the field.

Section 3 defines the ACARS MU Message Handling Protocols including priorities and multiblock handling.

Section 4 describes the VHF ACARS.

Section 5 describes Link Management for a VHF air/ground network.

Section 6 defines an optional capability of the ACARS MU to allow the VHF transceiver which is used for Data communications, to be used for VOICE as well.

Section 7 describes the air/ground satellite link protocol for transporting character-oriented ACARS messages.

Section 8 describes the air/ground HF data protocol for transporting character-oriented ACARS messages.

Section 9 describes the processes needed to operate multiple communications media simultaneously and, when needed, discontinue use of one or more media.

Section 10 describes the requirements of the CMU for Mode A operation with the ARINC 750 Data Radio.

Section 11 describes how ACARS messages are transported over VDL Mode 2 data link layer.

Note: Initially the functionality described in this specification applied to ACARS Management Units (MU). With the introduction of the Communications Management Unit (CMU), the editorial device CMU was utilized in this specification to indicate that the provisions were to be applied to both LRUs. In Supplement 6, this nomenclature was abandoned. The nomenclature CMU should be read as applicable to both CMU and MU.

1.4 ACARS System Description

ACARS enables airborne devices to function as mobile communications terminals. See Attachment 1 which shows a typical end-to-end communications environment and applicable characteristics/manuals.

COMMENTARY

Generally, the airlines own and control their ground network and the aircraft network. Normally, a Data link Service Provider (DSP) supplies the air/ground network to pass messages between the airlines' airborne and ground networks. Some airlines own and operate their own VHF air/ground network. These airlines may also offer this service to other airlines as a service provider.

There are currently three types of air/ground networks. The first system introduced was the VHF ACARS which uses a VHF signal between the aircraft and a ground station. SATCOM ACARS was introduced later and uses a signal which passes from the aircraft to a communications satellite which itself is linked to a ground station. The ACARS message protocol described in this document is used over all media.

HF ACARS was introduced later and uses an HF signal between the aircraft and an HF ground station.

The format and protocols used to transfer messages between the ACARS User's ground system and the Data link Service Provider's network differs from the format and protocol used to exchange messages between the airborne user and the data link service provider. It is the responsibility of the data link service provider to provide translation between these formats and to provide message routing. Those two functions are described in ARINC Specification 620.

This document defines the protocol and message format for exchange of information by airborne user and the DSP across the air/ground link.

1.5 ACARS Components

1.5.1 Ground System Equipment

The service provider's ground network consists, as a minimum, of an ACARS data link service processor and a communications network connecting the processor and the ground stations.

For VHF ACARS, the ground stations consist of a microcomputer connected to a VHF receiver and transmitter. For SATCOM ACARS, the ground stations are connected to a ground earth station of a communications satellite operator. For HF ACARS the ground stations consist of a computer connected to an HF receiver and transmitter.

1.5.2 Airborne System Equipment

The airborne equipment consists of an ACARS Management Unit (MU) or the Communications Management Unit (CMU) operating as an ACARS MU. Older MUs are connected to an associated control/display device. The CMU is connected to the control/display unit (either dedicated or multi-purpose). Like the MU, the CMU may be connected to one or more ancillary equipment that supports the CMU in its function such as the Optional Auxiliary Terminal (OAT), Digital Flight Data Acquisition Unit (DFDAU), or cockpit printer.

To access the VHF ACARS air/ground network, the ACARS MU is connected to a VHF transceiver.

To access the satellite ACARS air/ground network, the ACARS CMU is connected to the Satellite Data Unit (SDU). The satellite system is described by ARINC Characteristics 741 and 761.

COMMENTARY

ACARS MUs are not designed to support the Network Layer functions required by SATCOM as described within ARINC Characteristic 741 and commonly referred to as Data Level 3 SATCOM (as described within the INMARSAT System Definition Manual (SDM). However, an ACARS CMU may be designed to support Data Level 2 SATCOM as described within the INMARSAT SDM. The ACARS CMU/SATCOM SDU protocol interface and a definition of SATCOM Data Levels are described within Section 7.0 of this Specification.

To access the HF ACARS air-ground network, the ACARS CMU is connected to the HF Data Unit (HFDU) or HF Data Radio (HFDR). The HF datalink system is described by ARINC Characteristic 753.

1.6 ACARS Messages

The ACARS air ground data link provides a general purpose data link capable of handling a wide variety of character-oriented messages.

Two message formats are utilized by the ground service provider. ACARS message formats used across the RF link with the aircraft are designed for efficient use of the spectrum. Other formats are used when data is exchanged between the service provider and the user airline’s ground facilities. See Section 2 of ARINC Specification 620 for further definition of the interaction of the service provider with user facilities.

The format of ACARS air/ground messages is defined in Section 2 of this specification. The definition of the text portion to be inserted for each specific message is contained in Section 6 of **ARINC Specification 620:** *Data Link Ground Systems Standard and Interface Specification*. The messages passed between the airline’s ground facilities and the service provider’s ground network should be formatted and processed in accordance with the ATA/IATA Interline Communications Manual (ICM).

1.6.1 Downlink Messages

Air-to-ground (downlink) messages transmitted from aircraft are received by the service provider’s ground station(s). One or more of these stations pass the message to a central processor for processing in accordance with the provisions of ARINC Specification 620.

1.6.2 Uplink Messages

Ground-to-air (uplink) messages are passed from the airlines’ network to the service provider who in turn converts it to data link format and sends the message to a ground station in its network for transmission to the aircraft. The air/ground protocol for the aircraft equipment then acknowledges receipt of the message.

1.7 Relationship to Other Documents

The documentation of the protocols to be exercised within the ACARS environment is shown pictorially in Figure 1-1 of Attachment 1 to this specification.

The protocols and procedures to be used for communications between the airborne user and the data link service provider network are described in this specification. The protocols used onboard the aircraft by subsystems participating in ACARS are defined in **ARINC Specification 619:** *Airborne Equipment Protocols for File Transfer of Character Data.*

The capabilities of the onboard equipment are defined in ARINC Characteristics 597, 724, or 724B as applicable. Information from these specifications and characteristics is not duplicated in this document except as necessary to clarify the data link service provider to data link user interface.

The protocols and procedures to be administered by the data link service provider are contained in **ARINC Specification 620:** *Data Link Ground System Standard and Interface Specification (DGSS/IS).*

The protocols used between the ground-based user and the data link service provider network are described in the ATA/IATA Interline Communications Manual (ICM).

1.8 Documents Referenced

This specification refers to a number of other documents. Most of these documents are published by ARINC. References to ARINC Standards should be interpreted as the most recent version of the mentioned document.

ARINC Specification 410: *Mark 2 Standard Frequency Selection System*

ARINC Specification 429: *Mark 33 Digital Information Transfer System (DITS)*

ARINC Characteristic 546: *Airborne VHF Communications Transceiver System* (No longer held in inventory)

ARINC Characteristic 566: *Airborne VHF Communications Transceiver & Mark 1 VHF SATCOM System*

ARINC Characteristic 566A: *Mark 3 VHF Transceiver*

ARINC Characteristic 597: *Aircraft Communications Addressing and Reporting System (ACARS)*

ARINC Specification 600: *Air Transport Avionics Equipment Interfaces*

ARINC Specification 619: *Airborne Equipment Protocols for Avionic End Systems*

ARINC Specification 620: *Data Link Ground System Standard and Interface Specification (DGSS/IS)*

ARINC Specification 622: ***ATS Data Link Applications over ACARS Air/Ground Network***

ARINC Specification 623: ***Character-Oriented Air Traffic Service (ATS) Application***

ARINC Specification 631: ***VHF Digital Link (VDL) Mode 2 Implementation Provisions***

ARINC Characteristic 716: *Airborne VHF Communications Transceiver*

1.0 AIR/GROUND COMMUNICATION

ARINC Characteristic 724: *Mark 2 Aircraft Communications Addressing and Reporting System (ACARS)*

ARINC Characteristic 724B: *Aircraft Communications Addressing and Reporting System (ACARS)*

ARINC Characteristic 741: *Aviation Satellite Communications System, Part 1 – Aircraft Installation Provisions*

ARINC Characteristic 741: *Aviation Satellite Communications System, Part 2 – System Design and Equipment Functional Description*

ARINC Characteristic 750: ***VHF Data Radio (VDR)***

ARINC Characteristic 758: *Communication Management Unit (CMU) Mark 2*

ARINC Characteristic 761: *Second Generation Aviation Satellite Communication System, Aircraft Installation Provisions*

Proceedings of the IRE, January 1961: *Cyclic Codes for Error Detection,* Code of Federal Regulations (USA)

VDL SARPs: *VHF Digital Link (VDL) Standards and Recommended Practices, Annex 10 to the Convention on International Civil Aviation, Volume III, Part I – Digital Data Communications Systems*, November 6, 1997.

ATN SARPs: *Aeronautical Telecommunication Network (ATN) Standard and Recommended Practices (SARPs) Sub-Volume 5 Internet Communications Service Version 2.2*, 16 January 1998.

ISO/IEC 3309: *1976(E) Data Communications – High-Level Data Link Control Procedures – Frame Structure*

ISO/IEC 4335: *1993(E) Information Technology – Telecommunications And Information Exchange Between Systems – High-Level Data Link Control Procedures (HDLC) – Elements Of Procedures*

ISO/IEC 7809: *1993 Information Technology – Telecommunications And Information Exchange Between Systems – High-Level Data Link Control (HDLC Procedures – Classes Of Procedures*

ISO/IEC 8885: *1993 Information Technology – Telecommunications And Information Exchange Between Systems – High Level Data Link Control (HDLC) Procedures – General XID Frame Information Field Content And Format*

ISO/IEC 8208: *1995(E) Information Technology – Data Communications –X.25 Packet Layer Protocol For Data Terminal Equipment*

ISO/IEC 9755: *1990(E) Information Technology – Protocol Identification In The Network Layer*

2.0 AIR/GROUND BLOCK STRUCTURE

2.1 General Format Description

The format of the Air/Ground message is governed by this specification.

The fields of ACARS messages are encoded according to the seven-unit convention specified in ICAO Annex 10. The ISO-5 character set is illustrated in Table 3-1 of Attachment 3. An eighth bit is added to each character to complete the octet and render character parity odd. In this specification, the ISO 5 characters are represented symbolically with an expression in the general form of (column/row) such as (1/6) to represent the SYN character.

The Block Check Sequence (error detection scheme) is composed of 16 bits which do not comply with this coding convention. The BCS characters are distinguished from communications control characters by their relative position.

Message blocks prepared for transmission should have the following format:

NAME OF FIELD	FIELD LENGTH (CHARACTERS)	NOTES
Start of Heading	1	
Mode	1	
Address	7	
Technical Acknowledgement	1	
Label	2	
Uplink/Downlink Block Identifier	1	
Start of Text	1	1
Text	220	2,3
Suffix	1	
Block Check Sequence (BCS)	2	16 bits
BCS Suffix	1	

Notes:

1. This character is used only for messages containing text.

2. Satellite Category B text size may be limited due to Ground-Ground communications restrictions. For example, Type B messages may be restricted to 3840 characters. Applications should break too large a message into multiple messages, if necessary.

3. VHF (Category A or B) or Satellite Category ACARS messages are limited to 16 blocks, each with at most 220 characters in the text field. Satellite Category B deviates from this limit if arrangements have been made with the service provider and CMU vendor.

2.2 Downlink Block Format

Refer to Table 15-1, in Attachment 15 for the General Format of Air/Ground Downlink Messages. The format shown is that of a message consisting of a single ACARS block. The text of such a block is limited to 220 characters. It is possible to transmit longer messages by using multiple blocks. These longer messages are broken up into several blocks. See Section 3.6.2 for the construction of multiblock downlink messages.

The descriptions below expand on the use of these fields for downlink messages.

2.2.1 Start of Header

A Start Of Header (SOH) character (0/1) should be transmitted to indicate the start of the message header. The SOH character is also used to mark the beginning of the text to be evaluated by the Block Check Sequence (BCS) but should not be included in the characters on which the check is based.

2.2.2 Mode Character

The Mode characters are divided into two basic categories which refer to Category A (reference Section 5.8) or Category B (reference Section 5.9) network operation.

2.2.2.1 VHF Category A Mode Character

All Category A downlinks are uniquely identified with a 2 (3/2) in the Mode character position.

2.2.2.2 VHF Category B Mode Character

All Category B downlinks are identified with a Mode character within the block of characters @ (4/0) through (5/13). The actual Mode character inserted in each transmission depends upon the preferred ground system access code selected by the CMU based on the uplink Mode character as described in Section 2.3.2.2.

2.2.2.3 Satellite Category A Mode Character

The Mode character should be set to the value 2 (3/2) for default service provider routing.

2.2.2.4 Satellite Category B Mode Character

The Mode character can be set to select a specific satellite service provider. All Category B SATCOM downlinks are identified with a Mode character within the block of characters at <@> (4/0) through right bracket <]> (5/13). The Mode character inserted in each transmission identifies the DSP that the downlink is intended for.

SATCOM Category B Mode Characters are assigned permanently to each DSP. These assignments are found in Attachment 6.

2.2.2.5 HF Mode Character

The Mode Character is not used for HF. The default value of 2 should be entered in the Mode Character position.

2.2.3 Address

The information in the Address field identifies the aircraft with which the ground processor is communicating.

In air-to-ground messages, the Address field should contain the aircraft registration mark only as derived from the aircraft. The aircraft registration mark may be provided by wiring at the MU's interface within the aircraft (typical of Characteristic 597 and 724 MU's) or it may be provided in the form of ARINC 429 data words by an external sub-system (typical of the ARINC 724B MU).

The aircraft's registration mark should be encoded using ISO-5 characters (A-Z, 0-9, <->, and <.>) in accordance with the seven-unit character coding scheme shown below. In the event that the registration mark occupies less than seven characters, it should be right-hand justified and filled with leading periods. The most significant character of the address should be transmitted first, following any periods, thus:

Transmission Order	1	2	3	4	5	6	7
Registration Mark Address	.	.	N	3	8	7	2

The CMU should not transmit any downlink messages unless it has a valid aircraft registration mark. Once the CMU acquires the aircraft registration mark then it should remember it at least until power to the CMU is removed.

COMMENTARY

Optionally, the CMU may prompt the crew to enter the aircraft registration mark address when it is not provided by the aircraft. The CMU may store the aircraft registration mark in nonvolatile memory; however, precautions should be implemented to prevent the CMU from using an old aircraft registration mark when it is removed and reinstalled on a different aircraft, e.g., the CMU may detect removal from aircraft).

2.2.4 Positive Technical Acknowledgment

Every message should contain a one-character Positive Technical Acknowledgment field immediately following the Address field.

The Positive Technical acknowledgment character in a downlink message should consist of an A - Z (4/1 - 5/A), or a - z (6/1 - 7/A), or a NAK (1/5) control character.

2.2.5 Label

Each downlink message contains a two-character Label field in the message preamble. The Label character is used as a shorthand method of describing the message. One piece of information this field carries is a classification of the content of the message being transmitted.

The contents of the Label field may also be used to determine routing and addressing.

A list of assigned labels is defined in ARINC Specification 620.

The CMU should be capable of generating all downlinks identified as system-essential. The CMU need only generate those service-related downlinks specified by the user to his supplier.

2.2.6 Downlink Block Identifier

The Downlink Block Identifier (DBI) field is a single character field. The Downlink Block Identifier character should consist of a 0-9 (3/0 - 3/9) character.

COMMENTARY

Initially, the Downlink Block Identifier (DBI) was optional. The initial system definition did not include the DBI and there may still be some old avionics that don't implement the DBI.

2.2.7 End of Preamble

The end of preamble is indicated by the control character STX (0/2).

2.2.8 Text

The Text field is a field not exceeding 220 characters in length. For Satellite Category B the Text field may contain up to 3,520 characters*.* See Section 5 of ARINC Specification 620 for defined message lengths.

The Text field of all messages must consist of the non-control characters of the ISO-5 Character set. The Application Text may consist of entirely free text, entirely fixed text or a combination of fixed text followed by free text. The shaded portion of Table 3-1 in Attachment 3 indicates those characters that are not recommended in the "Free Text" portion of an air/ground message. Furthermore, portions of some ground networks are confined to the more limited baudot subset of ISO-5 characters. Thus, DSPs cannot ensure successful end-to-end delivery of messages containing non-baudot characters. The shaded portion of Table 3-2 in Attachment 3 indicates the characters which are outside the baudot subset. Use of any of these shaded characters in the "Free Text" portion is not recommended. See ARINC Specification 620 for a description of "Free Text".

Every downlink transmission should include a Message Sequence Number (MSN) and Flight Identifier as part of the message text.

The Message Sequence Number (MSN) is a four character field used for ground based message reassembly. Refer to Section 3.4.1 for details.

The Flight Identifier consists of a two character Airline Identifier and a four character Flight Number field. These two fields should be present in all downlinks. It is recommended that applications that require flight number information include it in the Text field portion of the message.

COMMENTARY

Some airline host systems currently require the Flight Identifier field to reflect the flight number that is in effect at the time a message is generated. In such cases, the Flight Identifier field may not necessarily contain the current operating flight number.

Aircraft Address (see Section 2.2.3) is used instead of Flight Identifier to uniquely identify Business and Commuter Aircraft. The Flight Identifier field of Business and Commuter aircraft is generally encoded with a fixed value (e.g., UV0000).

The CMU should not transmit any downlinks unless it has a valid airline identification. Once the CMU acquires the airline identification then it should remember it at least until power to the CMU is removed.

Optionally, the CMU may prompt the crew to enter airline identification even when it is provided by the aircraft. The CMU may store the airline identification in nonvolatile memory; however, provisions should be made to allow updating the airline identification.

In some downlinks additional information can include sublabels and addresses. Refer to Sections 3.2.2.1 and 3.2.3.2 of ARINC Specification 620 for details.

2.2.9 Suffix

Each single block should be terminated with the control character ETX (0/3).

In multiblock messages all text blocks except the last one should be terminated with the control character ETB (1/7). The final block should be terminated with ETX (0/3).

2.2.10 Block Check Sequence

A Block Check Sequence (BCS) of 16 bits is transmitted following the ETB or ETX character and is used in the error detection process that controls the generation of the technical acknowledgment character described in Section 2.2.4. The BCS is the result of a Cyclic Redundancy Check (CRC) computation using the CCITT polynomial:

$$P(x) = x^{16} + x^{12} + x^5 + 1.$$

The portion of the message over which the BCS is to be computed is treated as a single sequence of binary digits in the order in which they are transmitted, which is: bytes in natural message order and bits within each byte ordered least significant bit (LSB) to most significant bit (MSB). The sequence of binary digits is assumed to be the sequence of coefficients of a polynomial in one variable over the field of integers, modulo two. For example, 11001 becomes:

$$1x^4 + 1x^3 + 0x^2 + 0x^1 + 1x^0 = x^4 + x^3 + 1.$$

The sixteen bits of the BCS are the coefficients of the remainder upon dividing x^{16} times the message polynomial by the CCITT polynomial. The polynomial long division is carried out exactly like an ordinary algebraic polynomial division except that all arithmetic on the coefficients is done modulo two. Hence, for example:

- $(x^2 + x) - (x + 1) = (x^2 + 1)$ and
- $(x^3 + 1) / (x^2 + 1) = x$, with remainder $(x + 1)$

The initial multiplication of the message polynomial by x^{16} effectively adds sixteen zero bits to the message. These bits drive the remainder out of the shift register often used in a hardware implementation of the algorithm. Implementors should note that the bitwise exclusive-or (xor) operation gives results identical to both bitwise addition modulo two and bitwise subtraction modulo two.

Example: The two-character string “K7” (not a valid message by itself) is represented with odd parity in hexadecimal as CB 37, which in binary, shown with the LSB first is:

- 11010011
- 11101100

The CRC calculation yields the remainder bit sequence:

- 01111100 11010110

which would appear at the end of the message as two BCS bytes expressed in hexadecimal with MSB first as 3E 6B.

The 16 bits of the BCS are used as reference bits in an error detection process based on the division of the equivalent polynomial representation of the received message by P(x) in the receiving terminal. This error detection process controls the generation of the technical acknowledgment characters is described in Section 2.2.4.

The BCS is initiated by, but does not include, the SOH character, and is terminated by, and does include, the ETB or ETX character. The BCS is generated on the entire message, including parity bits.

A more detailed description of this technique of error detection should be found in the January 1961 issue of the Proceedings of the IRE, in a paper entitled Cyclic Codes for Error Detection.

COMMENTARY

As stated in Section 3.2.1, a downlink block with an incorrect BCS may not elicit a response from the DSP. If the ACARS CMU has a message queued for downlink that fails the BCS check, the CMU will likely enter a NOCOMM condition until it is reset. One potential source of BCS failure occurs when an <ETX> or <ETB> character is inadvertently included within the text portion of a message, perhaps caused by a message originated from an onboard system (peripheral). CMU equipment manufacturers are encouraged to develop a robust design to preclude the lock-up condition stated above, perhaps by truncating or discarding an objectionable message with appropriate notification.

2.2.11 BCS Suffix

The modulation scheme selected for ACARS necessitates the presence of a BCS Suffix character to enable the last bit of the Block Check Sequence (BCS) to be decoded. The control character 'DEL' (ISO-5 character 7/15) should be transmitted following the BCS for this purpose.

2.3 Uplink Block Format

Refer to Table 15-2 of Attachment 15 for the General Format of Ground/Air Uplink Message. The format shown is that of a single ACARS block. The text of such a block is limited to 220 characters. It is possible to transmit longer messages by using multiple blocks. These longer messages are broken up into several blocks. See Section 3.6.4 for the construction of Multiblock uplink messages.

The descriptions below expand on the use of these fields for uplink messages.

2.3.1 Start of Header

The CMU should recognize the Start of Header (SOH) character as the start of an ACARS transmission and an indication of the need to perform a block check sequence on the data that follows.

2.3.2 Mode Character

The CMU should recognize the Mode character transmitted by a ground station to be an indicator of whether the ground network supports Category A or Category B Network operation.

2.3.2.1 Category A Mode Character

All Category A uplinks are uniquely identified with a “2” (3/2) in the Mode character position.

2.3.2.2 Category B Mode Character

All Category B uplinks are identified with a Mode character which is within the block of characters from the grave <`> (6/0) through the right curly bracket <}> (7/13). See Attachment 6 for the full set of allowable Mode Characters.

The actual Mode character inserted in each transmission is controlled by the service provider.

2.3.3 Address Recognition

The CMU should only process incoming messages intended for the aircraft on which it resides. The CMU should compare the address of each incoming uplink block with the addresses of the aircraft to screen out messages destined for other aircraft.

The CMU should be capable of recognizing the Aircraft Registration Mark and Flight Identifier as a valid address for the aircraft. The Aircraft Registration address is the preferred address scheme and must be used for ATS messages. **The CMU should be capable of recognizing the squitter address (a.k.a All Call) as**

defined in Section 2.3.3.3 as a valid address also. In this document the phrase “valid address” refers to these 3 addresses: Aircraft Registration Mark, Flight Identifier, and All Call address.

Once the CMU recognizes a valid address in an uplink message, it should process the succeeding data as indicated by the Label characters contained in the message.

When the CMU determines that the address in an uplink is not its own, no further processing of the message is necessary.

2.3.3.1 Aircraft Registration Uplink Address

The format of Aircraft Registration in the Address field of an uplink is identical to the format of Aircraft Registration in the Address field of a downlink. See Section 2.2.3.

2.3.3.2 Flight Identifier Uplink Address

The Flight Identifier is composed of three fields: 1) a period (13/2), 2) Airline (or agency) Identifier (two characters) and 3) Flight Number (four characters).

The Flight Identifier should be right justified in the Address field and filled with a leading period. The period (13/2) is transmitted first followed by the Airline Identifier and then the Flight Number, thus:

Transmission Order	1	2	3	4	5	6	7
Flight Identifier	.	9	X	0	3	2	A

In this example the Airline Identifier has a value of 9X and the Flight Number has a value of 032A.

See Section 2.2.8 for additional requirements pertaining to the Flight Identifier.

2.3.3.2.1 Airline Identifier

The Airline Identifier is a 2 character fixed length field. The most significant character can have any value in the range of 0 to 9 and A to Z. The least significant character can have any value in the range of 0 to 9 and A to Z.

COMMENTARY

Initially, this field was limited to the alphabetic characters (A to Z). Due to the growth in the number of airlines, IATA has been forced to use numbers as well as alphabetic characters in making airline code assignments possible. Currently, there is at least one alphabetic character in the Airline Identifiers containing a numeric, e.g., 5X and H2.

2.3.3.2.2 Flight Number

The Flight Number is a 4 character fixed length field. Each character can have any value in the range of 0 to 9 and A to Z. The Flight Number comes from crew input, either directly or indirectly. If the Flight Number data received by the CMU is less than 4 characters in length, then the data is right justified and filled with zeros.

In the example shown in Section 2.3.3.2, only the characters 32A have to be entered. If necessary, the CMU will add the 0 character.

2.3.3.3 Squitter Address

The uplink squitter address is comprised of 7 NUL (0/0) characters. The CMU should recognize the squitter address as an All Call address. See Section 3.2.2 for the appropriate response.

2.3.4 Positive Technical Acknowledgment

Every uplink message should contain a one-character Positive Technical Acknowledgment field immediately following the Address field.

The positive acknowledgment character in an uplink message should consist of an a “0”-”9” (3/0 - 3/9) or a NAK (1/5) character.

2.3.5 Label Recognition

The CMU should determine which of its functions it should perform in response to an uplink by reference to the Label characters. All uplink label definitions are contained in ARINC Specification 620.

2.3.6 Uplink Block Identifier

The Uplink Block Identifier (UBI) should consist of an “A” - “Z” (4/1 - 5/A) or “a” - “z” (6/1 -7/A) or NUL (0/0) single character.

2.3.7 End of Preamble

The CMU should recognize the control character STX as the end of preamble indicator for uplink messages containing header/text and the control character ETX as the end-of-message indicator for all uplinked messages containing no text (typically acknowledgments).

2.3.8 Text

The Text field is a block not exceeding 220 characters in length. See Section 2.2.8 for restrictions to the use of characters in the Text field. For Satellite Category B the Text field length may contain up to 3,520 characters.

2.3.9 Suffix

Each single block message should be terminated with ETX (0/3).

In multi-block messages all text blocks except the last one should be terminated with the control character ETB (1/7). The final block should be terminated with ETX (0/3).

2.3.10 Uplink BCS Check

The CMU should form a code polynomial of the incoming data as described in Section 2.2.10. The 16-bit sequence of the uplinked BCS check characters which will be used by the CMU to determine whether or not the uplinked message is error-free.

2.3.11 BCS Suffix

Refer to Section 2.2.11 for a definition of the BCS Suffix field.

3.1 Basic Message Protocol

This section details the protocol for ACARS Message handling.

The ACARS protocols will be replicated for each available medium. Separate messages may be processed concurrently across each available medium.

COMMENTARY

The timing provisions of this section apply to all air/ground networks unless specified otherwise in Sections 7 or 8. For ease of description, the nomenclature of the timers assumes the VHF case; e.g., VAT1.

3.1.1 Downlinks

In the absence of ground-initiated uplinks requiring responses, or link maintenance traffic, the airborne subsystem remains quiescent until the occurrence of a pre-defined event or a pilot-entered command to send a downlink to the ground arms the airborne subsystem for transmission.

Downlinks initiated by the CMU (that is, transmissions which are not generated in response to a ground message) should contain the Negative Acknowledgment character <NAK> in the Technical Acknowledgment field (see Section 2.2.4 of this document) of each transmission.

3.1.2 Uplinks

The air/ground block(s) will be transmitted sequentially to the aircraft through a ground station using the procedure detailed here. Each block should be successfully delivered to the aircraft before the transmission of the next block is attempted. The DSP is informed of delivery success by Acknowledgment from the aircraft.

The procedure for the initiation of messages by the ground processor is similar to the foregoing. The Technical Acknowledgment field of each uplink block that is not sent in response to a downlink block should contain the Negative Acknowledgment character <NAK>.

On receipt of an uplink block in the aircraft, the airborne subsystem should perform a BCS error check and, if the block is error free, transmit a downlink block containing a Positive Acknowledgment (either an <ACK> character or the Uplink Block Identifier character) to the ground. This Positive Acknowledgment should be downlinked immediately (subject to RF channel availability):

1. In the Preamble of the next air-to-ground downlink if the airborne subsystem is armed to transmit, or
2. In the Preamble of a General Response message (see Section 4.2.1 of ARINC Specification 620.

When a downlink block is the vehicle for the Positive Acknowledgment, the ground processor after performing an error check on the block and finding it error-free returns to the aircraft with another Positive Acknowledgment, contained in:

1. A General Response message, or
2. A new uplink message if it has one for that aircraft.

If the General Response uplink is used, the airborne subsystem returns to the quiescent state upon receiving it. Use of an uplink message for a Positive Acknowledgment should result in another acknowledgment cycle being initiated. When the original Positive Acknowledgment is downlinked in a General Response message, the airborne subsystem returns to the quiescent state as soon as transmission of the response is complete.

3.2 Acknowledgment Protocols

Each downlink block (other than the General Response message) sent by the avionics subsystem should be acknowledged by the ground network to confirm its receipt. Similarly, the CMU should acknowledge each uplink block to assure the ground network that delivery to the aircraft has been accomplished.

COMMENTARY

As with all good rules, there are exceptions to the requirement for acknowledgment. The exceptions are noted in the following subsections.

3.2.1 Acknowledgment of a Downlink Block

The CMU should internally maintain a numeric register containing a one digit Downlink Block Identifier (DBI) character as defined in Section 2.2.6. The current DBI register value is inserted into a downlink block when it is sent. Each new block, i.e. not a retransmission initiated by the retry counter, should contain a different DBI value than the block preceding it. Restarting of message transmission caused by media change, service provider change, or timer VAT10 expiration may affect the DBI value to be inserted in the block.

Once the CMU has completed a transmission requiring an acknowledgment, using a specific DBI value, the CMU should wait according to its retransmission requirements for an acknowledgment or until an uplink message directed to it is received.

The CMU should manage the DBI register to ensure that the next block transmitted has a different value than the block prior to it, unless it is a retransmission. The value of the DBI register should be incremented when any one of the following conditions occurs:

1. The CMU receives an acknowledgment to the downlink block.
2. When the CMU has to transmit a system control downlink prior to the expected acknowledgment, i.e., the No ACK timer (VAT7) has not expired. The System Control downlink does not require an acknowledgment. See Section 3.8.1.

3. The No ACK timer (VAT7) expires and the CMU chooses to transmit a different downlink block.

The CMU should determine if the acknowledgment from the ground network is associated with the most recent downlink block by comparing the DBI with the value contained in the Technical Acknowledgment field of the uplink block. A match should cause the CMU to mark the associated downlinked message block as acknowledged and increment the DBI value.

When the value of the field reaches “9” it should next be set to “0”.

The DBI value should also be incremented upon a No Communications (NOCOMM) declaration.

COMMENTARY

> When a NOCOMM condition exists, the CMU will conclude that the ground network will not be able to uplink an acknowledgment.

Recognition of an uplink containing a Negative Acknowledgment <NAK> (1/5) character in the Technical Acknowledgment field should be treated as a No Acknowledgment response.

Failure of the BCS check of a downlinked message may elicit no response from the ground rather than an uplink containing a <NAK>.

Reception by the CMU of an uplink block which does not positively acknowledge a preceding downlink block, for which an acknowledgment is outstanding, should result in the downlink block being retransmitted immediately (in accordance with Section 4.5.2). This downlink retransmission should retain the MSN and the DBI of the original downlink block. In addition, it should contain an acknowledgment to the uplink block just received. The retransmission should both increment the retransmission counter (VAC1) and reset the NO ACK timer (AT7) as described in Section 5.4.2.

When the CMU prepares an unsolicited downlink (not a response to an uplink), it should insert a <NAK> character in the Technical Acknowledgment field.

3.2.2 Acknowledgment of an Uplink Block

The DSP should manage the UBI to ensure that the next block transmitted has a different value than the block prior to it, unless it is a retransmission.

The CMU should generate a positive response or a negative response to any uplink requiring acknowledgment based on the criteria below.

Acknowledgment criteria:

1. Valid address for the receiving terminal and good Block Check Sequence (BCS) should yield a positive response.
2. Valid address and bad Block Check Sequence (BCS) should yield a negative response.

3. Any message with the All Call address (7 NULs) should not elicit an acknowledgment. See Section 2.3.3.2.3.
4. Any message with an address which is not valid for the CMU should be ignored in terms of acknowledgment handling.

Negative acknowledgment is always accomplished by transmitting a <NAK> (1/5) character in the Technical Acknowledgment field.

An uplink not in response to a downlink will, by default, contain a <NAK> (1/5) in the Technical Acknowledgment field.

Any acknowledgment transmitted by the CMU must be directed to the ground station originating the uplink.

A VHF downlink block which does not positively acknowledge a preceding VHF uplink block, for which an acknowledgment is outstanding, will result in the VHF uplink block being retransmitted immediately. Uplink retransmissions should retain the UBI of the original uplink block. In addition, it should contain an acknowledgment to the downlink block just received, i.e., imbedded ACK. See Section 7.6.1 for satellite operation.

COMMENTARY

Alternate VHF solutions are possible, but they may consume more RF spectrum and delay the delivery of one of the messages. If the DSP cannot support the imbedded ACK, then the DSP may acknowledge the downlink block, which does not positively acknowledge a preceding uplink block, with a General Response acknowledgment message. Then the uplink timers should be allowed to expire and the uplink message should be transmitted as a new message starting with the first block. This implementation will delay the delivery of the uplink. If the DSP requires more time to respond to the downlink, then the DSP may ignore the downlink block and retransmit the uplink with the same UBI and a NAK in the Technical Acknowledgment field. This implementation will delay the delivery of the downlink.

3.3 Message Addressing

Addressing of ACARS messages covers a broad spectrum of operation and relates to the service provider, airline host or user and to aircraft systems. Its purpose is to provide the necessary information to support message routing mechanisms using the ACARS character message protocols. The reader is referred to ARINC Specification 620 for more details on this subject.

3.3.1 Uplinks

3.3.1.1 Aircraft Address

Each uplink transmission contains basic address information concerning the aircraft to which the uplink is intended.

To enable the CMU to perform further processing, the uplink Preamble contains a seven-character field which must contain either the Aircraft Registration (See Section 2.3.3.1) or the Flight Identifier (See Section 2.3.3.2). For purposes of frequency management and Category B operation, the CMU should also be capable of **extracting SQP data and the Mode Character from** all uplink traffic regardless of address.

The CMU should only process incoming messages intended for the aircraft on which it resides. The CMU should compare the address of each incoming uplink block with the addresses of the aircraft to screen out messages destined for other aircraft. When the CMU determines that the address in an uplink is not its own, no further processing of the message is necessary.

The CMU should be capable of recognizing the Aircraft Registration Mark and Flight Identifier as a valid address for the aircraft. The Aircraft Registration address is the preferred address scheme and must be used for ATS messages. **The CMU should be capable of recognizing the squitter address (a.k.a All Call) as defined in Section 2.3.3.3 as a valid address also**. **In this document, the phrase valid address refers to these 3 addresses: Aircraft Registration Mark, Flight Identifier and All Call address.**

Once the CMU recognizes a valid address in an uplink message, it should process the succeeding data as indicated by the Label characters contained in the message.

3.3.1.2 SITE Address

When in a VHF Category B environment, the particular ground station SITE is identified in all uplink transmissions. This is accomplished in the Mode character within the Preamble. If the CMU supports Category B operation, the SITE address should be stored by the CMU for use in addressing subsequent downlinks.

3.3.1.3 Onboard Routing

An incoming message may be for direct consumption by the ACARS CMU or may need to be relayed to an onboard device such as a printer or an FMC.

Two fields typically provide information for message routing onboard the aircraft. The first field is the two character Label field contained in the Preamble of all uplinks. The second is an optional two character Sublabel field.

The CMU must decode the Label field of each message to determine the basic routing and/or purpose of the message for further processing. The Sublabel field, when used, provides the final address for an onboard system.

In addition to these, other routing schemes exist when User Defined labels are used. Messages with User Defined labels may contain user defined Sublabels within the message text. These definitions are outside the scope of this specification.

3.3.1.4 DSP Identity

When in a Satellite Category B environment, the DSP is identified in all uplink transmissions. This is accomplished in the Mode character within the Preamble. The CMU should utilize the same DSP when responding to Satellite Category B uplinks.

In a Satellite Category A environment, the Mode Character in the Preamble will be a “2” (3/2). The Mode Character 2 indicates that a default DSP is utilized.

3.3.2 Downlinks

3.3.2.1 Aircraft Address

Each downlink transmission contains basic address information concerning the identity of the aircraft from which the downlink originated.

The downlink Preamble always contains the Aircraft Registration number only. In addition each downlink should contain the agency Flight Identifier immediately following the downlink Message Sequence Number (MSN) field. This information is used by service providers to identify the intended airline host to which the message is to be delivered. See Sections 2.2.3 and 2.2.8 for the details of coding the aircraft address.

3.3.2.2 VHF SITE Address

When in a VHF Category B environment, the ACARS CMU should direct downlink traffic to an appropriate ground station SITE. This is accomplished by setting the Mode character within the Preamble to the value of the desired SITE. Only the ground stations SITE selected will process this transmission.

3.3.2.3 End User Address

Two fields typically provide basic message routing for the ground-based systems and are similar to the uplink process. The first field is the two character Label field in the Preamble of all downlinks. The second is an optional two character Sublabel field.

The CMU supplies the Label field for all downlinks. Use of the Sublabel field is optional. When used, the Sublabel field provides the final address of the host to which the message is to be delivered. These fields, combined with the Flight Identifier, allow the DSP to determine the address(es) to deliver the message to.

In addition, other schemes exist when User Defined labels are used and may also include User Defined sublabels within the message text. In this case the DSP uses only the Flight Identifier for routing and final routing is performed by the airline host using the user-defined data. These definitions are outside the scope of this Specification.

3.3.2.4 DSP Identity

For Satellite Category A operation, the CMU should direct downlink traffic to a default DSP by setting the Mode character within the Preamble to the Category A value of “2” (3/2).

For Satellite Category B operation, the CMU should direct downlink traffic to a specific DSP by setting the Mode character within the Preamble to the specific Satellite Category B value for that DSP as shown in Attachment 6.

3.3.3 Supplementary Addresses

In downlink messages, the DSPs allow the airborne system to supply one or more optional addresses for direct routing by the service provider in addition to the normal message routing.

Only specific labels defined in ARINC Specification 620 may contain the Supplementary addresses in the message text of the downlink. In addition, Supplementary addresses are sent only in the first block of a multiblock downlink message.

Supplementary address(es) are located immediately following the Agency ID in messages without Sublabels, and immediately following the Message Type Identifier in messages with label (H1) which include a value in the Sublabel field.

The Supplementary address may be an originator address captured from an associated uplink message. The acquisition of the originator address may be performed by the CMU or end system and then utilized in a downlink response back to the originator.

Multiblock messages may contain Supplemental addresses. The first block of the message should contain the Supplemental addresses in its header. Subsequent blocks of a multiblock message will not contain these Supplemental addresses.

3.4 Message Sequencing

3.4.1 Downlink Message Sequencing

The airborne subsystem and the ground service provider should implement the downlink Message Sequence Number (MSN) field as defined herein order to provide a method for detecting incomplete multiblock downlinks.

COMMENTARY

The downlink Message Sequence Number field includes both BLOCK and MESSAGE tracking capability. This feature also simplifies ground based handling of traffic.

Each downlink should contain a 4-character downlink Message Sequence Number following the Start of Text character. The format for all messages is shown below:

Character	Definition	Range
1	Originator	See Table in 3.4.1.1
2-3	Message Number	(00..99)
4	Block Sequence Character	(A-Z)

Single block message examples:

M05A with ETX = Message from MU
D01A with ETX = Message from DFDAU

Multiblock message example:

M06A M06B M06C ... until ETX received

Note: The message sequence number for BLOCK 3 of Message 6 generated by the CMU would be M06C.

COMMENTARY

An earlier version of Message Sequencing was in use and may continue to be used by some MU's. A description of the original format, which has been superseded by the definition herein, has been retained in Appendix A.

Satellite Category B accommodates a full size message as a single entity. Multiblocking of messages is not supported by Satellite Category B and therefore nesting of multiblock messages is not performed.

Two levels of downlink nesting are defined. Level one applies to single and multiblock messages. Level 2 applies to single block messages only.

Nesting of multiblocks to at least one level plus a second level for only single block message should be supported by the DSP.

COMMENTARY

Supplement 1 of ARINC Specification 619 defines 16 levels of priority for ACARS messages. ATS messages are assigned priority levels 1 through 4. Even though only 1 level of multiblock nesting is necessary at this time, it is recommended that the service provider consider the anticipated broadening of ATS data link utilization and the potential need for additional levels of downlink nesting. Therefore, it is recommended that the DSP support at least 4 levels of multiblock nesting.

When the DSP detects a MSN for the first block of a new multiblock downlink message and the previous multiblock is not complete, then the DSP should:

1. Hold the previous multiblock as a partial message until completed later or VGT4 expires

2. Begin to assemble the new message
3. Restart VGT4

The DSP will wait until the Incomplete Multiblock timer (VGT4) expires to forward any incomplete downlink multiblock message(s) to the host. If the new message is completed and the DSP receives the remaining blocks for the previous incomplete multiblock message before the VGT4 timer expires then the DSP will deliver the completed downlink. Note that a downlink block containing an MSN indicating that it is the first block of a new downlink message should <u>not</u> cause the DSP to terminate the partial multiblock message preceding it until Retry timer VGT4 expires. If the interrupted multiblock is not resumed subject to the VGT4 timer (see Section 5.4.1), the message will be delivered as incomplete.

MSG1	1A	1B						1C	1D	LEVEL0
MSG2			2A	2B		2C	2D			LEVEL1
MSG3					3A					LEVEL2
VGT4	START		RESTART							

Time ------------------->

Sample Nesting Pattern

For example:

VGT4	Block	Action
Start	M01A	The DSP holds the partial message (no ETX)
	M01B	
Restart	M02A	DSP begins a new message
	M02B	
	M03A	Nested single block
	M02C	
	M02D	Last block of message 2 continues
	M01C	Message 1 continues
	M01D	If VGT4 not expired

3.4.1.1 Message Originator

The downlink Message Originator character is used to indicate which aircraft subsystem generated the downlink Message. Table 3.4.1.1-1 contains the message sources that have been defined and their corresponding identification codes.

Table 3.4.1.1-1 – Message Sources and Identification Codes

Origin	ID Code	Notes
CFDIU	***C***	1
DFDAU	D	2
FMC 1 (Left Side)	F	3
FMC 2 (Right Side)	F	3
FMC 3 (Center)	F	3
CMU (ATS Functions)	L	12
CMU (AOC Applications)	M	4
System Control	S	
OAT	O	6
Cabin Terminal 1	1	7
Cabin Terminal 2	2	7
Cabin Terminal 3	3	7
Cabin Terminal 4	4	7
User Terminal	5	
User Terminal	6	
User Terminal	7	
User Terminal	8	
User Defined	U	8
EICAS/ECAM/EFIS	E	9
SDU	Q	10
ATSU/ADSU	J	11
HF Data Radio	T	13

Notes:

1. CFDIU: refers to all systems intended to meet the functionality of ARINC Report 604 or 624 by performing LRU maintenance functions; e.g., CMC and the CMS.

2. DFDAU: refers to all systems intended to meet the functionality of ARINC Characteristic 717 by performing engine and/or flight data reporting functions; e.g., ACMS, ADAS, AIDS, etc.

3. FMC: refers to all systems intended to meet the functionality of ARINC Characteristic 702 by performing flight management functions; e.g., FMS, FMGC, FMGEC, etc.

4. CMU: refers to the system performing the basic ACARS functionality of ARINC Characteristic 724 or 724B.

5. System Control: refers to message generated by the CMU to perform the system control functions defined in this specification.

6. OAT: refers to any system interfacing with the CMU on the OAT data bus port.

7. Cabin Terminal: refers to any system interfacing with the CMU on the Cabin Terminal data bus port.

8. User Defined: refers to any system interfacing with the CMU on the User Defined data bus port.

9. EICAS: refers to all systems intended to perform the functionality of instrumentation reporting; e.g., EICAS, ECAM, EFIS, etc.

10. SDU: refers to the Satellite Data Unit. (See ARINC Characteristics 741 and 761).

11. ATSU/ADSU: refers to the ATS Unit or ADS Unit. These LRUs may house Air Traffic Service Application Software.

12. CMU (ATS Functions) refers to the ATS and any other functions performed by the CMU which are isolated from the basic ACARS functionality described in Note 4 above.

13. HFDL refers to the HF Data Link System. (See ARINC Characteristic 753).

3.4.1.2 Message Number

The Message Number is a two-digit number in the range 00 to 99 that increments for each downlink message and wraps around from 99 to 01. Each block of the downlink message should contain the same value of Message Number.

The avionics should only use the value 00 in the Message Number field for the first message after a reset. The service provider will not classify a downlink block with a Message Number value of 00 as a duplicate. The DSP will always deliver a message with a message Number of 00 to the airline, and this may occasionally result in the delivery of a duplicate message.

3.4.1.3 Block Sequence Character

The Block Sequence character is a one-character field that contains an upper case letter (A to Z). The first block of a downlink message should always contain the block sequence character A. The block sequence character increments for each block of a multiblock message. Thus, the second block of a downlink message should always contain the Block Sequence character B.

3.4.1.4 DSP Processing of Out-of-Sequence MSNs

Upon receipt of an out-of-sequence block of an in-progress multiblock downlink (e.g., M01A, M01B, M01C, M01E, ...), the DSP should continue to collect all remaining blocks and then forward it to the airline host computer as an Intercept message. If the out of sequence block is a restart (repeat of the first block of the current multiblock message) then the processing of Section 3.6.3 applies.

Similarly, if the DSP receives a block of a new message that includes an MSN representing a block other than the first block (e.g., M05C vs M05A), then the DSP should collect and deliver all blocks of the partial message and forward them to the airline host computer as an Intercept message.

COMMENTARY

Receiving the first block of a new downlink prior to the completion of the previous downlink is within the limits of normal operation and should be processed as described in Sections 3.4.1 and 3.6.2.2.

3.4.2 Uplink Message Sequencing

COMMENTARY

There are no current provisions for uplink block sequencing. Therefore, the airborne subsystem cannot determine with absolute certainty that it is receiving the first block of a new uplink message. Timers are relied upon to identify when an old message has been aborted and a new message (the retransmission of the old message) has been started. As a result, errors in the assembly of multiblock uplink messages may occur. The sort of errors that can occur are: 1) two messages may be concatenated or 2) a single message may be incorrectly divided into two partial messages.

Additional provisions are planned to expand the uplink block sequencing capability to complement the capability for nesting uplink messages.

Satellite Category B accommodates a full size message as a single entity. Multiblocking of messages is not supported by Satellite Category B and therefore nesting of multiblock messages is not performed.

3.5 Retransmissions

The facility for retransmission of message blocks is necessary to provide a reliable communications link between the aircraft and ground. Retransmissions are necessary because messages are not always delivered. On these and other occasions the associated acknowledgment is not received at the sending station.

The ground station (uplink) or CMU (downlink) is permitted to make several retransmissions. See Sections 5.4.4 and 5.4.3 for a definition of the Retransmission counters (VAC1 and VGC1) and the description of retransmission timing is provided in Section 5.5.

COMMENTARY

Transmissions deemed a duplicate may contain an acknowledgment in the Technical Acknowledgment field, while the original transmission may have contained a <NAK> in this field. The Technical Acknowledgment should be processed as described in Section 3.2.

3.5.1 Uplink Retransmission Detection

The ground stations are programmed to retransmit blocks for which an acknowledgment has not been received within a specified time period (VGT1). See Section 5.4.1 for a description of the No ACK timer (VGT1).

The CMU should use the Uplink Block Identifier (UBI) field to detect uplink retransmissions. See Section 2.3.6 for a description of the UBI character field.

The CMU should compare the character found in the UBI position of each block uplinked via VHF with a reference character in order to determine whether or not the uplink is a retransmission of that immediately preceding it. If the two characters are the same, then the uplink should be deemed a duplicate.

Normally, the reference character should be the character contained in the UBI character position of the immediately preceding uplink. However, if the UBI Reset timer (VAT8) expires, the value of the reference UBI character position should be set to the control character <NUL>. See Section 5.4.2 for a description of the UBI Reset timer (VAT8).

COMMENTARY

> Processing of the UBI when the block is uplinked via satellite is different. See Section 7.6.1 for treatment in a satellite connection.

An uplink message identified as a retransmission should be acknowledged by a downlink response.

When the CMU cannot handle an uplink message it should downlink a response message. See Section 3.7 for the details of the response.

3.5.2 Downlink Retransmission Detection

The ACARS CMU is programmed to retransmit messages for which an acknowledgment has not been received from the ground station within a specified time period (VAT7). See Section 5.4.2 for a description of the No ACK timer (VAT7).

The MSN is used by the DSP to detect such duplicate downlink transmissions. The DSP should compare the MSN of the incoming block with the MSN of the preceding block. If the two MSN values match, then the downlink should be deemed a duplicate and discarded.

3.6 Multiblock Processing

Multiblock Messages are ground-to-air or air-to-ground transmissions in which the header/text information exceeds the 220 character limit in the ACARS text field In order to send the message, multiple blocks are required.

Present Airline Ground Communication Standards limit Ground-Ground Messages to 3840 characters including all address information.

Multiblock message length is limited to 16 blocks.

COMMENTARY

This value is provided for guidance to determine the maximum air-ground message length.

Multiblock Messages can be handled essentially in one of two ways. The ACARS CMU may operate in Pass- through or Store-and-Forward modes. Which method is used depends on the aircraft, service provider, and user needs.

3.6.1 Store-and-Forward

Store-and-Forward designs mean the ACARS CMU must buffer entire messages (all blocks) before forwarding to onboard systems or downlinking.

In some installations and applications, it is possible for the CMU to merely “pass blocks” between the ground and peripheral which simplifies the internal CMU requirements and buffering capabilities needed. However, if the CMU is the source or destination of the Multiblock, then Store-and-Forward is most likely required.

A multiblock message transfer diagram illustrating the interaction of the airborne and ground-based timers in Store-and-Forward operation is provided in Attachment 4-1.

This specification enables a CMU to be designed using either basic method, but either implementation does have its limitations. These limitations are briefly described below.

COMMENTARY

If Store-and-Forward is not used, then the system will not work in many installations. The most common problem is that the speed in which the network can deliver/accept the blocks is considerably slower than the on-board device protocol allows. A typical example is an ARINC 740 Printer which needs Blocks or Records every 100 ms which is much faster than the ACARS MU

The following describes Multiblock Handling in terms of the industry preferred solution. This implementation includes Store-and-forward, Positive Acknowledgment, Enhanced Message Sequence Number, and Special Multiblock timers.

COMMENTARY

However, many variations from this exist and will continue to exist. The acceptance of such a system into actual network operation, other than what is described, is subject to negotiations between the user and service provider(s).

3.6.2 Multiblock Downlinks

The suffix of downlink blocks allows the Data link Service Provider (DSP) to recognize whether a block is, or is not, the last block of a message. This is accomplished by using the End of Block <ETB> character as the suffix of intermediate blocks and the End of Transmission <ETX> character as the suffix of the last block of a message.

The downlink Message Sequence Number (MSN) described in Section 3.4.1 allows the DSP to recognize independent messages and the sequence of blocks in a multiblock message. The DSP procedures for delivering incomplete multiblock downlink messages are described in ARINC Specification 620.

Single block downlink messages are those where the first block is adequate to contain the entire message. An avionics subsystem, (the CMU or a peripheral to the CMU may prepare a downlink message that has text which is longer than the field provided in a single ACARS downlink block. In this case the message is partitioned into as many blocks as is required, up to the 16 block maximum. The partitioning will be performed by the CMU or the peripheral depending on the origin of the message (CMU or peripheral) and the type of ARINC 429 interface between the CMU and peripheral (character or Williamsburg).

The final block of any message, either single or multiblock, is terminated by <ETX>. The first and intermediate blocks of a multiblock message are terminated by <ETB>. The final block is terminated with an <ETX>.

For multiblock messages all ACARS blocks of the same message are reassembled by the DSP before transmission in a single Ground/Ground message to the ground user.

A reassembly session is closed by one of the following events:

1. The last ACARS block of the message is received, or
2. The Incomplete Downlink Message Delivery timer, VGT4, expires. See Section 5.4.1 for a list and description of ground based timers.

3.6.2.1 Incomplete Multiblock Downlink

The service provider should maintain an Incomplete Downlink Message Delivery timer (VGT4) set to the length of the interval which can elapse between the first block and the last block of a multiblock downlink message before it is declared incomplete. All nested multiblock messages must be completed before the timer VGT4 expires in order to be delivered as completed messages by the DSP. Any nested multiblock downlink for which the last block has not been received prior to the expiration of VGT4 is considered to be an incomplete message by the service provider.

If the Incomplete Message Delivery timer (VGT4) expires before the last block is received, then the service provider should identify the message as incomplete, including any nested multiblock messages for which the last block has not been received and forward the partial message(s) to the host.

Each block of the downlink message is retained by the DSP until the final block is received or the Incomplete Downlink Message Delivery timer (VGT4) has expired (See Section 5.4.1).

The CMU should recognize that the multiblock downlink has not been delivered because the ACK to the final block has not been received before Multiblock Message timer VAT10 has expired.

COMMENTARY

Disposition of the undelivered multiblock downlink message by the CMU will be determined by the user.

3.6.2.2 Nesting of Multiblock Downlinks

The CMU may interrupt a multiblock message in order to downlink a higher priority single block or multiblock message, according to the order of prioritization defined in Section 3.8. The nesting of downlinks is a CMU option.

A multiblock message which has interrupted a multiblock message cannot be interrupted by yet another multiblock message, but can be interrupted by a single block message or a system control downlink.

If the CMU generates a multiblock message which exceeds the number of levels of multiblock nesting supported by the DSP, then the DSP will abort the first (interrupted) message and forward the partial message to the host as an incomplete (intercept) message.

COMMENTARY

The above provision has been included to handle exceptions. This condition should not occur in practice.

3.6.2.2.1 Effect of a Nested Downlink on VAT10 and VGT4

The VAT10 timer will continue to run when a multiblock message is interrupted by a higher priority single block downlink message. If the VAT10 timer expires before the last block of the interrupted multiblock message is acknowledged, then the CMU will retransmit the entire message starting with block 1 as described in Section 5.4.2.

The VGT4 timer will continue to run when the DSP detects a nested single block downlink. If the VGT4 timer expires before the last block of the interrupted multiblock message is received then the DSP will deliver the partial message and consider that message transaction closed. Any future reception of that downlink is considered a completely independent and unrelated message transaction.

COMMENTARY

It is possible to significantly extend the completion of a multiblock downlink by nesting a large number of single block messages in it.

See Figure 12-1 in Attachment 12 for an example.

The VAT10 timer for an interrupted multiblock is re-started when multiblock downlink nesting occurs. Any multiblock downlink that has not received an acknowledgment to its last block (ETX) before the VAT10 timer expires needs to be transmitted again starting with block 1. See Figure 12-2 in Attachment 12 for an example.

The VGT4 timer is re-started when the DSP detects a nested multiblock downlink. If the VGT4 timer expires before the last block of the nested multiblock message is received then the DSP will deliver the partial messages (nested and interrupted messages) and consider those message transactions closed. Any future reception of either downlink is considered a completely independent and unrelated message transaction. If the VGT4 timer expires after the last block of the nested multiblock downlink and before the last block of the interrupted multiblock message is received then the DSP will deliver the partial interrupted message and consider that message transaction closed. Any future reception of that downlink is considered a completely independent and unrelated message transaction.

COMMENTARY

It is possible to significantly extend the completion of a multiblock downlink by nesting several large multiblock block messages in it.

3.6.2.3 Interleaving of Multiblock Downlinks

The air-ground protocol expressly prohibits interleaving blocks of multiblock downlink messages.

3.6.2.4 Reblocking a Multiblock Downlink

The CMU may need to reblock the downlink data. This process should not modify the actual message. Reblocking has implications in both Message Sequencing and Addressing. Reblocking can only be done in the Store and Forward implementation.

3.6.3 Restart Multiblock Downlink

The CMU should use the Multiblock Message timer (VAT10) to determine when a multiblock message should be restarted.

Multiblock messages partially sent should also be restarted if: 1) the transmission is interrupted by change of the VHF transceiver to VOICE mode for a period of time such that the Voice Mode timer (VAT9) expires or 2) the CMU loses contact with the ground station for a period of time such that NOCOMM timer (VAT6) expires. See Section 5.4.2 for definitions of the timers.

In addition, if the CMU switches base frequencies or air-ground media, the multiblock message should be restarted.

When the CMU restarts a multiblock downlink, it should use the same Message Sequence Numbers that were used in the original transmission, but with new DBI characters.

COMMENTARY

Some airlines may not wish to restart multiblock messages if they are not delivered prior to the expiration of the Multiblock Message timer (VAT10). In this case, the airline may elect for the CMU to discard the message or take some other action.

When the DSP recognizes that the CMU has restarted a message before completing the previous transmission of the same message, the DSP will forward the partial message as incomplete.

3.6.4 Multiblock Uplinks

In uplink multiblocks it is the aircraft that must reassemble blocks.

Diagrams illustrating the interaction of these timers are provided in Attachment 4.

The airborne subsystem should implement a Message Assembly and an Interblock timer which operate in conjunction with equivalent service provider timers on the ground, to provide a consistent method for detecting incomplete multiblock uplinks. If the ACARS CMU is a Pass-through implementation, then the Message Assembly and Interblock timers must be implemented in each peripheral LRU (i.e., ACMS, FMC, etc.).

The ground station should maintain a No ACK timer and a Message Reject timer to avoid inadvertent concatenation of duplicate messages.

COMMENTARY

The effect of these timers is to help the ACARS CMU interpret when an incoming uplink block belongs to a new message. This approach is not an ideal solution to the problem in that it requires blocks that have already been successfully sent to an aircraft to be resent if there is a break in coverage.

Utilizing these timers also potentially lengthens message delivery time since it forces the service provider to wait until the Message Assembly Timer (VAT4) has run out if, in the case of logical channel changeover, a message has to be restarted from the first block.

Also, in a Category A environment, the No ACK timer (VGT1) is set high because copies of the downlink from ground stations within range must be collected and processed before the acknowledgment can be generated.

This technique is a partial solution. Without a positive identification of the first block of a multiblock uplink, then the problem remains how long to wait between blocks and how to recognize whether the ground has started a new message or continued with an old one. In the uplink case there is no MSN and the solution is to specify airborne and ground timers in an attempt to permit the aircraft to interpret messages correctly. See Section 5.4 for the definition of these timers.

The Text part of an ACARS block is limited to 220 characters. Ground generated messages may be longer than one ACARS block in length. In that case, the DSP divides the uplink Ground/Ground message into as many multiple ACARS blocks as necessary, up to 16, and sends them block-by-block to the airborne avionics.

If the message can be contained in a single ACARS block, this block will be terminated by <ETX> which terminates both the block and the message.

If an uplink message is split up into multiple ACARS blocks all the blocks except the final block will have a text part of length 220 followed by a block terminator <ETB> which indicates that there is a further block to be transmitted. The final block will contain any remaining characters in the text followed by the <ETX> character which terminates both the block and the message.

If a multiblock message contains a sub-label, the sequence DASH/SPACE/POUNDSIGN <-SP#> will be sent with each block.

For OAT/OAX messages, the DSP examines the beginning of the text part of the Type B message to text whether the message contains a sublabel. If the text begins with the [DASH SPACE POUNDSIGN] <- #> character sequence, the two characters following the POUNDSIGN <#> are taken to be the sublabel. If the message is a multiblock, this sublabel will be placed at the beginning of any subsequent ACARS blocks. If the DSP finds any character other than

POUNDSIGN <#> at the position described, the message is treated as containing no Sublabel.

3.6.4.1 Message Assembly Timer

The airborne subsystem should contain a Message Assembly timer (VAT4) in order to detect when a multiblock uplink is incomplete, regardless of whether one uplink or two uplink messages are outstanding. See Section 5.4.2.

If the Message Assembly timer (VAT4) times out, then the CMU should assume that the next block received is the first block of a new message and process any partial messages as specified by the user.

If two uplink messages are outstanding when the Message Assembly timer (VAT4) expires, both messages should be deemed incomplete and processed accordingly.

All uplink blocks having the same label/sublabel received prior to expiration of the Message Assembly timer (VAT4) should be considered part of the same message, regardless of the ground site from which they were received.

3.6.4.2 Interblock Timer

The airborne subsystem may contain an Interblock timer (VAT5). VAT5 is the maximum time that the aircraft should wait for the receipt of a subsequent block in a multiblock message. The Interblock timer is defined in Section 5.4.2. VAT5 is active only while operating Category B.

If the Interblock timer (VAT5) runs out, the avionics should use its channel management to indicate to the service provider the path to be used to reach it.

3.6.4.3 Ground No ACK Timer

If the No ACK timer (VGT1) runs out, the service provider checks its retry logic to see if the block must be resent.

If a DSP uses optional uplink nesting then when VGT1 expires, the DSP should determine whether to retransmit the block or transmit a higher priority message.

If the retry limit, defined in Section 5.4.3, has not been exceeded then the ground station retransmits that block. When the retry limit is reached then the DSP will hold onto the message and wait for either a downlink from the aircraft or the Message Reject timer (VGT2) to time out.

3.6.4.4 Ground Message Reject Timer

The service provider should maintain a Message Reject timer (VGT2) to determine the point at which an attempted uplink should be declared unsuccessful. See Section 5.4.1 for a description of the Message Reject timer (VGT2).

When the Message Reject timer expires while a single uplink message is outstanding, then the service provider should send a message to the originator to report that the message could not be delivered, and indicating the reason for non-delivery in the message. If multiple uplink messages are outstanding when the Message Reject timer (VGT2) expires, all uplink messages should be deemed unsuccessful. For each incomplete message, the service provider should send a message to the originator to report that the message could not be delivered, and indicating the reason for non-delivery.

Further, the service provider should not transmit any uplinks to that airborne subsystem until the Incomplete Message Interval timer (VGT3) has expired in order to insure that the airborne subsystem’s Message Assembly timer has expired and the CMU has discarded the aborted uplink.

COMMENTARY

The delay imposed by the ground network’s Incomplete Message Interval timer is necessary because the airborne and ground Message Assembly timers are not synchronous. If there was no delay, under certain circumstances the airborne subsystem would accept the retransmission as if it were the completion of the partial message already received. This would result in the concatenation of two messages because there is no way for the airborne subsystem to positively identify the first block of an uplink.

The timer values have been chosen based on the assumption that the ground stations and airborne subsystems respond quickly to downlinks and uplinks respectively. These response times for ground stations and airborne subsystems are NOT specified anywhere.

The ARINC Category A network does not support the VGT2 and VGT3 timers.

3.6.4.5 Restart Multiblock Uplink

The DSP should restart the multiblock uplink if it switches air-ground media or changes base frequency.

3.6.4.6 Nesting of Multiblock Uplinks

A multiblock uplink in progress may be interrupted for the transmission of a higher priority message with a different label/sublabel. The higher priority message can be a single block or multiblock message. Uplink interruption will be performed according to the order of prioritization defined in Section 3.8. Only one level of multiblock interruption, or nesting, is supported with a maximum of two uplink multiblock messages that can be outstanding at any time.

The interrupted multiblock message should be resumed following the completion of the higher priority message.

In order to continue to re-assemble the interrupted multiblock message later, the ACARS CMU needs to store the UBI character of the last uplink block received for the interrupted message, in addition to the normal UBI reference character.

The DSP should ensure that all of the block(s) of the nested uplink contain different UBI values than the last uplink block transmitted prior to the interrupted message.

The CMU should recognize the resumption of the interrupted message by verifying the label and sublabel, and uses the previously stored UBI (prior to the interruption) to determine if the current uplink block is a duplicate of the last interrupted block, or the next (new) block in the sequence.

When the service provider wants to interrupt a multiblock uplink with a higher priority message with the same label and sublabel then there are two options:

1. Complete the uplink in progress then send the higher priority message.
2. Stop the uplink in progress, allow timers VGT2 and VGT3 to expire and then send the higher priority message. See Section 3.6.4.4. See Figures 4-3 and 4-5 in Attachment 4. The message which timed out cannot be continued. It must be restarted.

The service provider utilizes the SMI and MFI of an uplink message to formulate message priority.

COMMENTARY

Some MUs may be incapable of properly processing these uplinks. This new capability is not backward compatible with MUs designed to Specification 618-1. If a DSP transmits a nested multiblock uplink to an CMU that doesn't support this function, the interrupted message will be deemed incomplete by the DSP's may take DSP's may take precautions against this by enabling multiblock nesting only for those aircraft fleets that support it.

3.6.4.7 Interleaving of Multiblock Uplinks

The air-ground protocol expressly recommends against interleaving of multiblock uplink messages on a single medium.

3.7 Unable to Handle Uplink

When the CMU cannot handle an uplink block it should indicate this to the DSP. The downlink message should be an Unable to Deliver (Label Q5) or other cannot handle message as described in the following subsections. This response to the uplink should contain the technical acknowledgment for the uplink block. This message is a Level 1 priority (system control) message and is not retransmitted. See Section 3.8.1.

3.7.1 Unable to Deliver Messages

The CMU should respond to the receipt of an uplink message which temporarily cannot be delivered to the designated destination with a downlink containing an Unable to Deliver (Label Q5). The format of Label Q5 messages is provided in Section 5.2.5 of ARINC Specification 620.

The CMU should discard the undeliverable block. The CMU should set the UBI reference character to NUL. This procedure should enable the CMU to properly process a retransmission of the uplink message if it is received after the cannot handle condition has dissipated.

When retransmission is caused by the aircraft transmitting a message with the Unable to Deliver (Label Q5), then the original UBI is not retained.

3.7.2 Printer Reject Messages

The CMU may respond to the receipt of uplink messages which can not be delivered to the printer with a downlink containing the Label CA, CB, CC, CD, CE, or CF. The format of these messages is provided in Section 5.2.9 of ARINC Specification 620. Specific error codes, including Labels CA through CF, are given in ARINC Specification 620.

When retransmission is caused by the aircraft transmitting a message with one of the labels CA, CB, CC, CD, CE, CF, then the original UBI is not retained.

3.7.3 Unusable Messages

The CMU should send an intercept downlink containing the Unusable (Label QX) upon receipt of a message that is not supported or has an unrecognizable format and can not be delivered to the designated aircraft destination. All blocks received for delivery to such destinations can be discarded. The format of the Label QX message is defined in Section 5.2.7 of ARINC Specification 620.

Possible conditions that could result in an unusable message include: 1) Invalid Sublabel, 2) no onboard connection with destination, and 3) unknown format.

The CMU may discard the unusable message and should not expect a subsequent uplink of this message.

COMMENTARY

The service provider should not attempt retransmission of messages deemed unusable.

3.7.4 User Defined Messages

As an option, the ACARS CMU may provide user defined reject messages. In this case, the CMU should Acknowledge the undeliverable block (and subsequent blocks if multiblock) normally. It then transmits a reject message, of a user specified format, as normal downlink traffic.

COMMENTARY

When this method is used, the DSP will consider the uplink message delivered to its destination.

3.7.5 Undelivered Uplink Messages

When the CMU has acknowledged all the blocks of an uplink message, and is subsequently unsuccessful in its attempts to deliver that message to an airborne subsystem, the CMU should initiate a downlink message to the airline host system, indicating that the acknowledged message was not delivered. The format of the Undeliverable (Label HX) message is provided in Section 5.3.46 of ARINC Specification 620.

COMMENTARY

Note that the HX message is not a response to the DSP for an uplinked message, as are the other messages defined in Section 3.7. It is queued and downlinked after the DSP has already assumed that the uplinked message was successfully delivered. As with other MU-initiated messages, the HX message requires an acknowledgment from the DSP, however the meaning of the DSP response is transparent. Only the airline host system will know how to react to the HX message.

3.8 Message Prioritization

The ACARS CMU should provide the capability to sort downlink messages by priority according to the message originator (See ARINC Specification 619).

Section 9 of this Specification provides for expediting the delivery of high priority messages under changing air/ground data link conditions.

3.8.1 Priority of System Control Messages

System control (Level 1) messages should be accorded first priority in the CMU downlink message queue. System Control messages have highest priority because their transmission is used in maintaining the communications link. System Control downlink messages include the following:

Label	Message Title	Status
Q5	Unable to Deliver	
5P	Temporary Suspension	Optional
Q6	Voice to Data Changeover Advisory	Optional
F3	Dedicated Data Transceiver	
QX	Intercept	
CA-CF	Printer Reject	Optional

Refer to Section 6.4.4 for treatment of the Voice to Data, Label Q6, message.

When the CMU Retry timer limit is reached or the current block is acknowledged, the transmission precedence of the messages in the queue should be re-evaluated. In some cases, this will result in the next message (all blocks of a message must be moved together) in the queue being placed at the back of the line.

3.8.2 User Defined Priority Messages

Users should have the capability to define the priority of messages.

3.8.3 Regulatory Guidance on Priority

FCC Part 87 (amended by PR Docket No. 85-292 RM 4993) specifies the rules by which communications are exchanged in aviation service. The amendment provided for the differentiation of message types, relegating airline company administrative messages to a lower priority than airlines operational communications as shown in Table 3.8.3.

Table 3.8.3 – Message Priority

Type of Message	Priority Rank
Distress and Safety	Highest Priority
Air Traffic Control (ATC)	| |
Aircraft Operational Control (AOC)	| |
Airline Administrative Communications (AAC)	Lowest Priority

A more exhaustive list of priorities is provided in Attachment 11 of ARINC Specification 619. The goal of the CMU should be to expedite delivery of ATS messages within the Required Communications Performance criteria specified by regulatory authorities.

4.0 VHF ACARS

4.1 Radio Frequency Environment

In VHF ACARS data link, data is passed over the air-ground link on an aeronautical VHF radio frequency channel. The use of these channels is defined in Annex 10 of the ICAO charter.

In order to access the VHF radio frequency environment, the ACARS CMU is connected to the VHF communications transceiver. The ground stations DSP's network mirrors this configuration with a microcomputer connected to a VHF transceiver.

A VHF communications transceiver on the aircraft provides the airborne ACARS CMU with access to the RF environment. The system parameters specified in this document are optimized for communications through this medium.

Data link makes more efficient use of the RF spectrum than voice. Data link permits transmission of a typical 200 character message across the VHF channel in 1 second. When compared with voice transmission of the same message, channel occupancy time is reduced sufficiently to allow transfer of many more messages using the same level of VHF resources.

4.1.1 Equipment Architecture

In some installations the VHF transceiver which provides data communications may be shared (or used as a backup) between the ACARS and a voice communications function which utilizes different channel frequencies. Provisions are specified for the ACARS CMU to control the frequency to which the transceiver should be tuned for ACARS operations. Also, manual and automatic changeover from this frequency to a voice channel frequency selected via an external control panel is described in Section 6 of this document.

VHF Remote Ground Stations (RGS) are needed within line-of-sight of all locations where data link communications are desired. Generally, they are installed at all airports where data link equipped aircraft land. Where there are large distances between airports, enroute RGs are also installed.

4.1.2 Equipment Functions

In current installations, the VHF transceivers are identical to those used for voice communications. They are not adapted in any way to accommodate transmission of data. Data is exchanged between the ACARS CMU and the transceiver in the form of analog (sinusoidal) signals having two possible frequencies. For messages to be sent to the ground (downlink), these frequencies are used to modulate the VHF transceiver.

COMMENTARY

In the future, a VHF data radio (VDR) will be available and may be used to pass ACARS data across the air-ground link. In this case, the link from the ACARS CMU to the VDR will be a digital (ARINC 429) link and the modulation function will be performed by the VDR.

4.2 VHF Preamble

A preamble is sent before each transmission of an ACARS data block on the VHF frequency. The preamble consists of Pre-key, Bit Sync and Character Sync.

4.2.1 Pre-key

Each character of the Pre-key transmission should consist of all binary ones with all parity rules waived. During the Pre-key transmission, receiver AGC settling, transmitter power output stabilization and receiving modem local oscillator synchronization should be achieved.

The length of the prekey transmission should be kept to the minimum necessary to ensure the successful decoding of the data by the data link ground system. The maximum pre-key value is derived as follows:

Allowance for transmitter turn around/ramp-up 50 ms as specified in Characteristic 566A Section 6.4.1 and Characteristic 716 Section 3.7.10.

Ground System MSK AGC settling and 35 ms

phase demodulator discrimination allowance.

Total Maximum Pre-key Value 85 ms

The Pre-key length is measured from the time that the transceiver keying is initiated and is considered complete after the expiration of the above time.

COMMENTARY

> Service providers favor the shortest possible prekey length to maximize the utilization of the RF spectrum. Most ground stations will perform the AGC settling and MSK demodulator phase and discrimination task within 25 ms. Thus, avionics equipment designs with lower prekey values (53-75) are preferred where consistent with the avionics installation and ground stations used.

Any reduction in the aircraft radio transmitter turn around/ramp-up parameters as outlined in ARINC Characteristics 566A and 716 or in the ground station response time as noted above will result in a corresponding reduction in the above stated total maximum prekey value.

Transmission of the bit ambiguity characters should follow immediately as outlined in Section 4.2.2.

In order to accommodate aircraft installations in which VHF transceivers designed to Characteristics 546 and 566 are used, the industry has recognized the need to extend the above stated maximum figure. Until such a time as these units are retired from service in ACARS, the total maximum prekey value for these units will be determined by substituting the appropriate transmitter ramp-up time for the value used in the above calculation. The resulting total maximum prekey value will then be used in that particular aircraft configuration.

The Pre-key Length Select input discrete can be used to determine whether to employ the extended prekey for these transceivers. The discrete can be grounded locally or by a ground source from the VHF transceiver in order to inhibit the CMU from employing the extended prekey. In no instance should the total prekey value be alterable, by manual or automatic programming means, or set, by hard coding or in hardware, in excess of 190 ms.

4.2.2 Bit Synchronization

The plus <+> (2/11) and the asterisk <*> (2/10) characters should be transmitted, in that order, following the Pre-key transmission to enable bit ambiguity resolution to be accomplished.

4.2.3 Character Synchronization

Two consecutive Synchronization <SYN> (1/6) characters are transmitted to establish character synchronization.

4.3 BCS Suffix

The modulation scheme selected for VHF ACARS (see Section 4.4) necessitates the presence of a final character to enable the last bit of the Block Check Sequence (BCS) field (see Section 2.2.10) to be decoded. The Delete <DEL> (7/15) control character should be transmitted as the BCS Suffix immediately following the BCS field.

4.4 Modem Interface

4.4.1 Data Rate

The ACARS data rate is 2400 bits per second ±0.02 percent.

COMMENTARY

Since the VHF ACARS RF link relies on access to a radio spectrum shared with all equipped aircraft in the area, average throughput experienced by an individual aircraft avionics subsystem receiving data is less than the above-specified data rate.

4.4.2 Data Encoding

The method of coding data on the air/ground path is by modulating the amplitude of the VHF signal. The name of the modulation scheme applied is Minimum Shift Keying (MSK). This is equivalent to sending a succession of tones which have either a high or low pitch. A synchronization process enables the receiver to identify the first bit of the transmission and its value (1or 0). Modems in the aircraft and ground stations convert from this form to the standard serial or parallel form used inside all computers.

The encoding scheme demands that phase coherence be maintained through the transmission media for successful decoding to be possible. The establishment of correct phase relationships should be performed by the ground and airborne decoding hardware during the Pre-key period of preamble transmissions.

The presence of 1200 Hz indicates a bit change from the previous bit, the presence of a 2400 Hz tone indicates that there is no bit change. The phases of the two tones should be chosen such that the minimum phase discontinuity occurs at the interface with the preceding bit. The phase is further defined such that the amplitude of each tone is zero at the bit transition. The slope of the waveforms at the end of a bit cell should be positive for a binary “one” and negative for a binary “zero.” A diagram illustrating this encoding scheme is shown in Attachment 5 of this document. The tolerance on the tone frequencies is ±0.02 percent.

4.4.2.1 Parity Bit

With the exception of the prekey and the Block Check Sequence, the most significant bit (bit 8) of each byte transmitted is to be set so as to render odd parity to the byte.

4.4.2.2 Bit Transmission Order

The bits of each byte are to be transmitted starting with the least significant bit (bit 1), and ending with the most significant bit (bit 8).

4.4.3 Modulation

The CMU should convert the 2400 (±0.02%) bits per second downlink message serial bit-stream into VHF radio modulating signals of the type described in Section 4.4.2 of this Specification. The characteristics of the transmitter input to which these signals should be delivered are described in ARINC 716 and ARINC 566A.

Manufacturers’ should note that 13K0A2D RF emission has been authorized for ACARS operations. See Section 47 CFR 87.137(a) Footnote 5 of the USA Code of Federal Regulations for a definition of modulation types. The frequency response of the audio sub-carrier input port of the VHF transceiver with which the CMU is used should be extremely broad. In certain approaches to the generation of the modulating waveform, therefore, bandwidth limiting of the CMU signal output may be necessary to prevent the 13K0A2D emission limits from being exceeded. When such filtering is necessary, care should be taken to ensure that the differential phase delay of the 1200 Hz and 2400 Hz tones injected by the CMU is held to less than 10 microseconds.

If the CMU outputs audio to the VHF transceiver at a higher level than that for which the transceiver is adjusted, the transceiver should prevent over modulation of the RF output by compressing or clipping the applied audio. This may cause distortion. The nominal audio output level from the CMU should be 1 Vrms at 1800 Hz, and the transceiver receiving this audio should be capable of adjustment to a modulation level of at least 85 percent. The actual adjustment value depends on the characteristics of the associated VHF Transceiver.

4.4.3.1 Modulation Measurement Technique

This is a placeholder for information to be added at a later date.

4.4.4 Modulator Characteristics

The following characteristics are recommended for the ACARS CMU modulator:

PARAMETER	VALUE
Output SNR	72 dB or greater
Output Impedance	600 Ohms nominal
Output Level	1.0 Vrms ±2% into a 600 Ohm load
Baud clock drift	< ±200 ppm
Amplitude stability	< ±0.5 dB over the specified temperature range
Differential Phase	< 10 microseconds

4.4.5 Demodulation

The CMU should demodulate signals of the type set forth in Section 4.4.2 of this document. Series 500 VHF transceivers are specified to drive the 600 ohm CMU input with a 0.5 volt RMS signal from a source of 100 ohms impedance isolated from ground. Refer to Section 6.3 of ARINC Characteristic 566A, Section 10.3 of ARINC Characteristic 566 and Section 8.3 of ARINC Characteristic 546 for further details.

Series 700 VHF transceivers are specified to drive the 600 ohm CMU input with a 0.5 volt RMS signal from a source of 300 ohms (or less) impedance isolated from ground. Refer to Section 3.6.9 of ARINC Characteristic 716.

The CMU should extract data from the delivered waveform in the most efficient manner possible. Manufacturers may note that the waveform contains at least two signatures for each binary digit.

4.4.6 Demodulator Characteristics

At 12 dB Signal to noise ratio in an Additive White Gaussian Noise (AWGN) environment, the demodulator will be within 2 dB of theoretical bit error rate performance. The noise-free signal can have up to 83 microseconds of differential delay distortion over the baseband bandwidth of 600 Hz to 3 kHz and up to ±200 ppm of frequency drift.

The demodulator should be capable of successfully demodulating 99 percent of the frames under the following conditions:

PARAMETER	VALUE
Input level	0.5 Vrms into a 600 Ohm load
Input impedance	600 Ohms nominal
Baud clock drift	±200 ppm
Settled pre-key	27 bits
Frame length	100 octets (including header unit)
SNR (AWGN)	12 dB
Delay distortion	< 83 microseconds for 600 Hz to 3 kHhz (±200 ppm) frequency drift

COMMENTARY

The goal of the CMU design should be to achieve the maximum tolerable distortion delay in order to provide the best possible bit error performance. Designs are expected to exceed the minimum value given above.

4.4.7 ACARS Demodulator Performance for Processing Uplink ACARS Blocks

The guidelines specified in the following two sub-sections define the desired performance of the ACARS avionics system, consisting of an ARINC 566A, 716, or 750 compliant VHF transceiver and an ARINC 597, 724, 724B, or 758 compliant ACARS CMU. All performance criteria assume that the DSP RGS meets or exceeds the transceiver performance requirements specified in ARINC 716 and the ACARS modulator performance specified in Section 4.4.4 of this document. In all cases, the prekey value used for uplinks is at least 75 milliseconds.

COMMENTARY

To insure optimum ACARS throughput, delivery time, and efficiency, vendors are urged to provide avionics that meet the following guidelines. Nevertheless, it is recognized that a portion of the existing fielded CMUs will not be able to meet this performance. All new production equipment are expected to achieve this performance.

4.4.7.1 Uplink Performance in an ACARS RF Environment Free from Background Signals

The ACARS CMU should be able to properly decode and process at least 98% of all addressed uplink blocks arriving at the VHF transceiver antenna input port at signal levels from –10 dBm to –100 dBm. This performance requirement assumes that the ACARS channel is free from all other background signals and assumes that the uplink blocks will be transmitted at a rate of not greater than 1 block per 3 second interval.

4.4.7.2 Uplink Performance in an ACARS RF Environment Containing Interfering, Co-Channel Background ACARS Signals

In a dense ACARS operational environment, the CMU may need to contend with the reception of undesired, co-channel (on-tune) background ACARS signals (both uplink and downlink activity) while processing valid uplinks. The background signals are ACARS messages that are being exchanged with RGSs and aircraft located in the far field distance but are still detectable by the CMU. Two performance features are desired, (a) the ability of an ACARS modem to successfully decode an uplink when a much weaker ACARS signal appears simultaneously in the background and (b) the ability of the ACARS modem to terminate the decoding of a weaker ACARS message when it is interrupted by a much stronger ACARS uplink.

1. CMU should successfully decode 98% of all addressed uplink messages, when other (undesired) ACARS MSK activity appears after the beginning of the desired, addressed uplink and is at a signal level of 15 dB less than the addressed uplink block.

2. The CMU should effectively "reset" and begin decoding a new uplink block when it has detected that the first block (weaker) was interrupted while in-progress. The CMU should recognize this event by sensing parity errors (one or several) occurring in the in progress, interrupted block and the on-set of a new ACARS preamble (i.e., prekey). The CMU should successfully decode the new, interrupting uplink block, with a success rate of 98%, when it

appears at signal levels of at least 15 dB stronger (at the VHF transceiver input) than the interrupted ACARS block.

4.5 Medium Access Control

Since the VHF ACARS System is a multiple access network, an orderly method for granting channel access is required. Therefore, a channel access algorithm will be executed by the ACARS CMU and VHF ground stations to obtain channel access authorization. Prior to executing the channel access algorithm the ACARS CMU must have permission to send as outlined in Section 5.2.

4.5.1 Channel Sensing

The RF channel will be considered occupied or busy if either or both the MSK modulated audio signal frequencies (1200 Hz or 2400 Hz) are detected on the analog interface from the VHF transceiver.

The RF channel will be considered idle or clear if neither of the MSK modulated audio signals are detected on the analog interface to the VHF transceiver.

4.5.2 Radio Channel Access

The channel access algorithm to be executed by the ACARS CMU is Non-Persistent CSMA defined as follows:

1. If the channel is sensed idle, the CMU transmits the frame.
2. If the channel is sensed busy, then the CMU schedules the transmission some time later according to a uniform random distribution within the limits of 30 ms to 300 ms.
3. At the rescheduled point in time, the algorithm repeats until the channel is sensed idle and the frame is transmitted.

4.6 Transceiver Control

4.6.1 Transmitter Keying

The ACARS CMU should be capable of keying the VHF transceiver as defined in ARINC 597/724/724B according to the appropriate CMU form factor and type of VHF transceiver employed.

Once the Medium Access Control criteria are met as outlined in Section 4.5 the CMU should immediately key the transceiver.

Simultaneously with keying, the CMU should commence output of Pre-key data (binary “1”‘s with parity rules waived). See Section 4.2.1 for the formula for determining pre-key length.

At the end of the desired ACARS transmission (BCS Suffix) the CMU should immediately cease keying the VHF transmitter.

4.6.2 Radio Transceiver Tuning

The VHF transceiver connected to this output should operate on the commanded frequency when the CMU is given control of frequency selection. Such control should be accorded to the CMU at all times when the unit is in Data mode. Depending on configuration, the CMU may also perform frequency selection to support Voice mode (see Section 6).

The CMU manufacturer should allow for radio tuner settling time. See ARINC Characteristic 546, 566/A, and 716 for values.

The frequency to which the transceiver has been commanded to tune, if possible, should be available to the crew for display at all times. This facility is particularly important during Voice operations.

The ACARS CMU should provide for activation and use, at airline option, the ability to enter the VHF operating frequency manually. The CMU should support tuning of the VHF transceiver, for purposes of data and/or voice, a frequency range of 118.000 to 136.975 MHz.

Two basic methods of frequency tuning are used depending on the transceiver connected. These methods are described below. Any CMU must be able to support at least one of these two methods.

4.6.2.1 Serial Digital Tuning

The CMU should output, on the service connector pins assigned for this purpose, data channel frequency information for the purpose of tuning the ACARS-associated VHF radio transceiver.

The output should provide a BCD-encoded serial digital tuning signal having the characteristics defined for such signals in **ARINC Specification 429:** *Mark 33 Digital Information Transfer System (DITS)*. The frequency information should be supplied in the serial digital word VHF Com Frequency (Label 030) defined in Attachment 2 of ARINC Specification 429. ARINC Specification 429 should be followed in respect of all signal standards.

The CMU should output, on the service connector pins assigned for this purpose in the appropriate ARINC Characteristic, a DFS Port Select Discrete output. This output should be ON (grounded) whenever the CMU is providing valid frequency information to the VHF transceiver. It should be OFF at all other times. Typically the only time it is OFF is when the system is in VOICE mode and the frequency is being provided by an external control source. Refer to Section 6 for additional details.

COMMENTARY

Some radios do not conform to ARINC Characteristic 716 in that they do not respond to the All Call (00). The SDI bits in data words for these radios must be set to their actual location.

4.6.2.2 2 x 5 Tuning

The CMU should output, on the service connector pins assigned for this purpose in the appropriate ARINC Characteristic, discrete frequency information for the purpose of tuning the ACARS-associated VHF radio transceiver. The information should be supplied in the 2 x 5 code defined in ARINC Specification 410. ARINC Specification 410 should be followed with respect to signal and diode isolation standards also. These outputs are activated whenever the Frequency Select Common pin on the CMU is grounded.

5.1 Functional Capability of the Airborne Sub-System

The CMU should establish and maintain a link across the VHF medium with the Data Link Service Provider's (DSP) system. In order to do this, it should use the ACARS message protocol defined in this specification.

Since the frequency over which VHF data communications will be conducted is not fixed, ACARS MUs may need to have a frequency management capability. The CMU can be programmed with the different available frequencies and attempt link establishment on each frequency as described in this Section.

COMMENTARY

Each DSP will use at least one frequency, referred to herein as a Base frequency, over as large an area as possible. If the communications traffic were relatively light and the aircraft remained within the DSP's area of coverage, the link could be maintained without frequency change. Communications traffic congestion may cause the DSP to shift some connections to an alternate frequency(s). Traveling from one DSP to another may result in a need for the CMU to change Base frequency.

The airborne component of the ACARS should be capable of performing the functions described in the following Subsections.

5.2 Permission to Send

Prior to any ACARS VHF downlink transmission the CMU must receive permission to send to ensure transmission on an authorized frequency for data communications. Channel access authorization must still be obtained using procedures established under Medium Access Control as defined in Section 4.5.2. See Section 5.6 for frequency acquisition procedures.

Permission to send may be achieved by crew entered manual command, a user defined command or logic, via a service provider autotune command, or automatically from Frequency Management logic.

5.3 No Communications (NO COMM)

The airborne subsystem should be capable of recognizing when a condition exists which prevents reliable two-way VHF communications.

The CMU should declare a No VHF Communications (NO COMM) condition whenever it is in Frequency Acquisition for any reason.

Upon entering the NO COMM condition the NO COMM timer (VAT6) is started. All outstanding uplink/downlink traffic should be considered interrupted and retransmission may be required. The NO COMM condition should remain in effect until an error free uplink is detected. The crew may initiate a transmission command despite the existence of a NO COMM condition.

The 724B CMU should annunciate this condition to the appropriate onboard system(s) by updating the ARINC 429 status word Label 270 as defined in ARINC Characteristic 724B. Label 270 data words are used to inform other onboard computer subsystems that the VHF link is not available.

All CMUs should be capable of a NO COMM annunciation on the CDU as well as the NO COMM Annunciator Discrete output.

5.4 Timers and Counters

Timers and Counters are used by both the ground networks and the airborne subsystems as necessary to ensure that connectivity is maintained with the ground network and that when connectivity is lost, re-establishment of connectivity is initiated without undue delay. Timers have also been defined to ensure that long (multiblock) messages are delivered without undue segmentation.

COMMENTARY

The limits of some timer and counter values may be more restrictive than the ranges specified herein if the criteria of CAAs for ATS message delivery are to be met. Limits known at the printing of this document are noted in commentary in the following subsections. These limits may change in time. CMU designers should coordinate with service providers and aircraft manufacturers to determine the most current status.

5.4.1 Ground-Based Timers

The ground based timers are defined in the following sections.

5.4.1.1 VGT1, No ACK Timer

Name:	VGT1, No ACK Timer
Value:	Typically 10 seconds
	See Section 5.4.5.1.
Start:	VGT1 is started when the service provider uplinks a block.
Stop/Reset:	VGT1 is stopped and reset on receipt of an acknowledgment for the same block.
On Expiration:	Retransmit the original block if the retry count limit has not been reached.

5.4.1.2 VGT2, Message Reject Timer

Name:	VGT2, Message Reject Timer
Value:	80 seconds
Start:	VGT2 is started when a ground station uplinks the first block of a multiblock message.
Stop:	VGT2 should be stopped when an acknowledgment to the last uplink block is received.
Restart:	VGT2 should restart when the ground station transmits the subsequent block of the multiblock message. (Retransmissions of an uplink block do not affect this timer). See Note 1.
On Expiration:	Service provider should reject the message back to originator, inhibit uplinks to the aircraft and start VGT3. See Section 3.6.4.4.
Note 1:	Consecutive retransmissions of an uplink block do not affect this timer. Duplicate blocks, separated by an interrupting uplink message, should cause VGT2 to be restarted.

5.4.1.3 VGT3, Incomplete Message Interval Timer

Name:	VGT3, Incomplete Message Interval Timer
Value:	20 seconds
Start:	VGT3 is started when VGT2 expires.
On Expiration:	Enable uplinks to the aircraft.
Description:	VGT3 is the minimum time a service provider should wait after discarding an incomplete multiblock uplink message before sending any subsequent uplink block to the aircraft.

5.4.1.4 VGT4, Incomplete Downlink Message Delivery Timer

Name:	VGT4, Incomplete Downlink Message Delivery Timer
Value:	11 minutes
Start:	VGT4 should be reset and started when the first block of a multiblock downlink is received.
Stop:	VGT4 should be stopped when the last block of a multiblock message (containing ETX) is received.
On Expiration:	See Section 3.6.2.1
Description:	VGT4 sets a limit to the time the DSP should wait to recover the remainder of a partial downlink message before giving up.

5.4.1.5 VGT5, Unable to Deliver (Q5) Timer

Name:	VGT5, Q5 Timer
Value:	See Note 1.
Start:	VGT5 is started when an Unable to Deliver downlink message, Label Q5, is received.
On Expiration:	Retransmit the message with new UBI.
Description:	VGT5 is the time a ground service provider network waits before retransmitting a message that is temporarily undeliverable on the aircraft.
Note 1:	The VGT5 timer is service provider dependent. ARINC uses the value of 22 seconds.

5.4.1.6 VGT6, Squitter Timer #1

Name:	VGT6, Squitter Timer #1
Value:	2 minutes
Restarted:	VGT6 should be restarted each time an uplink message is transmitted in the area of coverage. See Note 1.
On Expiration:	When the VGT6 timer expires the ground network should ensure that a squitter message is transmitted.
Description:	VGT6 is the <u>maximum</u> time a ground service provider network waits before providing uplink traffic. It is effective during periods of inactivity within a specific area of coverage.
Note 1:	In a Category B network the uplink should be a Category B uplink, i.e., Mode character with a value other than “2.”

5.4.1.7 VGT7, Squitter Timer #2

Name:	VGT7, Squitter Timer #2
Value:	10 minutes
Restart:	VGT7 should be restarted each time a squitter message is transmitted to the area of coverage.
On Expiration:	When the VGT7 timer expires the ground network should ensure that a squitter message is transmitted.
Description:	VGT7 is the maximum time a Category B DSP’s network should wait before transmitting an uplink squitter during periods of normal traffic activity within a specific area of coverage.
Note 1:	The VGT7 timer should be active on all of the network’s frequencies including alternate frequencies.

5.4.1.8 VGT8, Temporary Suspension Timer

Name:	VGT8, Temporary Suspension Timer
Value:	10 minutes
Start/Restart:	VGT8 should be started whenever a 5P downlink is received.
Stop:	VGT8 should be stopped and reset whenever a downlink is received (normally Q6).
On Expiration:	When the VGT8 timer expires the DSP may resume uplinks to the aircraft.

If an ATC message is received for uplinking while VGT8 is running, the message should be uplinked via other media if available.

5.4.2 Airborne Timers

The avionics subsystem timers are as follows:

5.4.2.1 VAT1, Contact Timer

Name:	VAT1, Contact Timer
Value:	See Note 1.
Start:	VAT1 is started when the CMU has established a link with the ground network on the frequency of a Category A network and the aircraft is airborne.
Stop:	VAT1 is stopped when the aircraft lands.
Restart:	VAT1 should be restarted whenever any subsequent valid uplink message is heard.
On Expiration:	See Sections 5.8.2 and 5.9.2.
Note 1:	The VAT1 timer value is dependent upon the network to which the airborne subsystem is connected, but is typically set for twice the net interval between squitter or other uplink messages.
Note 2:	Timer VAT1 is optional.

5.4.2.2 VAT2, Scan Timer

Name:	VAT2, Scan Timer
Value:	See Notes 1 and 2.
Start:	VAT2 is started when the CMU enters the Frequency Acquisition state.
Stop:	VAT2 should be stopped when a valid uplink is received.
On Expiration:	See Section 5.6.2.1.3.
Note 1:	In the Fast Scan Mode, the timeout value should be 15 to 30 seconds.
Note 2:	In the Normal Scan Mode, the timeout value for the VAT2 timer may vary with the base frequency selected. The value chosen should be longer than the VGT6 (dependent upon service provider).

5.4.2.3 VAT3, Tracker Timer

Name:	VAT3, Tracker Timer
Value:	10 minutes. See Note 1.
Start:	VAT3 is started when an uplink message addressed to the aircraft which contains an acknowledgment to a downlink is received while the aircraft is airborne and operating in a Category A environment.
Stop:	Aircraft lands or switches to a category B network.
Restart:	VAT3 should be restarted by any uplink message addressed to the aircraft that contains an acknowledgment to a downlink.
On Expiration:	See Section 5.8.3.
Note 1:	VAT3 is optional. If implemented, VAT3 is maintained during Frequency Maintenance while operating Category A for airlines that want the DSP to perform flight following. VAT3 is suspended while the aircraft is on the ground.

5.4.2.4 VAT4, Message Assembly Timer

Name: VAT4, Message Assembly Timer

Value: 90 seconds

Start: VAT4 should be started when the airborne subsystem receives the first block of a multiblock uplink message.

Stop: VAT4 should be stopped when the last uplink block (terminated with an ETX) of the same message is received. See Note 2.

Restart VAT4 should be restarted when the subsequent uplink block of the same message has been received (uplinked). During the interruption of a multiblock uplink, VAT4 should be restarted upon receipt of the first, subsequent, and final blocks of the higher priority uplink.

On Expiration: See Section 3.6.4.1.

Note 1: VAT4 is not stopped and restarted when consecutive duplicate (retransmitted) blocks of the same message are received. Duplicate blocks separated by an interrupting uplink message should cause VAT4 to be restarted.

Note 2: Since uplink messages do not contain message sequence numbers, uplink message reassembly is not guaranteed to be error free. The CMU relies on the label/sublabel combination to discern between messages. The CMU also relies on the various timers associated with multiblock uplinks to detect error conditions and recover from the message reassembly process.

5.4.2.5 VAT5, Interblock Timer

Name: VAT5, Interblock Timer

Value: 30 seconds

Start: VAT5 is started when the airborne subsystem receives the first block of a multiblock uplink.

Restart VAT5 is restarted when the subsequent uplink block (ending in ETB) is received.

Stop: AT5 is stopped when the last uplink block (ending with ETX) is received).

On Expiration: See Section 3.6.4.2.

Note: VAT5 is optional and could be used while operating in a Category B environment.

5.4.2.6 VAT6, NO COMM Timer

Name: VAT6, NO COMM Timer

Start: VAT6 is started when communications across the air-ground path becomes not available. See Section 5.3.

Stop: VAT6 is stopped and reset when communications across the air-ground path are restored. Only new uplinks, not retransmissions, should cause VAT6 to be stopped.

On Expiration: See Section 3.6.3.

5.4.2.7 VAT7, No ACK Timer

Name: VAT7, No ACK timer

Values: Variable, uniformly distributed between a lower and upper limit. In CAT A environment, the limit should vary between 10-25 seconds. In CAT B environment, the lower limit can be as low as 2 seconds, depending on service provider requirements. The upper limit should not exceed 25 seconds. See Section 5.4.5.2.

COMMENTARY

For Category B ATS downlinks in Asia/Australian region, a range of 6-12 seconds is recommended to satisfy CAA message delay delivery criteria.

Start: VAT7 is started when a downlink block is transmitted or retransmitted.

Stop: VAT7 is stopped when an uplink is received that contains an acknowledgment. The acknowledgment indicates that the downlink message was received error free.

On Expiration: Increment Transmission counter, VAC1, and retransmit downlink if the value of VAC1 is less than the limit.

Note 1: Some DSPs have implemented a faster response time in their ground systems.

5.4.2.8 VAT8, UBI Reset Timer

Name:	VAT8, UBI Reset Timer
Value:	10 minutes
Start/Restart:	VAT8 should be started when the CMU receives an error-free uplink, including duplicates, excluding squitter uplinks.
On Expiration:	When the VAT8 timer expires, the CMU should set the reference UBI character to the control character <NUL>. See Section 3.5.1.

5.4.2.9 VAT9, Voice Mode Timer

Name:	VAT9, Voice Mode Timer
Value:	10 minutes
Start:	VAT9 should be started when the CMU enters VOICE mode.
Stop:	VAT9 is stopped and reset when the CMU is returned to the DATA mode.
On Expiration:	If the VAT9 timer has expired on return to data mode, the CMU should take the actions described in Section 6.8.2.

5.4.2.10 VAT10, Multiblock Message Timer

Name:	VAT10, Multiblock Message Timer
Value:	10 minutes
Start:	VAT10 should be started when the first block of a multiblock message is transmitted.
Stop:	The VAT10 timer should be stopped and reset when the uplink acknowledgment to the last downlink block of all messages in progress have been received.
On Expiration:	When the VAT10 timer expires any multiblock message in progress should be retransmitted beginning with the first block. Alternatively, the user may specify other action.
Description:	VAT10 is used to reflect actions taken by the DSP when the Incomplete Downlink Message timer (VGT4) expires.

5.4.2.11 VAT11, Auto Return to Data Timer

Name:	VAT11, Auto Return to Data Timer
Value:	User Defined
Start:	VAT11 should be started when the CMU changes to the Voice mode.
Restart:	The VAT11 timer should be restarted when keying is detected at the Voice-Go-Ahead Reset Discrete input or the PTT Discrete input.
On Expiration:	When the VAT11 timer expires the CMU should return to the Data mode. See Section 6.3.2.

5.4.3 Ground Counters

Name:	VGC1, Transmission Counter
Value:	3 per site (to a maximum of 14 in Category A networks)
Start:	VGC1 is started the first time an uplink block is transmitted.
Count:	VGC1 should be incremented by 1 each time the block is transmitted.

5.4.4 Airborne Counters

Name:	VAC1, Transmission Counter
Value:	no less than three, nor greater than eight
Start:	VAC1 should be started the first time a block is transmitted.
Count:	VAC1 should be incremented by 1 each time a block is transmitted.
Stop:	VAC1 is stopped when an uplink containing an acknowledgment indicating an error free downlink was received by the DSP.
On Expiration:	See Section 5.5.

5.4.5 VDL Mode A Timing Budget

A timing budget allocates propagation times to the various components of the network so each component gets an equitable share of the link time budget. Component upgrades that comply with the link time budget can be made without adversely impacting the network.

COMMENTARY

The ACARS network has existed an extended period of time without a time budget being defined. This was made possible because the avionics portion of the delay has been a small percentage of the total delay.

The insertion of the VHF Data Radio (VDR) and the associated digital (ARINC 429) interface and the redistribution of functions (see Section 10) causes the amount of time required for the avionics to process and respond to an uplink to increase to about 2 seconds. Therefore, a link time budget needed to be established so that the propagation delay of all the components is less that the end-to-end time specified by Timers VGT1 and VAT7.

5.4.5.1 VDL Mode A Timing Budget for VGT1

Figure 14-1 and 14-2 of Attachment 14 illustrate the components of the link time budget for an uplink with avionics that implement VDL Mode A as defined in Section 10. The propagation times stated herein come from the referenced documents and changes in those documents supersede these values. The components are:

1. Propagation of the uplink from the computer that manages Timer VGT1 through the service provider’s ground network, through the ground station until the ground station is ready to emit that uplink as an RF signal.
2. Typical MAC/CSMA delay for that network.
3. RF propagation
4. Propagation of the uplink through the VDR: RF signal detected by VDR, processed according to ARINC Characteristic 750 and ARINC 429 RTS word transmitted to the CMU: maximum 1 second according to ARINC Characteristic 750.
5. File transfer of uplink from VDR to CMU (RTS word to ACK determination): nominal maximum 0.20 second according to ARINC Characteristic 750 (assumes no delays).
6. Propagation of the uplink through the CMU: receive ARINC 429 file transfer (processing after ACK determination), uplink processing and response determination and prepare ARINC 429 file transfer (up to RTS word transmission): maximum 0.5 seconds (see Section 10).
7. File transfer of response from CMU to VDR (RTS word to ACK determination): nominal maximum 0.20 second according to ARINC Characteristic 750 (assumes no delays).
8. Propagation of the response through the VDR: delay from the file transfer ACK until the VDR is ready to emit an RF signal: maximum 0.1 second according to ARINC Characteristic 750.
9. Typical MAC/CSMA delay for that network.
10. Propagation of the downlink from the ground station, through the service provider’s ground network, to the computer that manages Timer VGT1.

The avionics (CMU and Mode A VDR) propagation delay is 2 seconds when everything works on the first attempt (i.e., CTS received, does not take into consideration for BUSY or NCTS responses). The VGT1 timer should be set to a value larger than the sum of the propagation delays listed above. The service provider should characterize the performance of its network and set the value of VGT1 accordingly. It is recommended that the value of VGT1 be larger than the minimum so that needless retransmissions are minimized.

For the traditional VGT1 value of 10 seconds this means that the service provider should ensure that its network (components a, b, j, and k) has a total propagation delay of less than 8 seconds (7 seconds would be a good goal). If the implementation of the ground network provides shorter propagation delays then the value of VGT1 may be reduced by a proportional amount.

COMMENTARY

If the value of VGT1 is not commensurate with the network performance then needless retransmissions may occur.

5.4.5.2 VDL Mode A Timing Budget for VAT7

Figure 14-3 of Attachment 14 illustrates the components of the link time budget for a downlink with avionics that implement VDR Mode A as defined in Section 10. The propagation times stated herein come from the referenced documents and changes in the referenced documents will supersede these values. The components are:

1. The CMU receives an ARINC 429 Acknowledgment word and starts VAT7.
2. Propagation of the downlink through the VDR: delay from the file transfer ACK determination until the VDR is ready to emit an RF signal: maximum 0.1 second according to ARINC Characteristic 750.
3. Typical MAC/CSMA delay for that network. VDR sends SOLO word indicating when transmission has occurred.
4. Propagation of the downlink from the ground station, through the service provider's ground network, to the computer that generates the response, propagation of the response through the ground network and the ground station until the ground station is ready to emit RF.
5. Typical MAC/CSMA delay for that network.
6. Propagation of the uplink through the VDR: RF signal detected by VDR, processed according to ARINC Characteristic 750 and ARINC 429 RTS word transmitted to the CMU: maximum 1 second according to ARINC Characteristic 750.
7. File transfer of uplink from VDR to CMU (RTS word to ACK determination): maximum 0.20 second according to ARINC Characteristic 750.
8. Propagation of the uplink through the CMU: receive ARINC 429 file transfer (processing after ACK determination), uplink processing.

The Timer VAT7 timer should be set to a value larger than the sum of the propagation delays listed above. The service provider should characterize the performance of its network (components c, d, and e) so that the avionics venders can set the value of VAT7 to a value compatible with the network performance. It is recommended that the value of VAT7 be larger than the minimum so that needless retransmissions are reduced.

COMMENTARY

If the value of Timer VAT7 is not commensurate with the network performance and the avionics performance then needless retransmissions will occur.

5.4.6 VDL Mode 2 Timing Budget

A timing budget allocates propagation times to the various components of the network so each component gets an equitable share of the link time budget. Component upgrades that comply with the link time budget can be made without adversely impacting the network. Refer to Appendix E for information concerning the VDL Mode 2 timing budget.

5.5 Retransmission Logic

Retransmission may be necessary when reception is marginal; e.g. when the aircraft is at the edge of coverage and portions of the message become corrupted (failed BCS) when received.

Occasionally two transmitting systems (airborne or ground) select the same instant to transmit, resulting in a collision at the receiver(s). Retransmission of these messages becomes necessary also. To preclude continued contention due to the unintentional synchronization of retransmissions, the time intervals between retransmissions in each CMU should vary randomly between an upper and lower limit.

Retransmission timing values should be optimized for specific service providers as needed. For Category A, a range of 10-25 seconds is optimal. For Category B networks the value varies with service provider. The retransmission interval should be random and uniformly distributed within the specified range.

When the Transmission counter (VAC1) reaches its limit then the CMU should stop retransmitting the downlink block until one of the following events occurs:

1. A valid uplink to any aircraft is heard.
2. Logic for entering Frequency Search state becomes valid.
3. Logic for falling back to a Base frequency from an Alternate frequency becomes valid.
4. In Category B, a new logical channel is established.

5.6 Frequency Management

The airborne subsystem has primary responsibility for performing frequency management. The airborne subsystem should provide the facility to cooperate with the ground network in its task of managing the limited VHF spectrum available for data message transfer.

A Base frequency is defined as the frequency for each ground network with which the aircraft may attempt to establish contact. Service providers may use alternative frequencies to offload traffic from its Base frequency.

DSP ground stations at the outer borders of DSP areas of coverage uplink squitter messages in the absence of normal operational uplink traffic to notify aircraft that they are entering a certain DSPs area of coverage. The squitter messages are generated by each DSP and conform to the timing characteristics described in ARINC Specification 618. DSPs should ensure that squitters transmitted from adjacent DSP ground stations do not collide.

COMMENTARY

In areas where multiple data link service providers offer coverage on the same frequency, these DSPs may receive downlink messages from the same aircraft. The DSP will deliver each and every block that it acknowledges. This practice may result in more than one copy of the message being delivered to the host. In the worst case, the message may be divided and delivered by the two DSPs as two partial messages. The DSP has primary responsibility for management of its Base and alternate frequencies to insure optimum utilization of the spectrum and to maintain a high level of communications performance as seen by the airborne systems. The DSP achieves these objectives by controlling the distribution of frequency assignments to active ACARS MUs.

5.6.1 Manual Base Frequency Management

The CMU should support the option for the aircrew to change the frequency used for VHF data communications via the CDU/MCDU.

The aircrew should be able to call up, for display on the CDU/MCDU, the frequency to which the transceiver has been commanded to tune as well as communications status (NO COMM, Voice mode etc). When the crew selects a different frequency for use that implies permission to send to and the Base Frequency Establishment state should be entered.

5.6.2 Automatic Base Frequency Management

This section applies only to airborne subsystems designed to accomplish automatic Base frequency management. This section applies only to the selection of a new Base frequency when a change of Base frequency is required. See Section 5.8 for procedures for transition between Base and alternate frequencies as specified by the autotune function.

Base frequency management is accomplished through operation in three states; the Acquisition State, the Establishment State and the Maintenance State. The relationship between these three states is shown in Figures 2-1 and 2-3 of Attachment 2. Figure 2-3 illustrates the relationship of base frequency acquisition to the autotune function. Figure 2-4 depicts the logical channel management.

5.6.2.1 Base Frequency Acquisition State

The Airborne Subsystem is in this state when it is searching for a new frequency on which to attempt contact. Figure 2-1 of Attachment 2 illustrates the Channel Acquisition Procedure. This state should be initiated during initial power application or after communication is lost on the service provider's Base frequency.

5.6.2.1.1 Frequency Selection Algorithm

The airborne subsystem should contain a table of candidate Base frequencies for data use. Parameters unique to each Base frequency and other DSP's operating parameters may be included with each entry in the table. This table is consulted while in the frequency acquisition state to determine the next Base frequency on which to attempt contact.

5.6.2.1.1.1 Base Frequency Scan Sequence

Each airline may select a sequence of Base frequencies to visit in its Base frequency scan cycle. This sequence will be held in the Base Frequency Scan Table. The sequence should be selected to best fit their expected usage of DSPs and geographical areas.

5.6.2.1.1.2 Geographic Filtering of Base Frequencies

To expedite Base frequency acquisition, positionally aware airborne subsystems may select a reduced set of Base frequencies from the Base Frequency Scan Table for scanning. This reduced set would be the Base frequencies for the DSPs known to operate in the current geographical region. This feature is optional.

5.6.2.1.1.3 Fast Scan of Base Frequencies

Many Base frequencies are very active during busy hours. During these hours uplinks are occurring without long intervening quiet times. To take advantage of this fact, the airborne subsystem may rapidly scan the designated available Base frequencies for uplink traffic. Each frequency should be visited for a time specified in Section 5.4.2 for the Fast Scan Mode. Exiting the Fast Scan mode is recommended after all available frequencies have been visited twice. Some airlines prefer their avionics to conduct a Fast Scan of all available frequencies prior to attempting to establish communications on any of the candidate frequencies supporting ACARS traffic. In this manner, the avionics may be able to support communications with a preferred DSP where two DSPs offer service in the same geographic region. This mode is optional.

5.6.2.1.1.4 Normal Scan of Base Frequencies

If Fast Scan is not implemented in the CMU or if a completed Fast Scan is unsuccessful because of light traffic conditions, the airborne subsystem should execute a Normal Scan. This scan should consist of traversing the sequence of selected Base frequencies with the Scan timer specified in Section 5.4.2 for the Normal Scan mode. Implementation of this mode is required.

5.6.2.1.2 Automatic Permission to Send Algorithm

After the airborne subsystem has selected a new Base frequency, it should verify that the selected frequency is a data frequency. One method is to passively monitor the frequency for a valid (correct BCS) ground to air (uplink) message. An uplink may be distinguished from a downlink by the presence of an Uplink Block Identifier (UBI). Other verification methods may also be used.

Once selected frequency has been validated, the CMU will have Permission to Send which allows the CMU to attempt contact with the ground service provider. However, channel access authorization must still be obtained using procedures outlined in Section 4.5.2. Once permission to send is obtained, the airborne subsystem will proceed to the Base Frequency Establishment State.

5.6.2.1.3 Scan Timer

In the event that the frequency chosen is not active in a particular location, the airborne subsystem will have a Scan timer to limit the time spent waiting on this frequency for valid uplink traffic in the Normal Scan Mode and in the optional Fast Scan Mode if it is implemented. See Section 5.4.2 for a definition of the Scan timer. When the Scan timer (VAT2) expires without the CMU hearing a valid uplink, the airborne subsystem should assume that the chosen frequency is not active at this location and select a new candidate Base frequency and resume listening for uplink traffic.

5.6.2.1.4 Uplink Squitter - Label SQ

As an aid to Base frequency acquisition and ground network identification, each ground service provider will cause a standard squitter message to be broadcast periodically on the Base frequency.

The CMU should accept uplink squitter messages which are broadcast by the ground networks. To support automatic Permission to Send logic in the MU, described in Section 5.2, each ground service provider will broadcast a standard squitter message periodically on its Base frequency.

In the event that there is no normal traffic or other transmissions from the ground station, the ground station may transmit a squitter uplink message to keep the channel alive. For purposes of this specification, the CMU should consider ANY uplink as normal traffic in a Category A network. Normal traffic in a Category B network is a Category B uplink only.

Under light traffic conditions, the squitter message will be transmitted at least once every two minutes as specified by the ground timer VGT6. Under heavy traffic conditions, the squitter message will be transmitted once every ten minutes as specified by ground timer VGT7 for ground station identification purposes.

Definition of the timers needed to support this provision is included in Section 5.4.1. The format of the uplink squitter message is as defined in Section 4.2.5 of ARINC Specification 620.

5.6.2.2 Base Frequency Establishment State

After a new Base frequency has been chosen, and permission to send has been received, the airborne subsystem should transmit (according to the Medium Access Control requirements of Section 2.3) a message to validate the integrity of the link. This message will inform the DSP that the aircraft is active in its system. The message selected for downlink may be an undelivered downlink message waiting in the downlink queue, a link test message or some other message specified by the user for this instance. Transmission of this message should use standard retransmission protocol (refer to Section 5.5). If the airborne subsystem receives an acknowledgment to one of its downlink attempts, it should conclude that the Frequency Maintenance state has been achieved. If the airborne subsystem cannot obtain an acknowledgment from the ground network, it should revert to the Base Frequency Acquisition State and select a new candidate frequency for its Base frequency of operation. The Base Frequency Establishment procedure is illustrated in Figure 2-1 of Attachment 2.

Once communications have been established on the Base frequency, the CMU should store this value.

5.6.2.3 Base Frequency Maintenance State

Once contact with a ground network has been established, the airborne subsystem is in a Frequency Maintenance state. The current value of the Base frequency should be maintained by the CMU until explicit system interaction (e.g. successful transition of a new Base frequency into the Frequency Maintenance state from the Frequency Establishment state) causes it to be changed. The system remains in the Frequency Maintenance state until the logic (Contact timer expires, NO COMM, etc) in the CMU indicates that the CMU should switch Base frequencies and enter the Base Frequency Acquisition state. During Category A operation, after expiration of the Contact timer, the airborne system should test to determine if contact still exists by transmitting a message as defined in Section 5.8.2 before exiting the Frequency Maintenance state. The Frequency Maintenance procedure is illustrated in Figure 2-1 of Attachment 2.

5.6.2.4 Power Interruption/Frequency Recall

When the aircraft is on the ground and power is lost or interrupted, for a period of up to 24 hours, the CMU should recall the last active Service Provider mode and frequency as outlined in the following two sections. In the event that the CMU is removed from the aircraft and replaced, the service provider/mode/frequency recall is not required.

5.6.2.4.1 While Operating in Base Frequency Maintenance State in POA

If the CMU was in POA and power is reapplied, it is expected to resume communications with implied permission (valid frequency) on a Base or an alternate frequency even after an overnight stay. The CMU should recover by resuming the Frequency Establishment State on last frequency used (Base or alternate) and thus immediately send a link test. If communication fails on an alternate frequency anytime during subsequent normal operation, the CMU should then reselect the last base frequency

established and re-enter the Base Frequency Establishment state described in Section 5.6.2.2.

COMMENTARY

In the case of POA, the CMU may also decide to restore the last ground station used, i.e. last Cat B RGS, even if last ground station has not been heard meanwhile.

5.6.2.4.2 While Operating in VDL Mode 2 AOA

If CMU was in VDL Mode 2 AOA, it is expected to try reconnecting on the last valid VDL2 frequency, as described in ARINC 631 (PECT table construction and Link establishment with a VGS). If connection establishment fails on a frequency different from the CSC, then CMU should attempt frequency recovery as defined in ARINC 631. If communication fails on the restored Service provider/Mode/frequency, the CMU should enter its nominal Mode/frequency acquisition.

COMMENTARY

In the case of AOA, the CMU may also decide to restore the last ground station used, i.e. VDL Mode 2 VGS, even if last ground station has not been heard meanwhile.

5.7 Operation on Alternate Frequencies

DSPs may supply multiple frequencies as required to minimize frequency congestion at high traffic areas. Under these circumstances, DSPs will uplink auto-tune messages to aircraft to cause aircraft avionics to change to the directed frequency and thereby balance traffic load across all available frequencies.

Individual studies among various service providers have shown that the optional use of multiple frequencies should provide separate frequencies for enroute and terminal communications. This may be achieved in two ways. If frequency management is controlled from the ground by the DSP, some indication is required when an aircraft changes air/ground status.

COMMENTARY

DSPs usually use the destination station within ON messages and both departure and destination stations within OFF messages to facilitate ground-based frequency management.

5.7.1 Data Transceiver Autotune Command

The service provider may use the Data Transceiver Autotune uplink command (Label :;) to offload VHF traffic to alternate frequencies. The airborne subsystem may receive the Autotune command while the aircraft is in any phase of flight (enroute, terminal or on the ground).

The format of the Data Transceiver Autotune command (Label :;) is defined in Section 4.2.6 of ARINC Specification 620.

The CMU should perform the following whenever it receives a Data Transceiver Autotune command uplink. The CMU should first respond on the present operating frequency with a technical acknowledgment message containing Label characters _DEL. Only one transmission should be made.

Note that if the optional debounce time used for AOA to POA transitions is included in the autotune uplink and the avionics is already in POA, the avionics should acknowledge the uplink, change frequency and disregard the VAT 13 timer or reject by downlinking a Label QV message.

After completing the acknowledgment downlink transmission, the CMU should then change the frequency code supplied to the transceiver to that of the new frequency contained in the Data Transceiver Autotune (Label :;) uplink. It should then, observing the Medium Access Control procedures provided in Section 4.5, immediately downlink the Link Test (Label Q0) message or its own traffic. This communication advises the ground processor that the airborne sub-system is active on the new frequency.

Normal Retansmission logic (whatever was in use for the particular network prior to the command) should be used to secure communications. However, a minimum of 3 downlink attempts should be conducted.

If an ATS message is in the process of being sent or is in queue when the transmission limit is reached on the autotune frequency, and another downlink media is available, the ATS message should be immediately routed to the alternate available media. If no alternate media is available, the ATS message should be attempted on the base VHF frequency per normal logic.

If communication fails (retransmission logic) anytime during autotune acquisition or subsequent normal operation, the CMU should then reselect the last Base frequency established and re-enter the Base Frequency Establishment state described in Section 5.6.2.2.

5.8 Category A Network Operation

Aircraft may transmit downlink messages to a DSP in either of the two methods described below:

1. CATEGORY A - Aircraft may broadcast the message to all DSP ground stations in the aircraft's VHF coverage area. Message delivery of this type is denoted by a "2" character in the mode character of the downlink message (see Section 2.3.2.1).
2. CATEGORY B - Aircraft may transmit the message to a single DSP ground station within the aircraft's VHF coverage area. Message delivery of this type is denoted by a character other than "2" in the mode character of the downlink message.

In Category A operation all ground station site selection and control is performed by the Service Provider. All Service Providers support Category A Operation.

COMMENTARY

Some category B implementations will respond to a category A downlink (Mode character is 2) with a category B acknowledgment (Mode character not 2).

When operating Category A, all ground stations within VHF range accept downlink messages. These ground stations transfer their copies of the message to the network's central processor. The central processor is then responsible for ensuring only one copy is delivered to the user. Received signal quality derived from the downlink may then be used in selecting the ground station site for any uplinks, including acknowledgments.

Messages are accepted from the airline host by the ground service provider's central processor and transferred to the current preferred ground station for transmission.

5.8.1 Establishment

Once the frequency has been established as defined in Section 5.6.2.2, the Contact timer and retransmission logic are then used to maintain the link. If the Contact timer expires and the attempts to deliver the subsequent downlink message is unsuccessful after all retransmissions, then the Frequency Acquisition state should be re-entered.

5.8.2 Contact Timer

While operating on its selected frequency, the airborne subsystem may maintain a Contact timer (VAT1). See Section 5.4.2 for a definition of the Contact timer. When the Contact timer (VAT1) exceeds the maximum value appropriate for the network, the airborne subsystem should take action to verify that contact still exists. The CMU should transmit any message in the downlink queue or trigger a Link Test (Label Q0) downlink. Normal Transmission logic (specific to the DSP) should be used for this contact verification message.

5.8.3 Tracker Message

A Tracker timer (VAT3) may be provided in the CMU to supply improved flight following information to the service provider. See Section 5.4.2 for the definition of the Tracker timer. If the Tracker timer is available (requested as a user option), it should be active during Frequency Maintenance while operating Category A. The Tracker timer is suspended while the aircraft is on the ground.

Upon expiration of the Tracker timer (VAT3) the CMU should trigger a Link Test (Label Q0) downlink message.

5.9 Category B Network Operation

In ground networks operating in Category B, each ground station (site) has an address. This address is placed in the Mode character position of Category B uplinks and squitter messages. If an MU places a site address in a downlink message, only the addressed site will process the message. Once the MU has selected the site it will use to communicate with the Data Link Service Provider (DSP), a “Logical Channel” has been established between the two.

In ground networks operating Category B, only the addressed site should accept a downlink message from the aircraft. This message is transferred to the network central processor for delivery to the airline host. Ground station site selection is performed by the MU.

A “logical channel” refers to the addressable connection maintained between the MU and the current selected site.

Only the site which has a Logical Channel to the aircraft should transfer messages to the network central processor. The central processor should use this same site to uplink messages to the aircraft.

COMMENTARY

> Some implementations of category B will use other sites in order to attempt to re-establish contact with the airborne subsystem after retries fail.

When operating in Category B, the MU should monitor all ground stations (sites) in range and perform handoffs when necessary in order to provide uninterrupted contact to the DSP.

Uplinks are accepted from the airline host by the ground service provider's central processor and transferred to the preferred ground station (selected by aircraft) for transmission.

Category B operation is identified with a Mode character as defined in Section 2.2.2.2. The actual Mode character inserted in each transmission depends upon the preferred ground system access code selected by the MU.

To support Category B operation, the MU should perform the following tasks:

- Maintain a ground station address table
- Establish a logical channel
- Maintain a logical channel

5.9.1 Ground Station (Site) Address Table

Category B Mode character bits are encoded to identify the logical access channel supported by the site within its Service Access Area (SAA). Bits numbered 1, 2, 3, 4, and 5 are encoded using five digit binary numbers, thereby enabling the avionics to receive ground system access code information for up to 30 logical access channels at any time.

A list of Category B Mode characters to be transmitted by ground sites are defined in Attachment 6 to this document.

A Ground Station (Site) Address table, which contains the current status of all possible sites, is constantly being updated by the CMU. This table is cleared on any frequency change.

The table is updated from any uplink traffic received having valid BCS and is maintained at all times while in data mode.

The table should contain the following information:

- Site ID – This is (or corresponds to) the mode character associated with the site.
- Quality Rating associated with that site.

Quality rating may be derived in any manner the CMU designer chooses that should provide efficient and timely handoffs between sites as they fall out of range.

The CMU should be capable of monitoring 2 or more sites. If more sites are available than the CMU table can manage, then the CMU should contain logic for dealing with this situation.

Operation of the Site Address table may continue during VOICE mode as defined in Chapter 7. When a return to Data mode is made, normal Channel Establishment/Frequency Acquisition logic should be applied.

5.9.2 Initial Operational Selection

The uplink message that allows the CMU to go from the Frequency Acquisition state to the Frequency Establishment state defines whether the CMU initially establishes a Category B Logical Channel or reverts to Category A operation. If the uplink contains Mode character "2," the CMU will establish a Category A link. If the uplink contains a site address, the CMU will select Category B operation using the site address provided in the uplink and go to the Logical Channel Establishment state.

5.9.3 Logical Channel Establishment

The CMU requests Logical Channel Establishment or Re-establishment by sending a downlink message containing the address of the selected site in the Mode character position. The address must be that monitored in an uplink message with Bit 6 of the Mode character set to zero (0). On receiving an acknowledgment for this downlink, the CMU can consider the "Logical Channel" established. Subsequently, all downlink messages sent will contain the site address and specifically, all acknowledgments to uplinks must include the address of the site that originated the uplink message. Category B operation can only be entered automatically since the CMU must hear an uplink with the site address.

Once the CMU has determined the need to automatically acquire the network (refer to Section 5.6.2) in a Category B mode the CMU should execute the sequence described in the following paragraphs.

The CMU should attempt to downlink existing messages in queue, or if there are none, send a Q0 downlink using appropriate retransmission logic defined in Section 5.5. This downlink message should be addressed using the Mode character received in the uplink message.

If the downlink fails, then the CMU should re examine the Site Address table for any other active sites. If there are, the CMU should select the next appropriate site, otherwise it should re enter Frequency Acquisition.

If the message is acknowledged then the link has been established.

When the CMU is trying to establish a logical channel, it attempts to establish communications with the best candidate ground station. The best candidate is determined to be the ground station with the highest acceptable quality rating that is not timed out.

If the CMU is unable to get an acknowledgment following retransmission logic, another ground station should be chosen. After exhausting all ground stations in the table the CMU should re enter the Frequency Acquisition state.

To expedite the delivery of high priority messages, such as ATS messages, it is desirable that, when necessary, the downlink message be requeued for transmission over an alternate medium without undue delay. When considering the possibility of undue delays in a Category B environment, the CMU should move to the alternate medium when the retry counter on the current VHF station is exhausted.

5.9.4 Channel Maintenance State

After Channel Establishment has been achieved, the CMU should go to the Channel Maintenance state.

Having selected a site, all downlinks are transmitted using the selected site address. When a site originates an uplink that is determined to be valid by the criteria of Section 3.2.2, then the CMU should transmit a Technical Acknowledgment to the same site that originated the uplink.

When contact is lost or the quality rating becomes low with the selected site, the CMU should try to establish contact with a new site if one exists by re entering the Channel Establishment state.

5.10 Statistical Data Collection and Reporting

It is recommended that the ACARS CMU be capable of collecting and recording VHF data link statistics. Two statistical data functions have been defined that provide data regarding the operation of the VHF protocol at different levels. One statistical data function collects data on the number of messages transmitted and received, number of ACKS/NAKs, etc. as defined in Attachment 8. The other statistical data function collects data on the performance of the VHF channel such as channel occupancy, channel access delays, etc. as defined in Appendix F to ARINC Specification 620.

5.10.1 Message Statistical Data Collection

Message Statistical Data Collection is performed for each flight leg as defined herein. The collection of VHF statistics data should be initialized when the first IN event occurs. The data collected from IN event to IN event forms a file.

The CMU should accept and comply with commands to enable and disable the data gathering function. The command may be delivered from the ground via an uplink. The data gathering function may also be enabled/disabled through other optional means provided by the equipment manufacturer.

The ACARS CMU should start a new statistics data record every time it switches frequency, ground station or OOOI state.

Table 8-1 of Attachment 8 defines the data within a record.

5.10.1.1 Statistical Data Reports

Data may be provided to the user in the form of reports: Summary reports and Detailed reports. Summary reports provide general information concerning network performance. Detailed reports provide more specific information and can be used for diagnostic purposes.

The CMU may be preprogrammed to automatically generate reports when specific events occur. The destination of these reports will be included in the programming.

The following subsections describe report formats. In all cases, it is assumed that the data gathering function was enabled and that the desired data is available for the report. If no data was collected, a No Data report should be sent, informing the requester that this is the case. This report is also described below.

5.10.1.1.1 Summary Reports

The ACARS CMU should generate a Summary report when a request is received. If the recording of the data was not enabled, making no data available, a No Data report should be rendered, per Section 5.10.1.1.3. See ARINC Specification 620 for message definition.

The request for a Summary report may be entered via the ACARS data link in the form of an uplink message. In this case, the CMU output should generate the Summary report and send it to the requester in a downlink message using the Label S1. See ARINC Specification 620 for message definition.

The request for a Summary report may be entered from an onboard source. In this case, the request should indicate the source of the request and the preferred destination. For example, the request may come from the MCDU and designate that the onboard printer or a computer on the ground receive the report. In response, the CMU should generate the Summary report and send it to the indicated destination. See ARINC Specification 620 for message definition.ground receive the report. In response, the CMU should generate the Summary report and send it to the indicated destination. See ARINC Specification 620 for message definition.

5.10.1.1.2 Detailed Reports

The ACARS CMU should also be capable of providing, on command, a full report of all the data records recorded for a flight leg in the form of a Detailed report.

The ACARS CMU should accept and execute commands to generate and downlink Detailed reports for the previous n flight legs. If the recording of the data was not enabled, making no data available, a No Data report should be rendered, per Section 5.10.1.1.3.

The request for a Detailed report may be entered via the ACARS data link in the form of an uplink message. In this case, the CMU output should generate the Summary report and send it to the requester in a downlink message using the Label S1. See ARINC Specification 620 for message definition.

The request for a Detailed report may be entered from an onboard source. In this case, the request should indicate the source of the request and the preferred destination. For example, the request may come from the MCDU and designate that the onboard printer or a computer on the ground receive the report. In response, the CMU should generate the Summary report and send it to the indicated destination. See ARINC Specification 620 for message definition.

5.10.1.1.3 No Data Reports

If a request for data is received and the data gathering function has been disabled, the ACARS CMU should provide a No Data report. The report should designate the time and date that the recording function was disabled. The CMU should generate the No Data report and send it to the indicated destination. See ARINC Specification 620 for message definition.

5.10.2 VHF Channel Performance Data

The purpose of the VHF Channel data function is to gather VHF air-ground channel performance data and transport it to the ground. It permits real time unsolicited or on-demand reporting of air-ground systems indicators pertinent to channel load level and protocol management.

When the aircraft is equipped with an ARINC 750 VDR that interfaces with the CMU via an ARINC 429 bus then some of this data is collected by the VDR. See ARINC Characteristic 750 for message formats. The CMU should accumulate the data.

5.10.2.1 VHF Channel Data Report Generation

VHF Performance data reports are generated by one of the following mechanisms:

1. Periodic report: An uplink to the CMU can enable Periodic reports. The uplink should contain the report period and how long to provide the periodic reports.
2. Snapshot report: An uplink to the CMU requesting that data be collected for n minutes and downlinked in a report.
3. Aircraft Profile Report: Aircraft Profile Report is issued upon request. The CMU can be programmed to automatically generate an Aircraft Profile Report when new software is loaded or a different CMU is installed in an aircraft.

4. See ARINC Specification 620 for the formats of the various VHF Performance (Label S2) reports.

COMMENTARY

Snapshot and Periodic reports have the same format. Aircraft Profile Report definitions will appear in Supplement 4 to Specification 620.

If the CMU is performing periodic reporting and a snapshot request uplink is received, then the periodic reporting is terminated and the snapshot report data gathering begun. A periodic request uplink should be sent to the CMU to start up periodic reporting after a snapshot.

If the CMU is performing a snapshot and a periodic request uplink is received then the snapshot is terminated and the periodic report data gathering begun.

If the CMU is performing periodic reporting and another periodic request uplink is received then the present periodic reporting is terminated and then periodic reporting is started again with the new values.

5.10.2.2 VHF Channel Report Parameters

The CMU should gather the following data for inclusion in VHF Channel Reports.

5.10.2.2.1 Cumulative VHF Channel Busy (Tcu)

The CMU should gather the following data for inclusion in VHF Channel Reports.

The CMU should measure the cumulative time that the VHF channel is busy. The CMU will sample the channel periodically and report the percentage of samples that detected the channel busy.

The percentage has a range of 0 to 99. The CMU should sample as frequently as possible without unduly burdening the CMU processor(s).

The cumulative VHF Channel Busy value, is set to zero at the beginning of each report interval.

5.10.2.2.2 Cumulative Block Delivery Delay (Tbdd)

The CMU should calculate the cumulative block delivery delay by summing the block delivery delay for each block transmitted. The block delivery delay is the elapsed time from the first transmission of the block until the ACK is received.

The cumulative block delivery delay should be reported with a resolution of milliseconds and have a range of 000000 to 999999. If the maximum value is reached then the maximum value should be retained until the next report interval. Each time the CMU transmits a block for the first time it will increment the cumulative block delivery delay until:

1. an ACK is received for that block or
2. the maximum value is reached or

3. the report interval end.

The cumulative block delivery delay is set to zero at the

beginning of each report interval.

If an acknowledged transmission occurred in a previous report interval then cumulative block delay time will continue incrementing from zero in the following report interval.

5.10.2.2.3 Cumulative MAC Delay (Tmac)

The CMU should calculate the cumulative MAC delay by summing the MAC delay for each block transmitted. The MAC delay is the elapsed time from when the block is sent to the MAC until the time when it is transmitted over the RF channel.

The cumulative MAC delay should be reported with a resolution of milliseconds and have a range of 00000 to 99999. If the maximum value is reached then the maximum value should be retained until the next report interval. Each time the CMU sends a block to the MAC, it should increment the cumulative MAC delay until:

1. the block is transmitted over the RF channel or
2. the maximum value is reached or
3. the report interval ends.

The cumulative MAC delay is set to zero at the beginning

of each report interval.

When the aircraft is equipped with an ARINC 750 VDR that interfaces with the CMU via an ARINC 429 bus then this data is collected by the VDR. See ARINC Characteristic 750 for message formats.

If a block is waiting for MAC to transmit it at the beginning of a report interval then the cumulative MAC Delay will begin incrementing from zero, until the block is transmitted.

5.10.2.2.4 Number of Blocks Buffered at Tf (B1)

The number of blocks in the downlink queue at the end of the report interval, including block that has been sent to MAC. The range is 00 to 99. If the number of blocks exceeds the maximum value then the maximum value should be reported. The number of blocks buffered is set to zero at the beginning of each report interval.

5.10.2.2.5 Number of First Downlink Blocks (D1)

The CMU counts the number of downlink blocks transmitted for the first time that require an ACK during the report interval. Downlinks, such as General Response, which do not require an acknowledgment from the DSP, see ARINC 620, are excluded from the count. The range is 00 to 99. If number of blocks exceeds the maximum value then the maximum value will be reported. The count is set to zero at the beginning of each report interval.

5.10.2.2.6 Number of Re-transmitted Downlink Blocks (D2)

The number of downlink blocks requiring an ACK that were re-transmitted during the report interval are counted by the CMU. The count is incremented each time a downlink block requiring an ACK is re-transmitted (but not on the first transmission) that has all ready been counted; see Section 5.10.2.1.5. The range of the counter is 000 to 999. If the number of re-transmissions exceeds the maximum value then the maximum value should be reported. The count is set to zero at the beginning of each report interval.

5.10.2.2.7 Number of Downlink Blocks Received From Surrounding Aircraft (D3)

The CMU counts number of downlink blocks received from surrounding aircraft during the report interval. The count is incremented each time the CMU hears a downlink block. The range of the counter is 000 to 999. If number of blocks exceeds the maximum value then the maximum value will be reported. The count is set to zero at the beginning of each report interval.

When the aircraft is equipped with an ARINC 750 VDR that interfaces with the CMU via an ARINC 429 bus then this data is collected by the VDR. See ARINC Characteristic 750 for message formats.

5.10.2.2.8 Number of Incomplete Downlink Blocks Received From Surrounding Aircraft (ID3)

The CMU counts the number of incomplete downlink blocks received from surrounding aircraft during the report interval. The count is incremented each time the CMU hears an incomplete downlink block. The range is 000 to 999. If number of blocks exceeds the maximum value then the maximum value should be reported. The count is set to zero at the beginning of each report interval.

When the aircraft is equipped with an ARINC 750 VDR that interfaces with the CMU via an ARINC 429 bus then this data is collected by the VDR. See ARINC Characteristic 750 for message formats.

5.10.2.2.9 Number of Downlink Blocks Received With Bad BCS From Surrounding Aircraft (BD3)

The CMU counts the number of downlink blocks with bad BCS received from surrounding aircraft during the report interval. The count is incremented each time the CMU hears a downlink block with bad BCS. The range is 000 to 999. If the number of the blocks exceeds the maximum value then the maximum value should be reported. The count is set to zero at the beginning of each report interval.

When the aircraft is equipped with an ARINC 750 VDR that interfaces with the CMU via an ARINC 429 bus then this data is collected by the VDR. See ARINC Characteristic 750 for message formats.

5.10.2.2.10 Number of ACKS Received (U1)

The CMU counts the number of acknowledgments, both embedded and General response, received during the report interval. The count is incremented each time the CMU receives an uplink containing an acknowledgment. The range of the counter is 00 to 99. If the number of acknowledgments exceeds the maximum value then the maximum value should be reported. The count is set to zero at the beginning of each report interval.

5.10.2.2.11 Number of First Uplink Blocks That Require an ACK (U2)

The CMU counts the number of uplink blocks received during the report interval for the first time that require an ACK. Uplinks, such as General Response, which do not require an acknowledgment from the CMU, (see ARINC 620) are excluded from the count. Re-transmitted blocks are excluded from the this count, see Section 5.10.2.1.12. The range of the counter is 00 to 99. If the number of blocks exceeds the maximum value then the maximum value should be reported. The count is set to zero at the beginning of each report interval.

5.10.2.2.12 Number of Uplink Re-transmissions That Require an ACK (U3)

The CMU counts the number of re-transmitted uplink blocks received during the report interval that require an ACK. Uplinks, such as General Response, which do not require an acknowledgment from the CMU, see ARINC 620, are excluded from the count. Blocks received for the first time are excluded from the this count, see Section 5.10.2.1.11. The range is 000 to 999. If the number of blocks exceeds the maximum value then the maximum value will be reported. The count is set to zero at the beginning of each report interval.

5.10.2.2.13 Number of Uplink Blocks Addressed to Aircraft With Bad BCS (BU3)

The CMU counts the number of uplink blocks that are addressed to the aircraft that the CMU is installed in and that fail the BCS check during the report interval. The range of the counter is 00 to 99. If the number of blocks exceeds the maximum value then the maximum value should be reported. The count is set to zero at the beginning of each report interval.

When the aircraft is equipped with an ARINC 750 VDR that interfaces with the CMU via an ARINC 429 bus then this data is collected by the VDR. See ARINC Characteristic 750 for message formats.

5.10.2.2.14 Number of Incomplete Uplink Blocks Addressed to Aircraft (IU3)

The CMU counts the number of incomplete uplink blocks that are addressed to the aircraft that the CMU is installed in during the report interval. The range is 00 to 99. If the number of blocks exceeds the maximum value then the maximum value will be reported. The count is set to zero at the beginning of each report interval.

When the aircraft is equipped with an ARINC 750 VDR that interfaces with the CMU via an ARINC 429 bus then this data is collected by the VDR. See ARINC Characteristic 750 for message formats.

5.10.2.2.15 Number of Uplink Blocks Addressed to Other Aircraft (U4)

The CMU counts the number of uplink blocks addressed to other aircraft heard during the report interval. The range of the counter is 000 to 999. If the number of blocks exceeds the maximum value then the maximum value will be reported. The count is set to zero at the beginning of each report interval.

5.10.2.2.16 Number of Uplink Blocks Addressed to Other Aircraft With Bad BCS (BU4)

The CMU counts the number of uplink blocks addressed to other aircraft heard that fail the BCS check during the report interval. The range of the counter is 000 to 999. If the number of blocks exceeds the maximum value then the maximum value should be reported. The count is set to zero at the beginning of each report interval.

When the aircraft is equipped with an ARINC 750 VDR that interfaces with the CMU via an ARINC 429 bus then this data is collected by the VDR. See ARINC Characteristic 750 for message formats.

5.10.2.2.17 Number of Incomplete Uplink Blocks Addressed to Other Aircraft (IU4)

The CMU counts the number of incomplete uplink blocks addressed to other aircraft heard during the report interval. The range of the counter is 000 to 999. If the number of blocks exceeds the maximum value then the maximum value should be reported. The count is set to zero at the beginning of each report interval.

5.10.2.2.17 Number of Incomplete Uplink Blocks Addressed to Other Aircraft (IU4) (cont'd)

When the aircraft is equipped with an ARINC 750 VDR that interfaces with the CMU via an ARINC 429 bus then this data is collected by the VDR. See ARINC Characteristic 750 for message formats.

5.10.2.2.18 Number of Distinct Squitters Received (SQ1)

The CMU counts the number of squitters heard from different ground stations, i.e. each mode character is counted once, during the report interval. If the report interval is less than 10 minutes then a squitter may not be transmitted by a RGS. The range of the counter is 00 to 32. The count is set to zero at the beginning of each report interval.

COMMENTARY

The CMU is only required to monitor the mode character, therefore when the aircraft is in a location that allows the CMU to hear uplinks from two ground stations with identical mode characters and different ICAO codes, then the CMU should report both ground stations as one.

5.10.2.2.19 Number of Squitters Received (SQ2)

The CMU counts the total number of squitters heard including multiple squitters form each ground station, during the report interval. The range of the counter is 00 to 99. If the number of squitters exceeds the maximum value then the maximum value should be reported. The count is set to zero at the beginning of each report interval.

5.10.2.2.20 Number of Squitters Received With Bad BCS (BSQ2)

The CMU counts the number of squitters heard that fails the BCS check, during the report interval. The range is 00 to 99. If the number of squitters heard that fail the BCS check exceeds the maximum value then the maximum value should be reported. The count is set to zero at the beginning of each report interval.

When the aircraft is equipped with an ARINC 750 VDR that interfaces with the CMU via an ARINC 429 bus then this data is collected by the VDR. See ARINC Characteristic 750 for message formats.

5.10.2.2.21 Number of Incomplete Squitters Received (ISQ2)

The CMU counts the number of incomplete squitters heard during the report interval. The range of the counter is 00 to 99. If the number of incomplete squitters exceeds the maximum value then the maximum value should be reported. The count is set to zero at the beginning of each report interval.

When the aircraft is equipped with an ARINC 750 VDR that interfaces with the CMU via an ARINC 429 bus then this data is collected by the VDR. See ARINC Characteristic 750 for message formats.

5.10.2.2.22 Number of Hand-offs in Category B (CTB1)

The CMU counts the number of times it switches ground stations (INCLUDE FAILED ATTEMPTS TO) during the report interval. The range of the counter is 00 to 99. If the number of switches exceeds the maximum value then the maximum value should be reported. The count is set to zero at the beginning of each report interval.

5.10.2.2.23 Number of Distinct Logical Channels Active in the SAA Table (CTB2)

The CMU reports the number of ground stations in the site table at the end of the report interval. The range is 00 to 30. The count is set to zero at the beginning of each report interval.

5.11 Transit Times

The transit times are of great concern and will therefore be discussed in more detail in the sections below: uplink (Host-to-DSP-to-ACFT), multiblock uplink (Delays between uplink blocks), single block downlinks (ACFT-to-DSP-to-Host), multiblock downlink (Delays between downlink blocks).

The uplink message transit time is the amount of time required for the first block of a message to be received by the aircraft after the entire message was sent by the datalink user (User-to- Aircraft).

Multiblock uplink transit times include all retransmission and network delays from the time the Nth block is sent by the service provider until the time that the service provider sends out block N+1 (assuming an ack is sent by the aircraft and received by the DSP, no channel congestion, and the aircraft response time is negligible).

Single block downlink transit times are measured from the time that the ground system receives the downlink message until the time that the datalink user (or a

Since the service provider waits until all blocks of a downlink message are received before forwarding to the end user, the air/ground transit time for each block must be taken into consideration to establish end-to-end transit times for downlink messages of any length. Please refer to Sections 3.6.2.1 and 3.6.4.1 for details concerning missing air/ground blocks and time-out rules.

Multiblock downlink transit times are measured from the time that the aircraft sends the Nth downlink block until the aircraft sends the block N+1 (Assuming no congestion on the RF, the aircraft is in range of a ground station, and the aircraft response time is negligible). This time will include any network transit delays and built in system delays.

6.0 VOICE MODE OPERATION

6.1 Introduction

Voice Mode Operation is an optional capability of the ACARS CMU. There are various operational and installation dependent characteristics in supporting VOICE mode.

COMMENTARY

As the ACARS CMU primary role is to provide a Digital Data Link service, use of the system for VOICE operation is at best disruptive and in general should be discouraged. This section is dedicated to what is meant by “disruptive.”

The following summarizes some of the variables:

1. Which type of CMU - 597,724,724B
2. Which type of Radio - 546,566,716
3. Number of VHF’s installed - 2,3,4
4. Types of changes supported (AUTO/MAN)

6.2 Manual Channel Changes (VOICE/DATA)

Manual (crew initiated) transitions between VOICE and DATA modes may be provided by external inputs to the CMU or via the ACARS CDU or MCDU.

6.2.1 ACARS CDU Changes

The ACARS CDU/MCDU may provide support for crew initiated DATA/VOICE and VOICE/DATA mode changes.

6.2.2 Remote VOICE/DATA Mode Select

A Remote Voice/Data Mode Select Discrete input is provided on the ACARS CMU service connector. The Remote Voice/Data Mode Select Discrete input should be used to change from DATA mode to VOICE mode and vice versa whenever a momentary airframe DC ground is applied.

In this Specification “Momentary” is defined as application of the ground for 50 milliseconds or more.

6.2.3 VOICE/DATA Mode Input

The VOICE/DATA Mode Discrete input is used to determine (control) whether the CMU should operate in DATA or VOICE mode. If the VOICE/DATA Mode Discrete input is grounded then the CMU should be in DATA mode, if open then VOICE mode.

6.3 Automatic Channel Changes (VOICE/DATA)

Both automatic DATA-to-VOICE and VOICE-to-DATA channel changes may be provided by the ACARS MU. Automatic, in this context, refers to no direct crew involvement.

Whether or not the CMU is enabled to provide the automatic channel changeover function is determined by the aircraft wiring of the associated Auto/Manual Channel Change Program pin. See Section 6.4.2.

6.3.1 DATA to VOICE

Automatic DATA to VOICE transitions may occur only upon receipt of an uplink Voice Go-Ahead (Label 54) uplink and all of the following are true:

1. The VHF is SHARED as defined by the Dedicated Receiver Program Pin (See Section 6.4.3).
2. The AUTO/MAN Channel Change Program Pin is set to AUTO (See Section 6.4.2).
3. VOICE mode is enabled (See Section 6.4.5).

6.3.2 VOICE to DATA

The CMU may implement an automatic return to DATA mode. The CMU is equipped with an Auto Return-to-Data (AT11) timer. Implementation of the Return-to-Data Mode function is subject to the following restrictions:

1. The CMU must have the ability to monitor the KEY line of the associated transceiver to determine if Voice communications are in progress.
2. The AUTO/MAN Channel Change Program Pin is set to AUTO. See Section 6.4.2.

The CMU may detect keying of the radio from either the Voice Go-Ahead Reset Discrete input or the XMTR Voice PTT input.

When the CMU enters VOICE mode, the Auto Return-to-Data timer (AT11) is started. The timer should be restarted upon key line detection. When the timer expires an automatic return to DATA mode may be initiated.

COMMENTARY

> This option should be used carefully as it is imperative that the CMU does not take command of the radio from the flight crew inadvertently.

If this option is implemented, then the second option, to allow the crew to inhibit the automatic return to DATA mode, is recommended.

6.4 Configuration Programming Functions

At a minimum three rear connector Program Pins are to be provided by the CMU to identify various installation configurations and support user requirements. As an option the CMU may provide one or more “Software” Program pin functions via internal software programs. Some Users have implemented these functions using User Defined pins.

COMMENTARY

> Provisions for these program pins may not be self evident in MUs built to ARINC Characteristic 597.

6.4.1 Voice Frequency Control Program Pin

When the ACARS CMU is to be used to provide VOICE frequency selection the Voice Channel Control Program pin should be connected to Program Pin Common on the CMU service connector.

When the aircraft is configured to provide VOICE frequency selection from an external control panel the Voice Channel Control Program pin should be left open.

6.4.2 Auto/Manual Channel Change Program Pin

When Automatic changeovers from VOICE and DATA mode are to be disabled the AUTO/MAN Channel Changeover Program pin should be connected to Program Pin Common on the CMU service connector.

If automatic changeovers are desired, then the pin should be left open. Reference Section 6.3 with respect to automatic changeovers.

6.4.3 Dedicated Transceiver Program Pin

When the aircraft in which the airborne sub-system is installed is equipped with a VHF transceiver dedicated to data communications, the Dedicated Transceiver Program pin should be connected to Program Pin Common on the CMU service connector. When the transceiver is to be shared with VOICE operations Dedicated Transceiver Program pin should be left open.

6.4.4 5P/Q6 Enable "Software" Program

An option may be provided to enable or disable the transmission of Temporary Suspension (Label 5P) and Voice to Data Channel Changeover Advisory (Label Q6) during VOICE/DATA transitions.

If this option is implemented, the preferred action of the CMU is to inhibit the transmission of these messages.

COMMENTARY

Studies have shown that, in many cases the overhead associated with transmission of 5P/Q6 message traffic is not beneficial to overall system operation. The user should be aware that if the airborne system relies heavily on multi-block capabilities in a shared COMM installation, that it may be of benefit to use the 5P/Q6 messages to reduce "incomplete messages."

6.4.5 VOICE Mode Enable Software Program

As an option, the CMU may provide the capability to enable VOICE mode capabilities. When enabled, this function will cause the ACARS CMU to switch to the VOICE mode in response to external inputs and allow the ACARS CDU access to VOICE mode. When not enabled, all VOICE mode capabilities will be disarmed.

6.5 AOC Voice Channel Signaling

The ACARS CMU may be used for bi-directional signaling for AOC voice communications SELCAL and CALSEL.

Note that the voice exchange is conducted on a different radio frequency channel from that employed for digital communications.

6.5.1 Voice Contact Request (CALSEL) - Label 54

Aircrew requests (downlinks) for voice contact with a specified party on the ground should contain Label characters 54.

The format of the Voice Contact Request (Label 54) downlink message is defined in Section 5.2.2 of ARINC Specification 620.

6.5.2 Voice Go-Ahead (SELCAL) - Label 54

Upon receipt of a Voice Go-Ahead (Label 54) uplink message the CMU should execute the Voice Go-Ahead (SELCAL) function.

The format of the Voice Go-Ahead (Label 54) uplink message is defined in Section 4.2.3 of ARINC Specification 620.

Recognition of the Voice Go-Ahead (Label 54) uplink may also be used to trigger an automatic changeover to the Voice channel. Refer to Section 6.3.1 for guidance for automatic changeover. Before the changeover is effected, however, the airborne subsystem must send a technical acknowledgment to the DSP, acknowledging the receipt of the Voice Go-Ahead (Label 54) uplink message. The Technical Acknowledgment may be included in either a Temporary Suspension (Label 5P) downlink or a Dedicated Transceiver Advisory (Label F3) downlink. The CMU determines which downlink to send based on the logic of Figure 7.1 of Attachment 7.

6.6 VOICE Mode Advisories to the Crew

6.6.1 Voice Go-Ahead Advisories

Receipt of a Voice Go-Ahead (Label 54) uplink message should cause the CMU to trigger an annunciation device in the cockpit to tell the crew that their party is on the line and that the conversation can begin.

If desired by the user on the ground, the frequency to which the VHF transceiver should be tuned for the voice conversation may be included in the text field of a Voice Go-Ahead (Label 54) uplink message. The CMU may provide the capability to tune the VHF radio to the Voice frequency. The CMU should output the voice frequency for display to the pilot.

Various forms of annunciation may be utilized depending on user requirements and aircraft configuration.

All CMUs should provide the capability to annunciate the SELCAL condition and associated frequency on the ACARS CDU.

All CMUs should also provide two sets of relay contacts which may be used to drive external annunciators such as a Chime (aural) and Lamp (Visual). Contact operation for each set may be specified by the user and is typically a continuous closure or a cyclic closure and may have a timed duration.

Additionally the CMU should provide a digital annunciator of SELCAL in its Label 270 output word on its General Purpose buses.

All CMUs should provide a Voice Go-ahead Alert Reset Input for purposes of externally extinguishing the annunciation. The CMU should cease to output the annunciation for the crew when the Voice Go-ahead Alert Reset Discrete input to the CMU is momentarily grounded.

The reset may also be activated within the CMU in response to appropriate flight crew action, e.g., acceptance of the Advisory via the CDU.

Either occurrence should re-arm the alerts to permit their output on recognition of the next Voice Go-Ahead (Label 54) uplink.

6.6.2 VOICE/DATA Mode Annunciation Outputs

The VOICE/DATA Mode Annunciation Discrete output is used to indicate whether the VHF radio associated with the ACARS CMU is to operate in VOICE or DATA mode. This discrete may be used to control the keying mode of the ARINC 716 VHF COM transceiver.

A Remote Voice/Data Status Annunciator Discrete Output should also be provided. This signal, having identical logic, is used to operate a status annunciator in the cockpit.

An annunciation on the ACARS CDU should always be provided at all times to indicate VOICE/DATA mode. In addition if the frequency is provided by the ACARS MU, the frequency currently being tuned for VOICE should be displayed on the ACARS CDU while in VOICE mode.

Additionally the 724B CMU should provide a digital annunciator of VOICE mode in its Label 270 output word on its General Purpose buses.

6.7 VOICE Mode Advisories to the DSP

The CMU should determine which downlink listed in the following subsections to send to the DSP based on the aircraft installation and the user preference. A table is provided in Attachment 7.

6.7.1 Dedicated Data Transceiver Advisory - Label F3

Under certain conditions the Dedicated Data Transceiver Advisory (Label F3) is used to acknowledge a Voice Go-Ahead (Label 54) uplink. See Attachment 7. This advises the ground processor controlling the system that data communications with that aircraft can continue.

The response of the CMU to the receipt of a Label 54 uplink should be to interrupt (abort) any multiblock downlink traffic in progress. A Label F3 downlink response should be transmitted in lieu of any other planned use for the downlink at that time.

The Dedicated Data Transceiver (Label F3) message should be transmitted only once when the RF channel is clear. The Label F3 message is not stored for retransmission.

Receipt of the Dedicated Data Transceiver Advisory downlink (Label F3) message will not be acknowledged by the DSP.

The format of the message is defined in Section 5.2.8 of ARINC Specification 620.

6.7.2 Temporary Suspension - Label 5P

Under certain conditions the optional Temporary Suspension downlink (Label 5P) is used. If the CMU generates Temporary Suspension (Label 5P) downlinks then it should also generate VOICE to DATA Channel Changeover Advisory (Label Q6) downlinks. A message containing Label characters 5P may be downlinked automatically prior to a transition from DATA mode to VOICE mode. See Section 6.7.1.

The Temporary Suspension (Label 5P) message should be transmitted only once when the RF channel is clear. The Label 5P message is not stored for retransmission. It should be discarded if transmission cannot commence within 2 seconds.

Receipt of the Temporary Suspension downlink (Label 5P) message will not be acknowledged by the DSP.

COMMENTARY

The Temporary Suspension downlink (Label 5P) message is used by the DSP to facilitate the system management functions necessitated by the transfer of the associated radio transceiver in the aircraft from a Data frequency to a Voice frequency. The DSP should recognize the message as advice to suspend the data transmissions to the aircraft until the airborne transceiver is returned to the Data frequency, which should be annunciated by receipt of a VOICE-to-DATA Channel Changeover Advisory (Label Q6) downlink or other traffic from the aircraft. Since the Label Q6 downlink may not be received by the DSP, as an alternative, the DSP may resume uplinks at the expiration of the Temporary Suspension timer, GT8, which is started at the receipt of the Label 5P downlink.

The format of the message is defined in Section 5.4.4 of ARINC Specification 620.

6.7.3 VOICE to DATA Advisory - Label Q6

The VOICE to DATA Channel Changeover Advisory downlink, Label Q6, is optional. However, if the CMU generates Label Q6 downlinks then it should also generate Temporary Suspension (Label 5P) downlinks. A message containing Label characters Q6 may be downlinked automatically after switching the VHF transceiver through which ACARS is operating from a voice frequency to an ACARS frequency and there is no other downlink message awaiting transmission. See Section 6.7.2.

This Voice to Data Channel Changeover Advisory (Label Q6) or other downlink is necessary when the transceiver is returned to the digital channel following a voice conversation, to inform the DSP that the airborne subsystem is once again ready to receive digital uplinks.

The format of the message is defined in Section 5.2.6 of ARINC Specification 620.

6.8 Mode Transition Logic

6.8.1 DATA Mode to VOICE Mode

Whenever a condition occurs initiating a transition from DATA mode to VOICE mode the following should occur:

Case 1: System is in NOCOMM (NO VHF LINK)

1. Current DATA Frequency should be stored.
2. Auto Return to Data Timer (AT11) may be started. VOICE mode may be immediately entered. If Voice frequency is CMU controlled, frequency should be available prior to transition.
3. Annunciate VOICE mode.

Case 2: System has Link Acquired, but is quiescent

1. Current Data Frequency should be stored.
2. Temporary Suspension (Label 5P) downlink may be sent if the 5P/Q6 function is enabled.
3. The VOICE mode timer (AT9) should be started.
4. The Auto Return to Data timer (AT11) may be started. VOICE mode may be entered. If Voice frequency is CMU controlled, frequency should be available prior to transition.
5. Annunciate VOICE mode.

Case 3: System has Link Acquired and traffic in progress

1. A Temporary Suspension (Label 5P) downlink, if enabled, is sent.
2. Current DATA Frequency should be stored.
3. A VOICE Mode timer (AT9) should be started.
4. The Auto Return-to-Data (AT11) timer may be started. VOICE mode may be entered. If Voice frequency is CMU controlled, frequency should be available prior to transition.
5. Annunciate VOICE mode.

If the VOICE Mode timer (AT9) expires during VOICE mode, then the CMU should activate all NOCOMM logic. If a multiblock downlink was in progress and the CMU did not deliver the message over a different media, then the CMU should retransmit all blocks. The CMU may downlink the message over a different media while in VHF Voice mode. If a multiblock uplink was in progress then the CMU should discard any partial message received.

All retransmission logic and timers remain active (continue to run) during VOICE mode.

6.8.2 VOICE Mode to DATA Mode

Whenever a condition occurs initiating a transition from VOICE mode to DATA mode the following should occur:

Case 1: System was in NOCOMM (NO VHF LINK) before switching to VOICE mode or VOICE Mode timer (AT9) has expired.

1. Last Base Data frequency should be reloaded as new frequency.
2. System should enter Frequency Acquisition; i.e., a VOICE to DATA Channel Changeover Advisory (Label Q6), or equivalent, message is not transmitted.

Case 2: System was in communication and VOICE Mode Timer (AT9) has not expired.

1. Last Data frequency should be reloaded as new frequency.
2. The CMU should, observing Medium Channel Access procedures, downlink a VOICE to DATA Channel Changeover Advisory (Label Q6) message if that option is enabled, or other traffic if the 5P/Q6 feature is disabled.

7.0 SATCOM INTERFACE

7.1 Overview

The SATCOM Interface provides a satellite-based data link capability using ACARS protocols. For downlinks, ACARS air-ground blocks, as described in Section 2 of this document, are encapsulated, then sent to a ARINC 741 or ARINC 761 Satellite Data Unit (SDU) for transmission. Uplink messages consist of ACARS Air-Ground blocks received from the SDU.

Except where noted within these sections, the ACARS message protocol, as defined in Section 3, and the VHF Link Management, as defined in Section 5 of this document, apply.

7.2 Data Bus Interface

The ACARS CMU should be connected to the Satellite Data Unit (SDU) by a pair of ARINC 429 data buses. The ACARS CMU should provide ARINC 429 output port(s) and ARINC 429 input port(s) as specified in the appropriate LRU ARINC Characteristic (597, 724, 724B or 758) for communications with SDU(s). The LRU ARINC Characteristic may identify interfaces for multiple SDUs to be installed.

Word size, voltage thresholds, and electrical interface specifications are also per ARINC Specification 429. The minimum word gap between two words should be 4 bit times, and the maximum gap should be 200 milliseconds.

7.3 Command and Control Interface

In addition to the sending and receiving ACARS block using the ARINC 429 BOP, additional support for this interface is provided by ARINC 429 discrete data words sent between the ACARS CMU and SDU as specified in Section 4.7.3 of ARINC Characteristic 741, Part 2 and ARINC Characteristic 761.

7.3.1 Subsystem Identifier (Label 172)

The SDU (ARINC 741 and ARINC 761) should transmit, at a rate of once per second on its output bus to the ACARS CMU, a Label 172 Subsystem Identifier. This word should contain the SAL of the SDU in bits 9 through 16. This data may subsequently be used by the ACARS CMU to facilitate subsystem LRU identification without specific interwiring definitions. This word should also provide a static indication in bits 17-29 of the satellite system(s) that the SDU is designed to support. See ARINC Characteristic 761 for the definition of the Label 172 Subsystem Identifier word generated by the SDU. [Dynamic (real time) indications of link availability are provided in Label 270 and in Label 271 through 275 as assigned for the relevant bearer systems Join/Leave data words of ARINC Characteristic 761.]

In conjunction with the Destination code provisions of the ARINC 429 Williamsburg protocol, this information may be used by the CMU to control its operation with an SDU having multi-bearer capabilities. This information is also used in the coding of Media Advisory (Label SA) messages and is defined in Section 5.3.51 of ARINC Specification 620. If no satellite system type is indicated, the CMU should assume that Inmarsat Aero service is supported.

COMMENTARY

Early versions of the ARINC 741 SDUs do not transmit the ARINC 429 data word Label 172.

7.3.2 ACARS CMU Status to SDU (Label 270)

Once per second, on the ACARS CMU bus associated with the SDU Output (or appropriate general purpose bus), the ACARS CMU should transmit a Label 270 data word as specified in ARINC Characteristics 724B and 758.

7.3.3 Status to ACARS CMU (Label 270)

The SDU should transmit a Label 270 data word once per second on the bus connected to the CMU input.

SDU status information carried in this data word is encoded as defined in Section 4.7.3.1 of ARINC Characteristic 741, Part 2, and Attachment 2 of ARINC Characteristic 761.

7.4 Link Interface

The interface between the ACARS CMU and SDU should use Version 1 of the Bit-Oriented-Protocol (BOP) as published in ARINC Specification 429 Part 3 except where noted within this section.

For BOP transmissions from the ACARS CMU to SDU, the CMU should use a System Address Label (SAL) reported previously by the SDU in its Label 172 data word output to the CMU. The following SAL assignments have been made:

Table 7.4-1 – System Address Label (SAL) Assignments

LRU	SAL	Transceiver Destination Code	End System Destination Code
SDU #1	307	S	See Spec 619
SDU #2	173	S	See Spec 619

For all BOP transmissions from an SDU to an ACARS CMU, the ACARS CMU should accept a received SAL of 304 octal and a destination code ‘M’ or 00_h.

All timer values for the CMU to SDU or SDU interface should be the default definitions in Tables 10-1 and 10-4 of ARINC Specification 429.

In addition, the ACARS CMU for the SDU interface (reference Table 10-3 of ARINC Specification 429) should use the following BOP Options:

Table 7.4-2 – Bit-Oriented-Protocol (BOP) Options

OPTION	SELECT	FEATURES	NOTE
O_1	Half	Half or Full Duplex	
O2	See Note	High Speed or Low Speed	1
O_3	Not Used	Send Automatic CTS when Ready	
O_4	Not Used	Accept Automatic CTS	
O_5	SDU	System Priority Resolution	
O_6	N/A	Reserved-obsolete	
O_7	N/A	Reserved-obsolete	
O_8	LOOP/TEST	Response to SOLO words	
O_9	N/A	Reserved-obsolete	
O_{10}	YES	Destination code Required	
O_{11}	YES	BOP verification response (ALR)	
O_{12}	NO	Use SAL from Aircraft with a ALO word	

Note1: Reference ARINC Characteristic 724B or ARINC Characteristic 758 as appropriate.

Reception of a SYN word should cause the receiving system to abort any reception or terminate transmission in progress. In addition, if the system was transmitting, it should re-initiate transmission of the File that was aborted.

On power-up, systems should transmit ALO words as opposed to sending NAK or SYN. All systems should respond with an ALR if an ALO is received as defined in O11.

COMMENTARY

Older SDUs may have been designed to send NAK or SYN words at power up. It is strongly recommended that the next software update change to using the ALO word at power up in order to facilitate the migration of to Williamsburg Version 3 that may be used for the new higher throughput satellite air-ground links.

7.5 ACARS Message Protocol

The following describes protocol exceptions to Section 3 of this document for traffic sent and received over the satellite data link.

Aircraft uplink address screening is performed by the SDU. The ACARS CMU should receive only uplink traffic that is addressed to that aircraft. The ACARS CMU should still validate the address as defined in Section 3.3 and discard the block if it does not match. A mismatch should not occur in normal operation, however.

Receipt of an uplink block with a bad BCS check should result in the immediate transfer of a general response block (<_DEL> Label with a <NAK>(1/5) in the technical ACK/NAK field) from the CMU. The CMU should not embed the NAK in a non-General Response block. The uplink block should be discarded by the CMU.

The CMU should only send blocks to the SDU when Bit 11 of Label 270 status word is set to zero indicating that the SDU has logged ON and has a Data channel available. If the CMU sends blocks to the SDU when the data channel is not available, the SDU should transmit a BUSY response to the ACARS CMU.

7.5.1 Acknowledgment of a Downlink Block

The UBI character in a general response uplink received via satellite should not affect the value of the satellite UBI reference character in the avionics.

7.5.1.1 Downlink Acknowledgment Scenario 1, Simple Case

When the DSP receives a downlink and there is NO proceeding uplink block, for which an acknowledgement is outstanding, then the DSP should immediately acknowledge the downlink block just received. To achieve this, the DSP should respond with an ACK in the technical ACK/NAK field of a General Response uplink. See Figure 10-1 in Attachment 10.

A Category B capable Satellite Ground Station should provide this acknowledgement. The DSP should not provide acknowledgements to downlinks in this mode. A Category B capable Satellite Ground Station should discard any general response uplink provided by the DSP.

7.5.1.2 Downlink Acknowledgment Scenario 2, Pending Uplink

When the DSP receives a downlink block and there is NO preceding uplink block, for which an acknowledgment is outstanding AND there is an uplink block in the DSP uplink queue waiting to be transmitted, then the DSP has 2 alternatives for acknowledging the downlink block:

1. The DSP can respond with an ACK in the technical ACK/NAK field of a General Response uplink followed by the uplink block
2. The DSP can respond with the queued uplink block and an embedded ACK. If the uplink block is retransmitted then it should retain the original UBI and contain a <NAK> (1/5) in the Technical Acknowledgment field

Figure 10-2 in Attachment 10 illustrates both alternatives.

COMMENTARY

A Category B capable Satellite Ground Station (SGS) may transmit an uplink with an embedded ACK. In this case, the ACARS CMU should ignore the embedded acknowledgement, as it should not correspond to any existing unacknowledged ACARS transaction (the SGS should have closed the transaction already).

7.5.1.3 Downlink Acknowledgment Scenario 3, Criss-cross

When the DSP receives a downlink block which does not positively acknowledge a preceding uplink block, for which an acknowledgment is outstanding, the DSP should immediately acknowledge the downlink block just received. To achieve this, the DSP should respond with an ACK in the technical ACK/NAK field of a General Response uplink to resolve the criss-cross condition. The ACK is sent in a General Response uplink rather than an immediate retransmission containing an embedded ACK due to time of delivery concerns and effective utilization of available RF resources. The uplink block retransmission should only be performed at either the expiration of the NO ACK timer (SGT1) defined in Section 7.7.1 or the receipt of a General Response containing a <NAK> (1/5) in the Technical Acknowledgment field. The retransmitted uplink block should retain the original UBI and contain a <NAK> (1/5) in the Technical Acknowledgment field. Figure 10-3 in Attachment 10 illustrates this scenario. An uplink retransmission can only be used to deliver an ACK when the DSP receives a downlink block immediately prior to the expiration of Timer SGT1. In this case the DSP has the option of using the retransmitted uplink block or a General Response uplink to deliver the ACK. This scenario is shown in Figure 10-4 of Attachment 10.

COMMENTARY

A Category B capable Satellite Ground Station may transmit an uplink with an embedded ACK. In this embedded acknowledgement, as it should not correspond to any existing unacknowledged ACARS transaction.

7.5.1.4 Category B Capable Satellite Ground Station

Satellite Category B operation requires the acknowledgment of a downlink to be created locally within the satellite ground station. In this mode of operation, the DSP does not provide an acknowledgement of a downlink to the CMU.

COMMENTARY

A Category B capable Satellite Ground Station has a burden to deliver a message to the designated DSP if it sends an ACK for the message. The Satellite Ground Station should carefully monitor each connection to each DSP to quickly recognize a failure and to stop accepting any more messages for that DSP until the link is restored. The Satellite Ground Station may utilize whatever method that is available, to deliver any messages accepted while the link to the Data Link Service Provider is down.

The Satellite Ground Station should verify the BCS of a message prior to acknowledgement. The acknowledgment to a downlink should be provided as an ACK in the technical ACK/NAK field of a General Response uplink (see Figure 10-1 in Attachment 10). Embedded acknowledgements to a downlink (provided by a DSP in an uplink) are ignored in this mode of operation.

The Satellite Ground Station may utilize any valid UBI in a general response uplink (reference Section 7.5.1).

A Category B capable Satellite Ground Station should NAK a downlink in the ACK/NAK field of a General Response uplink if the selected DSP is not reachable by that Satellite Ground Station, or if fails a BCS check.

A Category B capable Satellite Ground Station should command the Satellite Data Unit to LOGOFF and LOGON to a new Satellite Ground Station if it is not able to deliver a downlink directed to the default DSP (using a 2 in the Mode character in the Preamble).

Downlinks delivered to a DSP from a Category B capable Satellite Ground Station should not cause the DSP to transmit an acknowledgement of a downlink to the ACARS CMU.

7.5.2 Acknowledgment of an Uplink Block

It is essential to deliver messages in as timely a fashion as possible. To achieve this the MU should optimize its use of the RF spectrum. This also minimizes queuing delays of messages. The optimum response depends upon the sequence of events leading up to and including the transmission of the uplink block. The following subsections illustrate how uplinks should be acknowledged so as to minimize the RF spectrum utilization.

7.5.2.1 Uplink Acknowledgment Scenario 1, Simple Case

When the MU receives an uplink and there is NO preceding downlink block, for which an acknowledgment is outstanding, then the MU should immediately acknowledge the uplink block just received. To achieve this, the MU should respond with an ACK in the technical ACK/NAK field of a General Response downlink. See Figure 11-1 in Attachment 11.

7.5.2.2 Uplink Acknowledgment Scenario 2, Pending Downlink

When the MU receives an uplink block and there is NO preceding downlink block, for which an acknowledgment is outstanding AND there is a downlink block in the MU downlink queue waiting to be transmitted, then the MU has 2 alternatives for acknowledging the uplink block:

1. The MU can respond with an ACK in the technical ACK/NAK field of a General Response downlink followed by the downlink block
2. The MU can respond with the queued downlink block containing an embedded ACK. If the downlink block is retransmitted then it should retain the original UBI and contain a <NAK> (1/5) in the Technical Acknowledgment field

Figure 11-2 in Attachment 11 illustrates both alternatives.

7.5.2.3 Uplink Acknowledgment Scenario 3, Criss-cross

If the MU receives an uplink block which does not positively acknowledge a preceding downlink block, for which an acknowledgment is outstanding, the MU should immediately acknowledge the uplink block just received. To achieve this, the MU should respond with an ACK in the Technical Acknowledgment field of a General Response downlink to resolve the criss-cross condition. The ACK is sent in a General Response downlink rather than an immediate retransmission with an embedded ACK to facilitate quickest delivery over the satellite medium and to most effectively utilize available RF resources. See Figure 11-3 of Attachment 11.

The downlink block is only retransmitted when SAT7 expires or a General Response <_DEL> uplink containing a NAK is received. The downlink block retransmission should retain the original DBI and contain a <NAK> (1/5) in the Technical Acknowledgment field.

A retransmission can only be used to deliver an ACK when the MU receives an uplink block immediately prior to expiration of Timer SAT7. In this case the MU has the option of using the retransmitted downlink block or a General Response downlink to deliver the ACK. This scenario is shown in Figure 11-4 of Attachment 11.

7.6 SATCOM Link Management

The following subsections describe basic protocol exceptions to Section 5 of this document for ACARS traffic sent and received over the satellite data link. Due to different throughput of the Satellite data channel, different timer and counter values are specified. The timers and counters should be initialized to zero. The timer and counters for the 2400 baud MSK VHF link are defined in Section 5.4.

7.6.1 Ground Based Timers

The following timer values should be used.

Table 7.6.1-1 – Ground Based Timers

TIMER	VALUE IN SECONDS	TIMER NAME
SGT1	90	No ACK Timer
SGT2	270	Message Reject Timer
SGT3	20	Incomplete Message Interval Timer
SGT4	1260	Incomplete Downlink Message Delivery Timer
SGT5	Note 1	Q5 Timer
SGT6	N/A	Squitter Timer #1
SGT7	N/A	Squitter Timer #2
SGT8	600	DBI Reset Timer

Note 1: This value is service provider dependent (same as VHF).

7.6.2 Airborne Timers

The following timer values should be used.

Table 7.6.2-1 – Airborne Timers

TIMER	VALUE IN SECONDS	TIMER NAME
SAT1	N/A	Contact Timer
SAT2	N/A	Scan Timer
SAT3	4 hrs	Tracker Timer
SAT4	280	Message Assembly Timer
SAT5	N/A	Interblock Timer
SAT6	600	NOCOMM Timer
SAT7	180	NO ACK Timer
SAT8	600	UBI Reset Timer
SAT9	600	VOICE MODE Timer
SAT10	1200	Multiblock Message Timer
SAT11	N/A	

7.6.2.1 SATCOM Tracker Timer

A Tracker timer (SAT3) is provided to supply input for the DSP aircraft tracker table. The SATCOM Tracker timer is active whenever the SATCOM link is available, even when the aircraft is on the ground.

7.6.3 Ground Counters

The following counter values should be used.

Table 7.6.3-1 – Ground Counters

COUNTER	VALUE	COUNTER NAME
SGC1	3	Transmission Counter

7.6.4 Airborne Counters

The following counter values should be used.

Table 7.6.4-1 – Airborne Counters

COUNTER	VALUE	COUNTER NAME
SAC1	3	Transmission Counter

7.7 Media Utilization

Refer to Section 9 for a description on how the SATCOM should perform channel management and how the use of SATCOM interacts with other (VHF and HF) media.

ARINC Specification 620 contains a list identifying the characters that should be used for the various satellite based data links by the Media Advisory function defined in Section 9.

8.0 HF INTERFACE

8.1 Overview

The HF Interface provides a HF-based datalink capability using ACARS protocols. For downlinks, ACARS air-ground blocks, as described in Section 2 of this document, are encapsulated, then sent to a HF Data Unit (HFDU) or HF Data Radio (HFDR) for transmission. Uplink messages consist of ACARS Air-Ground blocks received from the HFDU or HFDR.

The requirements for the satellite interface defined in Section 7 of this document apply except where noted within these sections.

8.2 Data Bus Interface

The ACARS CMU should be connected to the HF Data Unit (HFDU) by a pair of ARINC 429 data buses. The ACARS CMU should provide one ARINC 429 output port and one ARINC 429 input port for communications with the HFDU. Additional port pairs should be provided if multiple HFDUs are installed.

Data transfer should be conducted at the low bit rate (12 to 14.5 Kbits per second) defined in ARINC Specification 429.

Word size, voltage thresholds and electrical interface specifications are also per ARINC Specification 429. The minimum word gap between two words should be 4 bit times, and the maximum gap should be 200 milliseconds.

8.3 Command and Control Interface

In addition to the sending and receiving ACARS block using the ARINC 429 BOP, additional support for this interface is provided by ARINC 429 discrete data words sent between the ACARS CMU and HFDU as specified in Section 6.4.3 of ARINC Specification 635.

8.3.1 HFDU/HFDR Subsystem Identifier (Label 172)

The HFDU/HFDR should transmit, at a rate of once per second on its output bus to the ACARS CMU, as specified ARINC Specification 635, a Label 172 Subsystem Identifier. This word should contain the SAL of the HFDU/HFDR in bits 9 through 16. This data may subsequently be used by the ACARS CMU to facilitate subsystem LRU identification without specific interwiring definitions. See ARINC Specification 429 for a definition of the Label 172 data word.

8.3.2 ACARS CMU Status to HFDU/HFDR (Label 270)

Once per second, on the ACARS CMU bus associated with the HFDU/HFDR Output (or appropriate general purpose bus), the ACARS CMU should transmit a Label 270 data word as specified in ARINC Characteristics 724 and 724B.

8.3.3 HFDU/HFDR Status to ACARS CMU (Label 270)

On the bus connected to the ACARS CMU input, the HFDU/HFDR should transmit a Label 270 data word once per second.

The HFDU/HFDR status information carried in this data word is decoded as defined in Section 6.4.3.1 of ARINC Specification 635.

8.4 Link Interface

The interface between the ACARS CMU and HFDU/HFDR should use the ARINC 429 Bit-Oriented-Protocol (BOP) as published in ARINC Specification 429-12 (or above), except where noted within this section, to exchange enveloped ACARS blocks.

For BOP transmissions from the ACARS CMU to HFDU/HFDR, the CMU should use a System Address Label (SAL) reported previously by the HFDU/HFDR in its Label 172 data word output to the HFDU/HFDR #1 is assigned the SAL of 340 octal and HFDU/HFDR #2 is assigned the SAL of 344 octal. Both HFDU/HFDRs use a destination code of “H.” For all BOP transmission from the HFDU/HFDR to ACARS CMU, the ACARS CMU should accept a received SAL of 304 octal and a destination code “M” or 00_h.

All timer values for the CMU/HFDU/HFDR interface should be the default definitions in Tables 10-1 and 10-4 of ARINC Specification 429.

In addition, the following BOP Protocol Options should be used by the ACARS CMU and HFDU/HFDR for this interface (Reference Table 10-3 of ARINC Specification 429):

Table 8.4-1 – BOP Protocol Options

OPTION	SELECT	FEATURES
O_1	Half	Half or Full Duplex
O_2	Low	High Speed or Low Speed
O_3	Not Used	Send Automatic CTS when Ready
O_4	Not Used	Accept Automatic CTS
O_5	HFDU/HFDR	System Priority Resolution
O_6	200mS	NAK Send Time after error detected
O_7	NO	NAK sent following power reset
O_8	LOOP/TST	Response to SOLO words
O_9	NO	Character format supported
O_{10}	YES	Destination code required
O_{11}	YES	BOP verification response (ALR)

Reception of a SYN word should cause the receiving system to abort any reception or termination transmission in progress. In addition, if the system was transmitting, it should re-initiate transmission of the File that was aborted.

On power-up, systems may transmit SYN words as opposed to sending NAK or ALO words.

On power-up, systems may transmit ALO words as opposed to sending NAK or SYN. All systems, however, must respond with an ALR if an ALO is received as defined in O_{11}.

COMMENTARY

Since the primary purpose of the ALO/ALR words re to verify the BOP protocol between two systems and BOP is the only protocol used for this interface, a transmission of the ALO word is not required and SYN may be used.

8.5 ACARS Message Protocol

The following describes protocol exceptions to Section 3 of this document for traffic sent and received over the HF data link.

Aircraft uplink address screening is performed by the HFDU/HFDR using the aircraft address. The ACARS MU should receive only uplink traffic that contains that address. The ACARS CMU should validate the address as defined in Section 3.3 and discard the block if it does not match. A mismatch should not occur in normal operation, however.

Receipt of an uplink block with a bad BCS check should result in the immediate transfer of a general response block (<_DEL> label with a NAK (1/5) in the technical ACK/NAK field) from the CMU. The CMU should not embed the NAK in a non-General Response block. The uplink block should be discarded by the CMU.

The CMU should only send blocks to the HFDU/HFDR when Bit 11 of Label 270 status words is set to zero indicating that the HFDU/HFDR has logged ON and has a Data channel available. If the CMU sends blocks to the HFDU/HFDR when it is not logged ON or in VOICE mode, then the HFDU/HFDR should transmit a BUSY response (see ARINC 429 Section 2.5.7.3) to the ACARS CMU.

8.6 HF Link Management

The following subsections describe the basic protocol exceptions to Section 5 of this document for ACARS traffic sent and received over the HF data link. Due to different throughput of the HF data channel, different timer and counter values are specified. The timer and counters for the 2400 baud MSK VHF link are defined in Section 5.4.

8.6.1 Acknowledgment of a Downlink Block

If the DSP receives a downlink block which does not positively acknowledge a preceding uplink block, for which an acknowledgment is outstanding, the DSP should immediately acknowledge the downlink block just received. The uplink block retransmission should be performed at either the expiration of the NO ACK timer (HFGT1) defined in Section 8.8.1 or the receipt of a General Response containing a NAK (1/5) in the Technical Acknowledgment field. The retransmitted uplink block should retain the original UBI and contain a NAK (1/5) in the Technical Acknowledgment field.

The UBI character in a general response uplink received via HF should not affect the value of the HF UBI reference character in the avionics.

COMMENTARY

It is essential to deliver messages in as timely a fashion as possible. To achieve this, the DSP should respond with an immediate ACK to resolve the criss-cross condition when it exists. This also minimizes queuing delays of downlink messages. The ACK is preferred to be an immediate retransmission with an embedded ACK due to time of delivery concerns and effective utilization of available RF resources.

8.6.2 Acknowledgment of an Uplink Block

If the CMU receives an uplink block which does not positively acknowledge a preceding downlink block, for which an acknowledgment is outstanding, the CMU should immediately acknowledge the uplink block just received. If HFAT7 expires or a General Response <DEL> uplink containing a NAK is received then the downlink block retransmission should retain the original DBI and contain a NAK (1/5) in the Technical Acknowledgment field.

COMMENTARY

It is essential to deliver messages in as timely fashion as possible. Given this statement, all reasonable efforts should be expended to provide the quickest resolution of a criss-cross condition. To achieve this, the CMU should provide an immediate downlink ACK for the received uplink. This minimizes the queuing delay of uplink messages. It is preferred that the downlink ACK be in the form of a General ACK to facilitate quickest delivery over the HF medium and to most effectively utilize available RF resources.

8.7 Timers and Counters

8.7.1 Ground-Based Timers

The following timer values should be used:

Table 8.7.1-1 – Ground Base Timers

TIMER	VALUE IN SECONDS	TIMER NAME
HFGT1	120	No ACK Timer
HFGT2	360	Message Reject Timer
HFGT3	20	Incomplete Message Interval Timer
HFGT4	1260	Incomplete Downlink Message Delivery Timer
HFGT5	Note 1	Q5 Timer
HFGT6	N/A	Squitter Timer #1
HFGT7	N/A	Squitter Timer #2
HFGT8	600	DBI Reset Timer

Note 1: This value is service provider dependent (same as VHF).

8.7.2 Airborne Timers

The following timer values should be used:

Table 8.7.2-1 – Airborne Timers

TIMER	VALUE IN SECONDS	TIMER NAME
HFAT1	N/A	Contact Timer
HFAT2	N/A	Scan Timer
HFAT3	N/A	Tracker Timer
HFAT4	370	Message Assembly Timer
HFAT5	N/A	Interblock Timer
HFAT6	600	NOCOMM Timer
HFAT7	180	NO ACK Timer
HFAT8	600	UBI Reset Timer
HFAT9	600	VOICE MODE Timer
HFAT10	1200	Multiblock Message Timer
HFAT11	N/A	Auto Return to DATA Mode

8.7.3 Ground Timers

The following counter values should be used:

Table 8.7.3-1 – Ground Timers

COUNTER	VALUE	COUNTER NAME
HFGC1	2	Transmission Counter

8.7.4 Airborne Counters

The following counter values should be used:

Table 8.7.4-1 – Airborne Counters

COUNTER	VALUE	COUNTER NAME
HFAC1	4	Transmission Counter

8.8 Media Utilization

Refer to Section 9 for a description on how the HF should perform channel management and how the use of HF interacts with other (VHF and SATCOM) media.

9.0 MEDIA UTILIZATION

9.1 Overview

9.1.1 ACARS BOP Data File

Data Files sent between the ACARS CMU and SDU/HFDU using the ARINC 429 BOP interface will contain an ACARS block or message. To support this, the General Format Identifier (GFI) of "E" or "1110" has been assigned in Table 11-6A of ARINC Specification 429. The GFI "1110" indicates to the receiving system that the data File contains an ACARS character based block.

The File Sequence Number is set to zero in both the ACARS CMU and SDU/HFDU at power-up and incremented by one for each new file transmitted.

An ACARS block, as defined in Section 2, is all data commencing with the <SOH> word through the <ETB/ETX> character and computed BCS data. In addition, a suffix <DEL> character is appended. For Satellite Category A, the File is limited to a single Link Data Unit (LDU). Therefore no multi-LDU file handling is necessary, and the LDU Sequence number should always be zero. For Satellite Category B, the file can exceed one LDU, so multi-LDU file handling is required of the CMU.

COMMENTARY

The BCS data is merely pass-through data from the Satellite or HF Data Link standpoint. The BCS data are evaluated by the ACARS CMU and Service Provider Ground Station. A BCS failure represents in this case a rather remote event as opposed to its use in the VHF RF environment.

The <SOH> is transmitted as the first octet of the first full data word transmitted and so on through the <DEL> character.

If the CMU cannot accept a block from the SDU/HFDU (received as an UPLINK) due to a BOP error or a Busy condition, the CMU should report Busy. The SDU/HFDU should discard the ACARS block.

If the ACARS CMU cannot deliver a block (to be sent as a DOWNLINK) to the SDU/HFDU due to BOP error, the CMU may need to store or discard the block based on user requirements.

9.1.2 Media Advisory

Options for downlinking messages include VHF, SATCOM, HF and potentially others depending on the aircraft configuration.

COMMENTARY

The list of active links can change (be reduced or expanded) as the aircraft moves geographically or when equipment failures occur. It is desirable for the user's host processor to have knowledge of the current active data link possibilities when it prepares a message for uplinking to the aircraft.

Whenever the MU recognizes that one of the media at its disposal for routing messages to the ground has changed status (by loss or addition), the MU should generate a downlink message to notify the users' host processor. The information should be sent using the Media Advisory (label SA) message defined in ARINC Specification 620. If an ATS message is waiting in queue to be serviced, the MU may downlink the ATS message (level 1-4 as defined by Attachment 11 of ARINC Specification 619) in advance of the Media Advisory message.

A Media Advisory message is generated when either of the following conditions occurs:

1. The status of an air/ground data link channel changes from COMM (established) to NO COMM (not established) and another link is available
2. The status of an air/ground data link channel changes from No COMM (not established) to COMM (established*)*

Figure 9-1 and Table 9-1 in Attachment 9; provide an example of the Media Advisory Logic, message content and routing of Media Advisory messages for an aircraft equipped only with SATCOM and VHF datalink. An aircraft equipped with HF and VHF datalink would use logic similar to the example shown in Attachment 9 with HF substituted for SATCOM and corresponding changes to the values used in the Media Advisory message (H instead of S). An aircraft equipped with VHF, HF and SATCOM would use logic similar to the example shown in Table 9-2 in Attachment 9.

Media Advisory is mainly used for ATC uplink message routing purposes and need not be supported for AOC-only system configurations.

9.1.3 Media Switching

The design of the ACARS MU should expedite the discovery of a lost medium connection and the re-routing of downlinks to other available media when permitted by the downlink's routing preferences. The goal is to deliver high priority downlinks (ATS) to the ground to support the performance criteria of CNS/ATM.

9.2 ACARS Satellite Datalink

9.2.1 Satellite Channel Operation

To ensure complete message delivery the ACARS CMU should treat each satellite link as a separate service provider. This means that the CMU can simultaneously transmit and/or receive messages via satellite and all other air/ground networks supported. This also means that if the CMU cannot complete a downlink on one of the other air/ground networks, and the ACARS CMU re-queues that downlink for transmission over the SATCOM link then the CMU should do so according to Section 3.6.3. When the air/ground link is re-established the ACARS CMU should complete any traffic in progress using SATCOM (i.e. continue downlinking all blocks of a multiblock downlink via satellite rather than leaving a partial message and re-starting the downlink on the re-established air/ground network).

If SATCOM fails or reports satellite data link not available (Label 270 data word from SDU to ACARS CMU, bit 11 set to one) while traffic is in progress it should be treated the same as losing coverage or exhausting retransmission logic.

COMMENTARY

Permission to send is provided by the SDU automatically when the satellite data link becomes available (Label 270, bit 11 is set to zero). No squitters or other traffic or manual override is available to cause transmission.

A satellite NO COMM should be declared either when the SDU reports not available or the Retransmission Counter (SAC1) expires as defined previously.

Upon entering the satellite NO COMM condition, all outstanding uplink/downlink traffic should be considered interrupted and retransmission may be required. The satellite NO COMM condition should remain in effect until one of the following events occur, at which point, downlink transmissions should be re-enabled:

1. An error free uplink is received
2. Satellite data link becomes available
3. Manual intervention by the crew (optional, as specified by the user)
4. Automatically after 10 minutes (optional, as specified by the user) following satellite NO COMM when the SDU has continued to report SAT data link available

Transmission of Contact Messages, as defined in Section 5.8.2 is not necessary in the satellite link.

In order to provide an end-to-end link between the DSP and the ACARS CMU, the ACARS CMU should initiate a link test or equivalent downlink each time the satellite link is established or re-established after a satellite log-off/on.

9.2.2 Satellite Category B Operation

Permission to send is provided by the SDU automatically when the satellite data link becomes available (label 270, bit 11 is set to zero). Squitters are provided to identify the available DSPs. No manual override is available to cause transmission.

In order to provide and end-to-end link between a selected DSP and the ACARS CMU, the ACARS CMU should initiate a downlink to each selected DSP each time a Satellite Category B capable link is established or re-established after a satellite log-off/on. The SGS will uplink a squitter for each available DSP once the SDU logs on. The SDU will log off when it determines the CMU is not available and should log on again when the CMU is available.

The Satellite Ground Station should uplink a squitter for each DSP that is available once the SDU requests a logon. In order to provide an end-to-end communications link between a selected DSP and the ACARS CMU, the ACARS CMU should initiate a downlink to each selected DSP each time a Satellite Category B capable link is established (transition to data link available and squitters received). The SDU will declare data link not available when it determines the CMU is not available, and should log on to a Satellite Ground Station again when the CMU becomes available.

Satellite Category B operation requires that the acknowledgment to a downlink be provided by the Satellite Ground Station. This acknowledgment is provided when the message is successfully delivered to the ground station; the message passes a BCS check, and when the message is directed to a DSP that is currently reachable.

If the CMU/DSP is unable to complete a multiblock message on another air/ground network and re-queues that downlink for transmission over a Satellite Category B link, it should be formatted as a single message without multiple blocks.

9.3 ACARS HF Data Link

9.3.1 HF Channel Operation

To ensure complete message delivery the ACARS CMU should treat the HF link as a separate service provider operating Category A. This means that the CMU can simultaneously transmit and/or receive messages via HF and all other air/ground networks supported. This also means that if the CMU cannot complete a downlink on one of the other air/ground networks, and the ACARS CMU re-queues that downlink for transmission over the HF link then the CMU should do so according to section 3.6.3. When the air/ground link is re-established the ACARS CMU should complete any traffic in progress using HF (i.e. continue downlinking all blocks of a multiblock downlink via HF rather than leaving a partial message and re-starting the downlink on the re-established air/ground network).

If HF fails or reports HF data link not available (label 270 data word from HFDU to ACARS CMU, bit 11 set to 1) while traffic is in progress, it should be treated the same as losing coverage or exhausting retransmission logic.

COMMENTARY

> This procedure applies to messages that have been designated for transfer to the ground through multiple media which includes HF. See ARINC Specification 619 for further details.

Permission to send is provided by the HFDU/HFDR automatically when the HF data link becomes available (label 270, bit 11 is set to zero). No squitters or other traffic or manual override is available to cause transmission.

A HF NOCOMM should be declared either when the HFDU/HFDR reports not available or the Retransmission Counter **(HFAC1)** expires as defined previously.

Upon entering the HF NOCOMM condition, all outstanding uplink/downlink traffic should be considered interrupted and retransmission may be required. The HF NOCOMM condition should remain in effect until one of the following events occur, at which point downlink transmissions should be re-enabled:

1. An error free uplink is received
2. HF status word (label 270) indicates HF data link status change from not available to available
3. Manual intervention by the crew (optional, as specified by the user)
4. Automatically after 10 minutes (optional, as specified by the user) if the HFDU/HFDR available

5. Transmission of Contact Messages, as defined in Section 5.8.2 is not necessary in the HF link

In order to provide an end-to-end link between the DSP and the ACARS CMU, the ACARS CMU should initiate a link test or equivalent downlink each time the HF link is established or re-established after a HF log-off/on.

9.4 ACARS Using VDL Mode 2 Data Link

9.4.1 ACARS Messages Over VDL Mode 2

To ensure complete message delivery the ACARS CMU should treat the VDL Mode 2 link as a separate service provider. This means that the CMU can simultaneously transmit and/or receive messages via VDL Mode 2 and all other air/ground networks supported. This also means that if the CMU cannot complete a downlink on one of the other air/ground networks, and the ACARS CMU re-queues that downlink for transmission over the VDL Mode 2 link then the CMU should do so according to Section 3.6.3. When the air/ground link is re-established the ACARS CMU should complete any traffic in progress using VDL Mode 2 (i.e., continue downlinking all blocks of a multi-block downlink via VDL Mode 2 rather than leaving a partial message and re-starting the downlink on the re-established air/ground network).

If VDL Mode 2 fails (Label 270 data word from VDR to ACARS CMU, bit 11 set to 1) while traffic is in progress, it should be treated the same as losing coverage or exhausting retransmission logic.

COMMENTARY

This procedure applies to messages that have been designated for transfer to the ground through multiple media that includes VHF.

Refer to Section 11.7.5.6 for a description of permission to send.

Refer to Section 11.7.6 for a description of NOCOMM.

Upon entering the VDL Mode 2 NOCOMM condition, all outstanding uplink/downlink traffic should be considered interrupted and retransmission may be required.

Transmission of Contact Messages, as defined in Section 5.8.2 is not necessary in the VDL Mode link because there is a similar mechanism within the VDL Mode 2 protocol.

In order to provide an end-to-end link between the DSP and the ACARS CMU, the ACARS CMU should initiate a link test or equivalent downlink each time the VDL Mode 2 link is established or re-established after an interruption of service.

10.0 CMU OPERATING WITH VDR OPERATING IN VDL MODE A

10.1 Overview

The ARINC 750 VHF Data Radio (VDR) provides a VHF-based data link capability using ACARS protocols and an ARINC 429 interface with the CMU. This mode of operation is called Mode A. The purpose of Section 10 is to define the CMU requirements for Mode A operation.

COMMENTARY

The ARINC 750 VDR defines several modes of operation. Mode 0 emulates ARINC 716 and is transparent to the CMU. Modes 1 and higher are not dealt with by ARINC 618 at this time.

ARINC 750 VDR Modes:

1. 716 Voice/Data mode uses existing analog, discrete and 429 interfaces and 618 protocol
2. 750 Data mode uses new 429 interfaces as defined in CMU spec and a protocol negotiated between the CMU and VDR.

Benefits of Mode A

1. Reduced aircraft wiring (2 twisted pairs vs. 10-12 wires: 60% reduction)
2. Dual CMU/VDR architecture supported without relays
3. Aircraft wiring would be VDL Mode 2 ready

Disadvantages of Mode A

1. New VDR software required
2. New CMU software required
3. Wiring change for retrofit
4. Improvement in performance

The ARINC 618 functions are distributed between the CMU and VDR as listed below:

CMU Functions

1. ACK/NAK logic
2. RGS selection logic
3. VHF frequency selection logic
4. Protocol selection logic
5. All ARINC 618 timers and counters
6. Command VDR data frequency
7. Command aircraft address
8. BCS calculation for downlink

VDR Functions (CSMA)

1. Add prekey, bit sync (+*) characters and byte sync characters to downlinks
2. Forward all uplinks addressed to aircraft and broadcast labels

3. Forward indication of all uplinks NOT addressed to aircraft (mode character, signal quality etc)

For downlinks, ACARS air-ground blocks, as described in Section 2 of this document, are encapsulated, then sent to a VHF Data Radio (VDR) for transmission. Uplink messages consist of ACARS Air-Ground blocks received from the VDR.

Except where noted within these sections, the ACARS message protocol, as defined in Section 3, and the VHF Link Management, as defined in Section 5 of this document, apply.

10.2 Data Bus Interface

The CMU is connected to the VDR by a pair of ARINC 429 data buses. ARINC 429 buses connect the CMU and VDR as defined in the appropriate equipment specification (ARINC 758 for example). The CMU may be connected to multiple VDRs.

Data transfer should be conducted at the high bit rate defined in ARINC Specification 429.

Word size, voltage thresholds, and electrical interface specifications are also per ARINC Specification 429.

Two versions of the ARINC 429 file transfer protocol BOP were defined to support Mode A.

10.2.1 BOP Version 1 Implementation

A BOP Version 1 implementation uses a tailored form of Version 1 of the bit-oriented ARINC 429 (Williamsburg) file transfer protocol (BOP) in the VDR in order to achieve the required performance (i.e. minimize propagation delay).

Section 5 of ARINC 750 contains the description of the ARINC 429 protocol used by the VDR. The timers that were changed were chosen to reduce the file transfer time, yet maintain interoperability with a standard Version 1implementation.

The CMU uses the standard Version 1 of the ARINC 429P3 BOP.

The minimum word gap between two words should be as defined in ARINC Characteristic 750.

10.2.2 BOP Version 3 Implementation

A BOP Version 3 implementation uses the standard definition of BOP Version 3 introduced by ARINC 429P3-17.

10.3 Command and Control Interface

In addition to the sending and receiving ACARS blocks using the ARINC 429 BOP, additional support for this interface is provided by ARINC 429 discrete data words sent between the CMU and VDR as specified in Section 5.5 of ARINC Characteristic 750-2 or newer.

10.3.1 Periodic ARINC 429 Words

10.3.1.1 Periodic ARINC 429 Words Transmitted by the VDR

See ARINC Characteristic 750.

10.3.1.2 Periodic ARINC 429 Words Transmitted by the CMU

See ARINC Characteristic 758.

10.4 Link Interface

For BOP transmissions from the CMU to VDR, the CMU should use the System Address Label (SAL) reported by the VDR in its Label 172 data word output to the CMU.

Table 10.4-1 – BOP Transmissions From CMU to VDR

VDR	SAL
1 left	251 octal
2 right	252 octal
3 center	253 octal

All BOP transmissions from a VDR to a CMU should use SAL 304 octal. The master CMU should accept a received SAL of 304 octal regardless of installed position, 1 or 2.

10.4.1 Link Interface Using BOP

The interface between the CMU and VDR uses either a customized **implementation** of Version 1 of ARINC 429 Bit-Oriented-Protocol (BOP) or a standard implementation of Version 3 ARINC 429 Bit-Oriented-Protocol (BOP). **The VDR Mode A-specific requirements for Version 1 BOP are** defined in ARINC Specification 750 Section 5.

On power-up, systems should transmit ALO words as opposed to sending NAK or SYN. All systems should respond with an ALR if an ALO is received as defined in $O_{10.}$

AEEC STAFF NOTE: The following tables are reproduced for the reader's convenience. See ARINC Characteristic 750 for the most current assignment of ARINC 429P3 data bus Options for this interface.

10.4.1.1 Link Interface Using Version 1 BOP

All protocol events for the CMU/VDR interface should be the default definitions in Table 10-1 of ARINC Specification 429. All timer values for the CMU/VDR interface should be the custom definitions in ARINC Characteristic 750. In addition, the following BOP Version 1 Options should be used by the CMU for the VDR interface (reference ARINC Specification 750 which has precedence):

Table 10.4.1.1-1 BOP Version 1 Options

OPTION	SELECT	FEATURES
O_1	HALF	Half or Full Duplex
O_2	HIGH	High Speed or Low Speed
O_3	Yes	Auto CTS
O_4	Yes	Accept Auto CTS
O_5	CMU	System Priority Resolution
O_6	Reserved	Reserved
O_7	Reserved	Reserved
O_8	YES	Use of SOLO word
O_9	Reserved	Reserved
O_{10}	YES	Destination code required
O_{11}	YES	Bit protocol verification (ALO/ALR)
O_{12}	NO	Use Subsystem SAL from ALO word

Table 10.4.1.1-1 is reproduced for reference. See ARINC Characteristic 750 for the most current assignment of ARINC 429W data bus Options for this interface.

Reception of a SYN word should cause the receiving system to abort any reception or transmission in progress. In addition, if the system was transmitting, it should re-initiate transmission of the file that was aborted.

10.4.1.2 Link Interface Using Version 3 BOP

All protocol events should be the default definitions in ARINC Specification 429. All timer values should be the default definitions in ARINC Specification 429.

In addition, the following BOP Version 3 Options should be used by the CMU for the VDR interface (reference ARINC Specification 750 which has precedence):

Table 10.4.1.2-1 – BOP Version 3 Options

OPTION	SELECT	FEATURES
O_1	FULL	Half or Full Duplex
O_2	HIGH	High Speed or Low Speed
O_3	N/A	Auto CTS
O_4	N/A	Accept Auto CTS
O_5	N/A	System Priority Resolution
O_6	Reserved	Reserved
O_7	Reserved	Reserved
O_8	YES	Use of SOLO word
O_9	Reserved	Reserved
O_{10}	N/A	Destination code required
O_{11}	YES	Bit protocol verification (ALO/ALR)
O_{12}	NO	Use Subsystem SAL from ALO word
O_{13}	COMMAND FRAME	Use of information or command frames
O_{14}	NO	Use of Pause function
O_{15}	N/A	Generate 32 bit CRC for information frame

Table 10.4.1.2-1 is reproduced for reference. See ARINC Characteristic 750 for the most current assignment of ARINC 429P3 data bus Options for this interface.

SYN word is not used by BOP Version 3.

10.4.1.3 CMU-VDR Messages

The CMU and VDR exchange the messages defined in ARINC 750. The messages defined in Sections 3 and 5 are used to control and configure the VDR.

ARINC 750 contains an attachment for each air-ground protocol and it defines the messages for that protocol. Each message transmitted by the CMU triggers a response message from the VDR. The CMU should wait for the response message before sending the next message. The VDR responds to each message as indicated in the message sequence charts contained in ARINC 750.

10.4.2 VDR Configuration

The VDR supports several modes of operation. Therefore the initial step in CMU-VDR communication is to establish the desired mode of operation, which is referred to as air-ground protocol negotiation or VDR configuration. VDR configuration must be performed at power up, and any time the VDR reports a protocol null condition, or a 716 mode.

Sections 3 and 5 of ARINC 750 define the primitives used to perform VDR configuration. The Air-ground protocol negotiation process is defined in Sections 3 and 5 of ARINC 750. See Figures 13-1 and 13-2 of Attachment 13 for examples of Air-ground protocol negotiation.

VDR configuration is performed using general data format GFI 2. Solo words and file transfer are used as indicated in Section 5 of ARINC 750 to perform the VDR configuration.

BOP Version 1 uses destination codes to distinguish between Command and Data files. Destination code 00h indicates command and Destination code 01h indicates Data.

BOP Version 3 uses the Command type field of the Command Data Frame to distinguish between Commands and Data. A Command type value of 00_b 00_h indicates command and a Command type value of 01_b 01_h indicates Data.

During VDR configuration, messages with GFI values other than 2 are considered errors and are ignored, other than error processing.

COMMENTARY

When the CMU resets and the VDR does not then it is possible for the CMU to receive protocol messages even though the CMU's state indicates that a protocol has not been selected yet.

Likewise, if the VDR resets and the CMU does not then it is possible for the CMU to transmit protocol messages before it detects the change in VDR state because there can be up to a 1 second delay in the annunciation of the change in VDR status.

The CMU and VDR designers need to consider this.

The next step after Air-ground protocol negotiation is initialization of the VDR with the data required for operation by the selected protocol, see Section 10.4.3.

10.4.3 VDR Initialization

After the VDR configuration VDR initialization should be performed (see Section 10.4.2), then the initialization data required by the selected protocol should be transferred to the VDR. VDR initialization is performed using general data format GFI $F_{\underline{h}}$ and the extended GFI associated with the selected air-ground protocol.

When Mode A (ACARS protocol) is selected then the initialization is performed using extended GFI F2h and destination codes **or Command type depending on whether BOP Version 1 or 3 is being used** as defined in Attachment 11 of ARINC Characteristic 750. VDR initialization should be performed after a successful VDR configuration, and any time the VDR reports a protocol RESET condition. VDR initialization is considered complete when the VDR signals protocol set state, and when ADDRESSES configuration has been successfully performed (ADDR.request, ADDR.confirm).

The extended GFI code F2h indicates that the ACARS protocol message set, as defined in Attachment 11 of ARINC 750-2, is being used.

Messages with GFI values other than 2 or F are considered errors and are ignored, other than error processing.

Messages with the GFI value of F and extended GFI values other than F2h are considered errors when the ACARS protocol has been selected and are ignored, other than error processing.

COMMENTARY

The CMU designer may choose to respond to invalid extended GFI codes by resetting the VDR or re-configuring the VDR or ignoring this unlikely event.

Other protocols, such as VDL Mode 2, will use different extended GFI values.

10.4.3.1 Mode A VDR Initialization

Attachment 11 of ARINC 750-2 lists the various messages that have been defined for CMU-VDR communication when the ACARS protocol is used.

In the ACARS protocol message set **when BOP Version 1 is used then** destination code 00 is used to identify control messages and destination code 01_h is used to identify data (uplink/downlink) messages. Destination codes other than 00 and 01 are considered errors when the ACARS protocol has been selected and are ignored, other than error processing.

In the ACARS protocol message set when BOP Version 3 is used then Command type Command (00_b) is used to identify control messages and Command type Data (01_b) is used to identify data (uplink/downlink) messages.

The CMU should initialize the VDR with the operational parameters (frequency, prekey, and modulation) and addresses (aircraft registration, flight identifier and broadcast address). At a minimum, the CMU uses the PARAM.request message and the ADDR.request message to initialize the ACARS protocol. See figures 13-3 and 13-4 in Attachment 13 for message sequence chart examples illustrating various approaches to performing the VDR initialization.

10.4.3.2 VDL Mode 1 Initialization

This configuration was defined by ICAO SARPs, but is being removed due to not being implemented.

10.4.3.3 VDL Mode 2 Initialization

See Section 11.2.3.6.

10.4.3.4 VDL Mode 3 Initialization

To be defined.

10.4.3.5 VDL Mode 4 Initialization

To be defined.

10.5 ACARS Message Protocol

The following describes protocol exceptions to Section 3 of this document for traffic sent and received over the VHF data link.

Aircraft uplink address screening is performed by the VDR using the addresses provided by the CMU. The CMU should receive only uplink traffic that contains one of these addresses. The CMU should still validate the address as defined in Section 3.3 and discard the block if it does not match. A mismatch should not occur in normal operation, however.

The CMU is NOT required to check the uplink BCS because the VDR performs BCS checking and discards uplinks that fail.

The CMU should only send downlink blocks to the VDR when it has completed the VDR initialization process. Bits 11 and 14 of the Label 270 VDR status word are 0 and 1 respectively when the VDR has received operational parameters, but these bits do not provide any indication regarding the address initialization.

10.5.1 Acknowledgment of a Downlink Block

As specified in Section 3. VAT7 should be set according to Section 5.4.5.2.

10.5.2 Acknowledgment of an Uplink Block

As specified in Section 3, the CMU should generate the response to an uplink and transmit the ARINC 429 RTS word to the VDR for the response downlink within 0.5 seconds of transmitting the ARINC 429 ACK word for receiving the uplink.

10.6 VDR Link Management

The following subsections describe basic protocol exceptions to Section 5 of this document for ACARS traffic sent and received over the VHF data link.

10.6.1 Functional Capability of the Airborne Sub-System

The CMU should establish and maintain a link across the VHF medium with the Data Link Service Provider's (DSP) system. In order to do this, it should use the ACARS message protocol defined in this specification.

Since the frequency over which VHF data communications will be conducted is not fixed, the CMU needs to have a frequency management capability. The CMU can be programmed with the different available frequencies and attempt link establishment on each frequency as described herein.

The CMU should be capable of performing the functions described in the following subsections.

10.6.2 Permission to Send

Prior to any ACARS VHF downlink transmission the CMU should receive permission to send to ensure transmission on an authorized frequency for data communications. Channel access authorization is performed by the VDR and should still be obtained using procedures established under Medium Access Control as defined in Section 4.5.2. See Section 10.6.6 for frequency acquisition procedures.

Permission to send may be achieved by crew entered manual command, a user defined command or logic, via a service provider autotune command, or automatically from Frequency Management logic.

10.6.3 VHF No Communications (NO COMM)

See Section 5.3.

10.6.4 Timers and Counters

See Section 5.4.

10.6.4.1 Ground-Based Timers

See Section 5.4.1.

10.6.4.2 Airborne Timers

The avionics subsystem timers are as follows:

10.6.4.2.1 VAT1, Contact Timer

Name:	VAT1, Contact Timer
Value:	See Note 1.
Start:	VAT1 is started when the CMU has established a link with the ground network on the frequency of a Category A network and the aircraft is airborne.
Stop:	VAT1 is stopped when the aircraft lands.
Restart:	VAT1 should be restarted whenever any subsequent valid UNITDAT.indicator message or SQP.indicator message is received from the VDR.
On Expiration:	See Sections 5.8.2 and 5.9.2.
Note 1:	The VAT1 timer value is dependent upon the network to which the airborne subsystem is connected, but is typically set for twice the net interval between squitter or other uplink messages.
Note 2:	Timer VAT1 is optional.

10.6.4.2.2 VAT2, Scan Timer

Name:	VAT2, Scan Timer
Value:	See Note 1.
Start:	VAT2 is started when the CMU receives a PARAM.confirm message from the VDR in response to a PARAM.requestmessage and the CMU is in the Frequency Acquisition state.
Stop:	VAT2 should be stopped when a valid UNITDATA.indication or SQP.indicator message is received from the VDR.
On Expiration:	See Section 10.6.6.2.1.3.
Note 1:	The time-out value for the VAT2 timer may vary with the base frequency selected. The value chosen should be longer than VGT6. (dependent on service provider)

10.6.4.2.3 VAT3, Tracker Timer

Name: VAT3, Tracker Timer

Value: 10 minutes. See Note 1.

Start: VAT3 is started when a valid UNITDATA.indication message which contains an acknowledgment to a downlink is received from the VDR while the aircraft is airborne and operating in a category A environment.

Stop: Aircraft lands or switches to a category B network.

Restart: VAT3 should be restarted when a valid UNITDAT_IND message that contains an acknowledgment to a downlink is received from the VDR.

On Expiration: See Section 5.8.3.

Note 1: VAT3 is optional. If implemented, VAT3 is maintained during Frequency Maintenance while operating Category A for airlines that want the DSP to perform flight following. VAT3 is suspended while the aircraft is on the ground.

10.6.4.2.4 VAT4, Message Assembly Timer

Name: VAT4, Message Assembly Timer

Value: 90 seconds

Start: VAT4 should be started when the airborne subsystem receives a valid UNITDATA.indication message that contains the first block of a multiblock uplink message.

Stop: VAT4 should be stopped when the airborne subsystem receives a valid UNITDATA.indication message that contains the last uplink block (terminated with an ETX) of the same message. See Note 2.

Restart: VAT4 should be restarted when the subsequent uplink block of the same message has been received via an UNITDATA.indication message. During the interruption of a multiblock uplink,

VAT4 should be restarted upon receipt of a UNITDATA.indication message that contains the first, subsequent, or final block of the higher priority uplink.

On Expiration: See Section 3.6.4.1.

Note 1: VAT4 is not stopped and restarted when consecutive duplicate (retransmitted) blocks of the same message are received. Duplicate blocks separated by an interrupting uplink message should cause VAT4 to be restarted.

Note 2: Since uplink messages do not contain message sequence numbers, uplink message reassembly is not guaranteed to be error free. The CMU relies on the label/sublabel combination to discern between messages. The CMU also relies on the various timers associated with multiblock uplinks to detect error conditions and recover from the message reassembly process.

10.6.4.2.5 VAT5, Interblock Timer

Name: VAT5, Interblock Timer

Value: 30 seconds

Start: VAT5 is started when the airborne subsystem receives a UNITDATA.indication message that contains the first block of a multiblock uplink.

Restart: VAT5 is restarted when a UNITDATA.indication message, which contains the subsequent uplink block (ending in ETB), is received.

Stop: VAT5 is stopped when a UNITDATA.indication message, which contains the last uplink block (ending with ETX), is received.

On Expiration: See Section 3.6.4.2.

Note: VAT5 is optional and could be used while operating in a Category B environment.

10.6.4.2.6 VAT6, NO COMM Timer

Name: VAT6, NO COMM Timer

Value: 10 minutes

Start: VAT6 is started when communications across the VHF air-ground path becomes not available. See Section 5.3.

Stop: VAT6 is stopped and reset when communications across the VHF air-ground path are restored. Only new uplinks, not retransmissions, should cause VAT6 to be stopped.

On Expiration: See Section 3.6.3.

10.6.4.2.7 VAT7, No ACK Timer

Name: VAT7, No ACK timer

Values: Variable, uniformly distributed between a lower and upper limit. In CAT A environment, the limit should vary between 10-25 seconds. In CAT B environment, the lower limit can be as low as 2 seconds, depending on service provider requirements. The upper limit should not exceed 25 seconds.

COMMENTARY

For Category B ATS downlinks in Asia/Australian region, a range of 6-12 seconds is recommended to satisfy CAA message delay delivery criteria.

Start: VAT7 is started when the CMU receives the ARINC 429 Acknowledgment word from the VDR indicating that the message was received error free **by the VDR, or VAT7 is started when the CMU receives the UNITDATA.confirm message from the VDR indicating that the message was transmitted.**

COMMENTARY

When the CMU-VDR interface uses BOP version 3 then the UNITDATA. confirm message must be used to start VAT7. When the CMU-VDR interface uses BOP version 1 then either the ARINC 429 Acknowledgment word or the UNITDATA.confirm message can be used to start VAT7.

Stop: VAT7 is stopped when an UNITDATA.indication message (uplink) containing an acknowledgment is received indicating no error.

On Expiration: Increment Transmission counter, VAC1, and send a UNITDATA.request message containing that block (or a higher priority message block) (retransmit downlink) if the value of VAC1 is less than the limit.

Note 1: Some DSPs have implemented a faster response time in their ground systems.

10.6.4.2.8 VAT8, UBI Reset Timer

Name:	VAT8, UBI Reset Timer
Value:	10 minutes
Start/Restart:	VAT8 should be started when the CMU receives a valid UNITDATA.indication message containing an error-free uplink, including duplicates, and excluding squitter uplinks
On Expiration:	When the VAT8 timer expires, the CMU should set the reference UBI character to the control character <NUL>. See Section 3.5.1.

10.6.4.2.9 VAT9, Voice Mode Timer

Name:	VAT9, Voice Mode Timer
Value:	10 minutes
Start:	VAT9 should be started when the VDR enters VOICE mode.
Stop:	VAT9 is stopped and reset when the VDR is returned to the DATA mode.
On Expiration:	If the VAT9 timer has expired on return to data mode, the CMU should take the actions described in Section 6.8.2.
Note:	The CMU should configure and initialize the VDR when it switches to data mode regardless of the status of VAT9.

10.6.4.2.10 VAT10, Multiblock Message Timer

Name:	VAT10, Multiblock Message Timer
Value:	10 minutes
Start:	VAT10 should be started when the UNITDATA.confirm message indicates that the first block of a multiblock message is transmitted.
Stop:	The VAT10 timer should be stopped and reset when a UNITDATA.indication message which contains the uplink acknowledgment to the last downlink block of all messages in progress has been received.
On Expiration:	When the VAT10 timer expires any multiblock message in progress should be retransmitted beginning with the first block. Alternatively, the user may specify other action.
Description:	VAT10 is used to reflect actions taken by the DSP when the Incomplete Downlink Message timer (VGT4) expires.

10.6.4.2.11 VAT11, Auto Return to Data Timer

Not applicable because the CMU does not control Voice/Data, see Section 10.8.10.6.4.3

10.6.4.3 Ground Counters

See Section 5.4.3.

10.6.4.4 Airborne Counters

Name:	VAC1, Transmission Counter
Value:	no less than three, nor greater than eight
Start:	VAC1 should be started the first time the CMU receives a UNITDATA.confirm message indicating the block is transmitted.
Count:	VAC1 should be incremented by 1 each time the CMU sends the same block to the VDR (UNITDATA.request message) and then receives a UNITDATA_ACK message indicating the block is transmitted.
Stop:	VAC1 is stopped when an uplink containing an acknowledgment is received indicating no error.
On Expiration:	See Section 10.6.5.

10.6.5 Retransmission Logic

Retransmission may be necessary when reception is marginal; e.g. when the aircraft is at the edge of coverage. and portions of the message become corrupted (failed BCS).

Occasionally two transmitting systems (airborne or ground) select the same instant to transmit, resulting in a collision at the receiver(s). Retransmission of these messages becomes necessary also. To preclude continued contention due to the unintentional synchronization of retransmissions, the time intervals between retransmissions in each CMU should vary randomly between an upper and lower limit.

Retransmission timing values should be optimized for specific service providers as needed. For Category A, a range of 10-25 seconds is optimal. For Category B networks the value varies with service provider. The retransmission interval should be random and uniformly distributed within the specified range.

When the Transmission counter (VAC1) reaches its limit then the CMU should stop retransmitting the downlink block until one of the following events occurs:

1. A valid UNITDATA .indication message or SQP.indicator message is received from the VDR
2. Logic for entering Frequency Search state becomes valid

3. Logic for falling back to a Base frequency from an Alternate frequency becomes valid
4. In Category B, a new logical channel is established

10.6.6 Frequency Management

See Section 5.6.

10.6.6.1 Manual Base Frequency Management

The CMU should support the option for the aircrew to change the frequency used for VHF data communications via the CDU/MCDU.

The aircrew should be able to call up, for display on the CDU/MCDU, the frequency to which the transceiver has been commanded to tune as well as communications status (NO COMM, Voice mode etc.). When the crew selects a different frequency for use that implies permission to send and the Base Frequency Establishment state should be entered. The CMU uses the PARAM.request message to transfer the selected frequency to the VDR and waits for a PARAM.confirm message from the VDR to verify that the VDR accepted the new frequency.

10.6.6.2 Automatic Base Frequency Management

See Section 5.6.2.

10.6.6.2.1 Base Frequency Acquisition State

The Airborne Subsystem is in this state when it is searching for a new frequency on which to attempt contact. Figure 2-1 of Attachment 2 illustrates the Channel Acquisition Procedure. This state should be initiated during initial power application or after communication is lost on the service provider’s Base frequency. The CMU sends a PARAM.request message to the VDR in order to change the frequency and waits for a PARAM.confirm message from the VDR to verify that the VDR accepted the new frequency.

10.6.6.2.1.1 Frequency Selection Algorithm

The CMU should contain a table of candidate Base frequencies for data use. Parameters unique to each Base frequency and other ground service provider operating parameters may be included with each entry in the table. This table is consulted while in the frequency acquisition state to determine the next Base frequency on which to attempt contact.

After the CMU has selected a new Base frequency, it should verify that the selected frequency is a data frequency. One method is to passively monitor the frequency for a valid (correct BCS) ground to air (uplink) message which the VDR should convey to the CMU via a UNITDATA.indication message or a SQP.indicator message. Other verification methods may also be used.

Once a selected frequency has been validated, the CMU will have Permission to Send, which allows the CMU to attempt contact with the ground service provider. Once permission to send is obtained, the CMU should proceed to the Base Frequency Establishment State.

10.6.6.2.1.2 Scan Timer

In the event that the frequency chosen is not active in a particular location, the airborne subsystem should use its Scan timer to limit the time spent waiting on this frequency for valid uplink traffic. See Section 10.6.4.2.2 for a definition of the Scan timer. When the Scan timer (VAT2) expires without the CMU hearing a valid uplink, the CMU should:

a. Assume that the chosen frequency is not active at this location
b. Select a new candidate Base frequency
c. Send a PARAM. request message to the VDR in order to change the frequency and wait for a PARAM. confirm message from the VDR to verify that the VDR accepted the new frequency
d. Manage the VAT 2 timer
e. Resume listening for uplink traffic

10.6.6.2.1.3 Uplink Squitter - Label SQ

See Section 5.6.2.1.4.

The CMU should initialize the VDR to accept uplink squitter messages that are broadcast by the ground networks.

10.6.6.2.2 Base Frequency Establishment State

See Section 5.6.2.2.

10.6.6.2.3 Base Frequency Maintenance State

See Section 5.6.2.3.

10.6.7 Operation on Alternate Frequencies

10.6.7.1 Data Transceiver Autotune Command

The service provider may use the Data Transceiver Autotune uplink command (Label :;) to off load VHF traffic to alternate frequencies. The airborne subsystem may receive the Autotune command while the aircraft is in any phase of flight (enroute, terminal or on the ground). The format of the Data Transceiver Autotune command (Label :;) is defined in ARINC Specification 620.

The CMU should perform the following whenever it receives a Data Transceiver Autotune command uplink. The CMU should first respond on the present operating frequency with a UNITDATA.request message to the VDR containing a technical acknowledgment message using Label characters _DEL. Only one transmission should be made.

After completing the acknowledgment downlink transmission, indicated by the UNITDATA.confirm message from the VDR, then the CMU should send the new frequency contained in the Data Transceiver Autotune (Label :;) uplink to the VDR using a PARAM.request message. When the CMU receives a PARAM.confirm message from the VDR, it should immediately send a UNITDATA.request message containing a Link Test (Label Q0) message or its own traffic to the VDR. This communication advises the ground processor that the airborne sub-system is active on the new frequency.

Normal retransmission logic (whatever was in use for the particular network prior to the command) should be used to secure communications. However, a minimum of 3 downlink attempts should be conducted.

If an ATS message is in the process of being sent or is in queue when the transmission limit is reached on the autotune frequency, and another downlink media is available, the ATS message should be immediately routed to the alternate available media. If no alternate media is available, the ATS message should be attempted on the base VHF frequency per normal logic.

If communication fails (retransmission logic) anytime during autotune acquisition or subsequent normal operation, the CMU should then reselect the last Base frequency established and re-enter the Base Frequency Establishment state described in Section 10.6.6.2.2.

10.6.8 Category A Network Operation

See Section 5.8.

10.6.9 Category B Network Operation

See Section 5.9.

When operating in Category B, the CMU should monitor all ground stations (sites) in range (using SQP_IND messages from the VDR) and perform hand-offs when necessary in order to provide uninterrupted contact to the DSP.

Category B operation is identified with a Mode character as defined in Section 2.2.2.2. The SQP.indicator solo word from the VDR contains the mode character and signal quality measurement of an uplink. The VDR transmits a SQP.indicator solo word each time it detects an uplink, even uplinks addressed to the aircraft or containing broadcast addresses.

To support Category B operation, the CMU should perform the following tasks:

a. Maintain a ground station address table
b. Establish a logical channel
c. Maintain the logical channel

10.6.9.1 Ground Station (Site) Address Table

Category B Mode character bits are encoded to identify the logical access channel supported by the site within its Service Access Area (SAA). Bits numbered 1, 2, 3, 4, and 5 are encoded using five digit binary numbers, thereby enabling the avionics to receive ground system access code information for up to 30 logical access channels at any time.

A list of Category B Mode characters to be transmitted by ground sites are defined in Attachment 6 to this document.

A Ground Station (Site) Address table, which contains the current status of all possible sites, is constantly being updated by the CMU. This table is cleared on any frequency change.

The table is updated with data from SQP.indicator solo words from the VDR (from any uplink traffic received having valid BCS) and is maintained at all times while in data mode.

The table should contain the following information:

1. Site ID - This is (or corresponds to) the mode character associated with the site
2. Quality Rating associated with that site

Quality rating may be derived in any manner the CMU designer chooses that should provide efficient and timely hand-offs between sites as they fall out of range.

COMMENTARY

It is envisaged that the SQP data provided in SQP.indicator SOLO words should be used in the calculation of the quality rating. ARINC 750 does not define how to measure SQP, the designer should expect variation between different VDR models. The SQP is only a relative indication of signal quality.

The CMU should be capable of monitoring 2 or more sites. If more sites are available than the CMU table can manage, then the CMU should contain logic for dealing with this situation.

Operation of the Site Address table may continue during VOICE mode as defined in Section 7. When a return to Data mode is made, normal Channel Established/

Frequency Acquisition logic should be applied.

10.6.9.2 Initial Operational Selection

See Section 5.9.2.

10.6.9.3 Logical Channel Establishment

See Section 5.9.3.

10.6.9.4 Channel Maintenance State

See Section 5.9.4.

10.6.10 Statistical Data Collection

See Section 5.10.

The CMU will need to collect some of the data required for the VHF Channel Statistical Data reports, defined in Section 5.10.2, from the VDR to support this function:

1. Command/control message from the CMU which enables/disables the data reporting function and controls the reporting interval to the CMU
2. Command/control message response, which the VDR sends to indicate that the command/control message was received, and should be obeyed
3. Data messages from the VDR at the commanded time intervals

See ARINC Characteristic 750, Attachment 11 for the detailed definitions of the messages.

10.7 Media Utilization

Refer to Section 9 for a description on how the CMU should perform channel management and how the use of VHF interacts with other (satellite and HF) media.

10.8 Voice/Data Switching

The aircraft wiring for a CMU/VDR installation is expected to give control of the VDR voice/data switching directly to the radio control panel. The CMU typically will have no control over switching the transceiver between voice and data modes, unlike the typical ACARS wiring. Instead the VDR status word will inform the CMU of the VDR state. This configuration will preclude the sending of Label 5P, Temporary Suspension, downlinks because by the time the CMU detects that a Label 5P downlink should be sent, the transceiver has all ready switched to voice. Label Q6 downlinks will also not be sent because they are only allowed when Label 5P downlinks are generated.

In an ATSU configuration, the ATSU controls the Voice/Data switching function and manages the transmission of Label 5P and Label Q6 Voice/Data status downlink messages.

11.0 ACARS OVER AVLC

11.1 Concept

ACARS over AVLC (AOA) is transporting ACARS ARINC 620 messages using ACARS routing over VHF Digital Link (VDL) Mode 2 Data link Layer. The Data link Layer of VDL Mode 2 is called Aviation VHF Link Control (AVLC). See Attachment 16 for description of the AOA Protocol Architecture.

COMMENTARY

The existing ACARS VHF frequencies are experiencing severe congestion and due to the scarcity of new VHF frequencies the only solution is to increase their efficiency. One expeditious way to do this is to use VDL Mode 2 as an ACARS air/ground subnetwork. VDL Mode 2 is quite capable of transporting ACARS messages and offers a factor of 10 improvement in data rate. It is anticipated that AOA can be implemented and fielded quicker than ATN. Also, using VDL Mode 2 in the existing ACARS system provides the opportunity to thoroughly test and debug the VDL Mode 2 subnetwork so that the industry will have a solid foundation to build on for ATN.

The migration to the Aeronautical Telecommunications Network (ATN) is the industry goal. The ATN migration is a significant investment and technological risk. A smooth and successful transition to the ATN is an achievable goal that depends on an approach that is planned to incorporate the essential foundation of the ATN, as well as support existing or legacy air-to-ground communications system protocols.

The foundation for the ATN is the air-to-ground communications protocols, as specified in the Internal Civil Aviation Organization (ICAO) SARPs. The existing or legacy air-to-ground communication protocol used today is ACARS and is unsuitable for ATN.

ACARS Over AVLC provides a solution that builds the foundation for ATN and provides a near term solution to the ACARS VHF frequency congestion problem.

The ATN compliant VDL Mode 2 specifies a three (3) layer communications protocol stack. The layers are as follows:

1. Physical: Differential Encoded 8 Phase Shift Keying (D8PSK)
2. Data link : Aviation VHF Link Control (AVLC)
3. Network : ISO Specification 8208 (ISO_8208)

As seen above, only a single type network layer protocol is specified: ISO 8208. The ISO 8208 protocol is used to implement ATN as specified in both the ATN SARPs and ARINC Specification 631.

The current network layer protocol used for air-to-ground communications for the past 20 years is ACARS. The provisions of this section enable legacy ACARS applications (messages) to be delivered over the new VDL Mode 2 air-ground link.

11.1.1 Multiple Network Layer Protocols

ARINC Specification 631 specifies a single network layer protocol, as ISO 8208 on-top-of a data link layer called AVLC. AVLC is a variation of a popular data link protocol called High Level Data Link Control (HDLC) as defined in ISO Specifications 4335, 3309 and 7809.

The system definition permits ACARS over AVLC to coexist with ISO 8208 and share the same AVLC Frame structure and AVLC resources. This allows portions of the system (aircraft) to be updated at different times based on the users (airlines) needs. The concept of multiple network layer protocols sharing AVLC data link layer is shown in Figure 17-1 of Attachment 17.

Figure 17-1 of Attachment 17 shows the Information (INFO) Field of the AVLC Frame containing either an AOA Packet or an ISO 8208 Packet.

A method to identify multiple network layer protocols is defined in ISO Specification 9577:1990(E) titled Protocol Identification in the Network Layer. ISO 9577:1990(E) specifies that the first octet of the header is to be an Initial Protocol Identifier (IPI) which would identify the network layer protocol used in that packet. The structure and values for the IPI are clearly specified. ISO 9577 defines IPI values for ISO 8208 packets. AOA packets implement a unique IPI value by using an extended IPI field in order to minimize possible conflict with future expansion of ISO 9577. To indicate that the IPI field has been extended by one octet, it uses a value of binary 1111 1111, which is reserved for future extension of ISO 9577:1009(E). The Extended IPI field uses a value of binary 1111 1111 to identify an ACARS over AVLC network layer protocol. This technique for identifying ACARS messages inside a data link frame using 1111 1111 and 1111 1111 is already being used today for High Frequency (HF) and SATCOM Data 2.

The AOA packet consists of IPI, extended IPI and ACARS message fields. Figure 17-2 of Attachment 17, shows the values and location for the IPI and Extended IPI fields when the payload of the AVLC Frame is an ACARS Message. The values for the IPI and Extended IPI fields apply to both uplink and downlink frames.

11.1.2 Downlink Block Processing

This section contains a simplified description and sequence diagram, Figure 18-1 of Attachment 18 for an ACARS Message Block flowing from an aircraft to a ground host system. Exceptions and some details are omitted in order to focus on the normal flow of events in downlinking an ACARS Message Block.

Preconditions:

The following conditions exist prior to sending a downlink message block to a customer’s ground host system from an aircraft.

1. An ACARS application, on board an aircraft, is to deliver an ACARS Message Block to the ground Data link Service Provider (DSP), and ultimately to the ground host system.
2. All VDL Mode 2 AVLC link establishment and handoff procedures have been successfully accomplished according to ARINC Specification 631.
3. The aircraft has selected a VDL Mode 2 Ground Station that supports the ACARS over AVLC (AOA) protocol as specified in the AVLC Specific Option table.

Steps in downlink process as illustrated in Figure 18-1 of Attachment 18.

Step 1 The aircraft has an ACARS Message Block to be transmitted to the ground system using VDL Mode 2. An ACARS Message Block is received from an airborne ACARS application to be transmitted to the Ground System using VDL Mode 2 data link.

Step 2 An Initial Protocol Identifier (IPI) and the Extended IPI are appended to the ACARS Message Block. The IPI and Extended IPI fields are set to binary 1111 1111 and 1111 1111. The mode character in the ACARS block is set to 2. The acknowledgment field is used and should follow the acknowledgment process specified in Section 3. The ACARS block format includes all of the characters from the <SOH> through the BCS suffix character <DEL> inclusive.

Step 3 An AVLC INFO frame is formatted according to ARINC Specification 631. The AOA Packet, which includes an IPI and Extended IPI, is inserted into the Information (INFO) field of the AVLC INFO frame. The frame format of an AVLC INFO frame is described in ARINC Specification 631.

Step 4 The aircraft transmits an AVLC INFO frame, that contains an ACARS Message Block, to a VDL Mode 2 Ground Station and starts timer VAT7.

Note 1: The aircraft waits until an acknowledgment is received from the DSP before sending another AVLC INFO Frame containing an ACARS Message Block.

Note 2: An ACARS Message Block (max size is 238 octets) could exceed the configurable size of an AVLC frame. To prevent this, the configurable size of the AVLC frame should not be set to less than 251 octets (238 octets ACARS Block + 2 octets IPI field + 11 octets AVLC Header yields a total of 251 octets). The Configurable maximum size of the AVLC Frame as specified in the ARINC Specification 631 is:

Maximum = 2063 octets
Minimum = 143 octets
Default = 1039 octets

Step 5 The VDL Ground Station transmits an AVLC acknowledgment frame to the aircraft. An AVLC acknowledgment frame (e.g., Receive Ready (RR)) is transmitted to the aircraft. This acknowledges the previous downlink AVLC INFO frame that contained the ACARS Message Block, as specified in ARINC Specification 631.

Note 1: The RR frame for acknowledgment was used for the sake of simplicity in this example. Other types of AVLC Frames may be used for acknowledgment as specified in ARINC Specification 631.

Note 2: The AVLC Frame processing algorithm, as specified in ARINC Specification 631, expects explicit acknowledgment for each AVLC INFO frame, both uplink and downlink.

Note 3: The AVLC uses the T2 Timer (delay before acknowledgment timer) with a default value of 500 ms (half second) per ARINC Specification 631. This should be sufficient for acknowledgment of the AVLC INFO frame containing an ACARS Message Block.

Note 4: AVLC frame processing, as specified in ARINC Specification 631, allows for a window of up to 4 frames to be transmitted before an AVLC acknowledgment is sent in reply. Only one AOA packet transaction should be in progress at any moment. An ACARS acknowledgement should be received before the next frame containing an AOA packet is transmitted.

Step 6 The VDL Ground Station sends an ACARS Message Block to the DSP. The VDL Ground Station examines the AVLC INFO Frame, received from the aircraft, to determine if the frame contains an ACARS Message Block. If the IPI and Extended IPI fields are set to 1111 1111 and 1111 1111 respectively, then the block is sent to the DSP.

Step 7 The DSP sends an ACARS Message Block Acknowledgment to the VDL Ground Station. The DSP replies to the ACARS Message Block, received from the VDL Ground Station, by sending an ACARS Block Acknowledgment message to the VDL Ground Station.

Step 8 The DSP formats and sends a Type-B ATA/IATA Message to the Customer's Ground Host System. After receiving a complete ACARS message from an aircraft, the DSP formats the ACARS Message Blocks into a Type-B ATA/IATA message. The DSP sends a Type-B ATA/IATA message to the customer's Ground Host System.

Step 9 The VDL Ground Station Appends an IPI and an Extended IPI. An IPI and Extended IPI are appended to the ACARS

Message. The IPI and Extended IPI fields are set to 1111 1111 and 1111 1111 respectively.

Step 10 The VDL Ground Station formats the AVLC INFO frame. An AVLC INFO Frame is formatted according to ARINC Specification 631. The AOA packet, which includes an IPI and Extended IPI, is inserted into the Information (INFO) field of the AVLC INFO frame.

Step 11 The VDL Ground Station transmits an AVLC INFO frame to the aircraft. The AVLC INFO frame containing the ACARS Message Block Acknowledgment is transmitted to the aircraft using normal AVLC Frame processing, as specified in ARINC Specification 631.

Step 12 The Aircraft transmits an AVLC acknowledgment frame to the VDL Ground Station. Upon receiving the AVLC INFO frame from the VDL Ground Station, the aircraft sends an AVLC acknowledgment frame (e.g., Receive Ready (RR)). This acknowledges the previous uplink sent by the VDL Ground Station, as specified in ARINC Specification 631.

Note 1: Normal AVLC INFO frame processing expects acknowledgments for each transmitted AVLC Frame.

Note 2: The RR frame for acknowledgment was used for the sake of simplicity in this example. Other types of AVLC Frames may be used for acknowledgment as specified in ARINC Specification 631.

Step 13. The Aircraft forwards an ACARS block acknowledgment. The aircraft examines the AVLC INFO frame received from the VDL Ground Station to determine if it contains an ACARS Message Block. If the IPI and Extended IPI fields are set to 1111 1111 and 1111 1111 respectively, the ACARS Block Acknowledgment is forwarded to the ACARS message processing on the aircraft.

11.1.3 Uplink Block Processing

This section contains a description and sequence diagram, Figure 18-2 of Attachment 18, for an ACARS Message flowing from an external ground host system to an aircraft. Exceptions and some details are omitted in order to focus on the normal flow of events in uplinking an ACARS message.

Preconditions:

The following conditions exist prior to sending an uplink message block to an aircraft from a customer’s ground host system.

1. A ground host ACARS system is to deliver an ACARS Message (i.e., Type-B IATA/ATA message) to an aircraft.

2. The normal, and expected, AVLC link connection/handoff procedures have been successfully accomplished according to ARINC Specification 631.
3. The aircraft has previously sent an ACARS downlink block over the VDL Mode 2 system which indicates that the aircraft is using the VDL system for its ACARS service.

COMMENTARY

The External Ground Host sends a single Type-B IATA/ATA message to the DSP. The DSP reformats the Type-B Message into one, or more, ACARS Message Blocks. Each block is transmitted one at a time using the normal stop-and-wait procedures for each block, as specified in Section 3 herein.

Steps in uplink process as illustrated in Figure 18-2 of Attachment 18.

Step 1 The External Ground Host System sends a Type-B IATA/ATA Message. The external ground host sends a Type-B IATA/ATA message to the existing/current DSP. This is identical to how Type-B IATA/ATA messages are handled today.

COMMENTARY

The customer Ground Host does not require knowledge that the destination aircraft is using a VDL Mode 2 Ground Station. If an aircraft is using ACARS Ground Stations (MSK) then the uplink is to be forwarded to the ACARS Ground Station. The identification for the type of service is handled by the DSP.

Step 2 The DSP sends an ACARS Message Block to the VDL Ground Station. The Type B IATA/ATA Message, received by the external ground host, is formatted into one (1), or more, ACARS uplink Message Blocks. Each ACARS Message Block is then sent to the VDL Ground Station to be transmitted to the aircraft.

Step 3 The VDL Ground Station appends IPI and Extended IPI. The IPI and Extended IPI fields are set to 1111 1111 and 1111 1111 respectively.

Step 4 The VDL Ground Station formats the AVLC INFO frame. An AVLC INFO frame is formatted according to ARINC Specification 631. The AOA packet, that now includes an IPI and an Extended IPI, is inserted into the Information (INFO) field of the AVLC INFO frame.

Note: An ACARS Message Block (max size = 238 octets) could exceed the configurable size of an AVLC frame. To prevent this, the configurable size of the AVLC frame should not be set to less than 251 octets. (238 octet ACARS Block + 2 octets IPI field + 11 octet AVLC Header totals 251 octets).

The configurable maximum size of the AVLC Frame as specified in ARINC Specification 631 is:

Maximum = 2063 octets
Minimum = 143 octets
Default = 1039 octets

Step 5 The VDL Ground Station transmits an AVLC INFO frame to the aircraft. The AVLC INFO frame containing the ACARS Message Block is transmitted to the aircraft using normal AVLC frame processing, as specified in ARINC Specification 631.

Step 6 The Aircraft transmits an AVLC acknowledgment frame to the VDL Ground Station. Upon receiving the AVLC INFO frame from the VDL Ground Station, the aircraft sends an AVLC acknowledgment frame (e.g., Receive Ready (RR)) containing an acknowledgment to the VDL Ground Station. This acknowledges the previous uplink sent by the VDL Ground Station, as specified in ARINC Specification 631.

Note 1. Normal AVLC INFO frame processing expects acknowledgments for each transmitted AVLC Frame.

Note 2. The RR frame for acknowledgment was used for the sake of simplicity in this example. Other types of AVLC Frames may be used for acknowledgment as specified in ARINC Specification 631.

Step 7 The Aircraft forwards the ACARS Message Block. The aircraft examines the AVLC INFO frame received from the VDL Ground Station to determine if it contains an ACARS Message Block. If the IPI and Extended IPI fields are set to 1111 1111 and 1111 1111 respectively, the ACARS Block is forwarded to the ACARS application on the aircraft.

Step 8 The Aircraft receives an ACARS Block acknowledgment to be transmitted. An ACARS Block acknowledgment is received from an ACARS application on the aircraft to be transmitted using the VDL Mode 2 data link.

Step 9 The Aircraft Appends the IPI and Extended IPI. The IPI and Extended IPI fields are set to 1111 1111 and 1111 1111 respectively.

Step 10 The Aircraft formats an AVLC INFO frame. An AVLC INFO frame is formatted according to ARINC Specification 631. The ACARS Block acknowledgment, which now includes an IPI and Extended IPI, is inserted into the Information (INFO) field of the AVLC INFO frame.

Step 11 The Aircraft transmits an AVLC INFO frame to the VDL Ground Station. The aircraft transmits an AVLC INFO frame that contains an ACARS Block acknowledgment to a VDL Mode 2 Ground Station.

Step 12 The VDL Ground Station transmits an AVLC acknowledgment frame to the Aircraft. An AVLC acknowledgment frame (e.g., Receive Ready (RR)) is transmitted to the aircraft. This acknowledges the previous downlink AVLC INFO frame, as specified in ARINC Specification 631.

Note 1: The RR frame for acknowledgment was used for sake of simplicity in this example. Other types of AVLC frames may be used for acknowledgment per ARINC Specification 631.

Note 2: The AVLC frame processing algorithm, as specified in ARINC Specification 631 expects explicit acknowledgment for each AVLC INFO frame, both uplink and downlink.

Step 13 The VDL Ground Station sends an ACARS Block Acknowledgment to the DSP. The VDL Ground Station examines the AVLC INFO frame, received from the aircraft, to determine if the frame contains an ACARS Block. If the IPI and Extended IPI fields are set to 1111 1111 and 1111 1111 respectively then the ACARS Block Acknowledgment is sent to the DSP.

11.2 CMU/VDR Interface Overview

In an aircraft installation, the VDL Mode 2 functions are distributed between the CMU and VDR. A local (within the aircraft) data link layer is used between the CMU and VDR in order for the two portions of the airborne VDL Mode 2 entity to work together and is defined herein. The description has been organized according to the OSI layers.

Communication between the CMU and VDR falls into 2 categories: VDR Control messages and air-ground protocol messages.

ARINC Characteristic 750 Sections 3 and 5 define the VDR Control messages exchanged.

The messages exchanged by the CMU and VDR for each air/ground protocol are defined in a separate attachment in ARINC Characteristic 750. Attachment 10 of ARINC Characteristic 750 defines the messages used for VDL Mode 2 (whether used by AOA or ATN).

11.2.1 CMU/VDR Interface Physical Layer

The CMU/VDR interface consists of a pair of ARINC 429 data buses. The CMU should provide ARINC 429 output port(s) and ARINC 429 input port(s) as specified in ARINC Characteristic 758 for communication with VDR(s). The VDR should provide ARINC 429 output port(s) and ARINC 429 input port(s) as specified in ARINC Characteristic 750 for communication with CMU(s).

Data transfer should be conducted using the ARINC 429 bit-oriented protocol Version 3 defined in ARINC Specification 429.

Word size, voltage thresholds, and electrical interface specifications are also per ARINC Specification 429. The word gap between two words should be at least 4 bit times and no more than 40 bit times.

11.2.2 CMU/VDR Interface Data Link Layer

For VDL Mode 2 operation the interface between the CMU and VDR should use the Bit-Oriented-Protocol (BOP) Version 3 as published in Part 3 of ARINC Specification 429-17.

11.2.2.1 Switch Between VDL Mode A and VDL Mode 2

Some VDRs only use BOP Version 1 for VDL Mode A. When the CMU is connected to such a VDR then the CMU should switch to BOP Version 1 to operate in VDL Mode A. Likewise, the CMU must switch to BOP Version 3 to operate Mode 2.

When the CMU is connected to a VDR that supports VDL Mode A over BOP Version 3 then the CMU can continue to use BOP Version 3 to operate in VDL Mode A.

The VDR Label 172 indicates whether the VDR supports the VDL Mode A over BOP Version 1 and/or BOP Version 3.

11.2.3 VDR Control Interface

The CMU controls the VDR operation using a variety of messages. The CMU uses the VDR Control messages defined in ARINC Characteristic 750, Section 5. These messages are sent using the ARINC 429 Bit Oriented Protocol version selected by the CMU. The CMU uses the ALO/ALR ARINC 429 Protocol selection process to select and switch the BOP version.

If the CMU changes BOP versions, then it uses the process defined in Section 11.2.3.4.

Data is also provided by ARINC 429 discrete data words transmitted by the CMU and VDR as specified in ARINC Characteristics 758 and 750 respectively.

11.2.3.1 VDR Subsystem Identifier (Label 172)

The VDR should transmit Label 172 as described in ARINC Characteristic 750. The Label 172 word contains the VDR SAL and data indicating which air-ground protocol(s) are supported by the software presently installed in the VDR.

11.2.3.2 CMU Status (Label 270)

The CMU should transmit a Label 270 data word as specified in ARINC Characteristic 758.

11.2.3.3 VDR Status (Label 270)

The VDR should transmit Label 270 as described in ARINC Characteristic 750. The VDR status information carried in this data word is decoded as defined in ARINC Characteristic 750.

11.2.3.4 VDR Control Messages

The CMU selects the BOP version to be used with the VDR prior to sending any messages. ARINC Specification 429 defines this process.

BOP Version 3 is used for VDL Mode 2 and AOA.

BOP Version 1 or Version 3 can be used for VDL Mode A, depending on what the VDR supports.

Depending on the ARINC 429 protocol supported and advertised for VDL Mode A by the VDR; and depending on the ARINC 429 protocol supported for VDL Mode A by the CMU, the CMU may have to change the BOP Version. VDL Mode 2 always uses BOP Version 3.

If the CMU and VDR have been operating in VDL Mode A using BOP Version 1, then when switching to VDL Mode 2, the CMU should direct the VDR to switch from BOP Version 1 to BOP Version 3. See ARINC Characteristic 750, Section 5.1.2.

ARINC Characteristic 750, Section 5, defines the VDR Control messages used by the CMU and VDR and the mechanism for switching ARINC 429 protocols and VDR modes. Each message sent by the CMU should trigger a response message from the VDR. The CMU should wait for the response message or for the response timer to expire, see ARINC Characteristic 750 for response times (typically 1 second), before sending the next message.

11.2.3.5 VDR Configuration (Air/Ground Protocol Selection)

The VDR may support several modes (air/ground protocols) of operation. Therefore, the initial step in CMU/VDR communication is to establish the desired mode of operation, which is referred to as air/ground protocol selection. VDR configuration is performed at VDR power up, and any time the VDR reports protocol null (see ARINC Characteristic 750) condition or ARINC 716 mode.

ARINC Characteristic 750, Sections 3 and 5, define the primitives (messages) used to perform VDR configuration. The air/ground protocol selection process is defined in ARINC Characteristic 750, Sections 3 and 5. See Figures 13-1 and 13-2 of Attachment 13 for examples of the VDL Mode A air/ground protocol selection, which is similar.

VDR configuration for VDL Mode 2, whether AOA or ATN, is performed using BOP Version 3 command frames, file type Command and GFI 2. SOLO words are also used. When the VDR has been configured then the bits in the VDR Label 270 broadcast word indicate protocol reset per ARINC Characteristic 750.

Before the configuration is completed, messages with GFI values other than 2 are considered errors and are ignored except for error logging.

11.2.3.6 VDR Initialization

VDR initialization is performed after the VDR configuration is completed. VDR initialization provides the initialization data used by the selected air/ground protocol. VDR initialization is performed using GFI ‘F’ and the extended GFI value that corresponds to the selected air/ground protocol.

When VDL Mode 2 is selected then the initialization is performed using extended GFI F1h and file type of Command (0) as indicated in ARINC Characteristic 750, Attachment 10. When the VDR has been initialized then the bits in the VDR Label 270 broadcast word indicate protocol set per ARINC Characteristic 750.

11.3 ACARS Message Protocol

Screening of aircraft uplink addresses is performed by the VDR using the addresses provided by the CMU. Typically the address set consists of the ICAO 24-Bit Aircraft Address; aircraft broadcast address and all station addresses. The CMU should receive only uplink traffic that matches one of the addresses. The CMU should still validate the address as defined in Section 3.3 and discard the block if it does not match. However, mismatch should not occur in normal operation.

The CMU should check the uplink BCS. Receipt of an uplink with a bad BCS check should result in the immediate transfer of a general response block (<_DEL> label with a <NAK> (1/5) in the technical ACK/NAK field) from the CMU. The CMU should not embed the NAK in a non-General Response message. The uplink block should be discarded by the CMU. The VDL Mode 2 CRC only protects message over the air/ground link whereas the BCS protects the message all the way from the ACARS DSP.

The CMU should only send downlink blocks to the VDR when it has completed the VDR initialization process. Bits 11 and 14 of the Label 270 VDR status word are 0 and 1 respectively when the VDR has received operational parameters, but these bits do not provide any indication regarding the address initialization.

11.3.1 Message Format

The format of the ACARS data in the VDL Mode 2 frame should follow the format described in Section 2.1 herein.

The data starts with the start of header character and retains the ACARS message structure through the BCS suffix character.

The Mode Character field should contain the character 2.

AOA supports multiblock ACARS messages. When a multiblock message is formatted then all blocks except the last one contains an ETB character instead of an ETX character. Only the last block contains an ETX character, just like plain old ACARS.

The text field of an ACARS block can be larger than 220 characters when the VDL Mode 2 parameter N1 is larger than 2008 (see Section 11.7.1). For example, if the service provider sets N1 to its maximum value, then it would be possible to transmit (uplink or downlink) a 16 block message as 2 supersize blocks in 2 VDL Mode 2 frames containing AOA packets.

The avionics may choose to continue sending 220 character blocks even when N1 is larger. The avionics does not have to supersize the downlink blocks.

The DSP may choose to continue sending 220 character blocks even when N1 is larger. The DSP does not have to supersize the uplink blocks.

The avionics should accept the largest uplink block that can be encapsulated into the largest possible VDL Mode 2 frame (16504 bits). This large block could contain up to 2032 text characters (16504 bits/8 minus 18 header characters minus 2 IPI bytes minus 11 octets AVLC header).

Conversely, the service provider can set N1 smaller than 2008 which means that the VDL Mode 2 frame is too small to hold a full size ACARS block. The avionics may choose to not use AOA under these conditions.

According to ARINC Specification 631 the service provider controls the values for N1. The uplink N1 parameter and downlink N1 parameter are allowed to have different values. The service provider can dynamically change the value of N1, but is strongly discouraged from doing so. For AOA operation the service provider should set the value of N1 to 2008 or larger.

If the service provider makes N1 values smaller, but still larger than 2008, and the avionics has been using a large ACARS block size then the avionics has to reduce its block size. When this occurs while a multiblock message is in progress then the avionics should either:

1. Finish the multi-block message in process and use the new block size for the next downlink
2. Dynamically adjust the block size and continue
3. Re-start the multiblock downlink, using the same MSN, with the new block size

When the avionics re-starts the multiblock downlink, the service provider detects this (same MSN) and discards the partial message and re-starts, collecting the blocks for the downlink.

11.3.2 Acknowledgment of a Downlink Block

It is essential to deliver messages in as timely a fashion as possible. To achieve this, the DSP should optimize its use of the RF spectrum. This also minimizes queuing delays of messages. The optimum response depends upon the sequence of events leading up to and including the transmission of the downlink block. The following subsections illustrate how downlinks should be acknowledged so as to minimize the RF spectrum utilization. This is not an exhaustive list of scenarios. The UBI character in a general response uplink received via AOA does not affect the value of the AOA UBI reference character in the CMU.

The DSP should reset its MSN reference value after a mode switch (AOA to POA, POA to AOA) to ensure that the first downlink received in the new mode will not be processed as a duplicate.

11.3.2.1 Downlink Acknowledgment Scenario 1, Simple Case

When the DSP receives a downlink and there is no preceding uplink block, for which an acknowledgment is outstanding, then the DSP should immediately acknowledge the downlink block just received. To achieve this, the DSP should respond with the DBI value of the received downlink in the technical ACK/NAK field of a General Response uplink. The sequence is analogous to the SATCOM case, illustrated in Figure 10-1 of Attachment 10.

11.3.2.2 Downlink Acknowledgment Scenario 2, Pending Uplink

When the DSP receives a downlink block and there is no preceding uplink block, for which an acknowledgment is outstanding and there is an uplink block in the DSP uplink queue waiting to be transmitted, then the DSP has two alternatives for acknowledging the downlink block:

1. The DSP can respond with the DBI value of the received downlink in the technical ACK/NAK field of a General Response uplink followed by the uplink block
2. The DSP can respond with the queued uplink block and an embedded ACK. If the uplink block is retransmitted, then it should retain the original UBI and contain a <NAK> (1/5) in the Technical Acknowledgment field. This option is preferred to Option 1

The sequence is analogous to the SATCOM case illustrated in Figure 10-2 of Attachment 10.

11.3.2.3 Downlink Acknowledgment Scenario 3, Criss-cross

When the DSP receives a downlink block, which does not positively acknowledge a preceding uplink block, for which an acknowledgment is outstanding, the DSP should immediately acknowledge the downlink block just received. To achieve this, the DSP should respond with an ACK in the technical ACK/NAK field of a General Response uplink to resolve the criss-cross condition. The ACK is sent in a General Response uplink rather than an immediate retransmission containing an embedded ACK due to time of delivery concerns and effective utilization of available RF resources. The uplink block retransmission should only be performed at either the expiration of the no ACK timer (VGT1) defined in Section 11.4.1 or the receipt of a General Response containing a <NAK> (1/5) in the Technical Acknowledgment field. The retransmitted uplink block should retain the original UBI and contain a <NAK> (1/5) in the Technical Acknowledgment field. Attachment 10, Figure 10-3 illustrates this scenario. An uplink retransmission can only be used to deliver an ACK when the DSP receives a downlink block immediately prior to the expiration of VGT1. In this case the DSP has the option of using the retransmitted uplink block or a General Response uplink to deliver the ACK. This scenario is shown, Figure 10-4 of Attachment 10.

11.3.3 Acknowledgment of an Uplink Block

It is essential to deliver messages in as timely a fashion as possible. To achieve this, the CMU should optimize its use of the RF spectrum. This also minimizes queuing delays of messages. The optimum response depends upon the sequence of events leading up to and including the transmission of the uplink block. The following subsections illustrate how uplinks should be acknowledged so as to minimize the RF spectrum utilization. This is not an exhaustive list of scenarios.

The DBI character in a general response downlink received via AOA does not affect the value of the AOA DBI reference character in the DSP.

The avionics should reset its UBI reference value after a mode switch (either POA to AOA or AOA to POA) to ensure the very first uplink block received in the new mode will not be processed as a duplicate block.

11.3.3.1 Uplink Acknowledgment Scenario 1, Simple Case

When the CMU receives an uplink and there is no preceding downlink block, for which an acknowledgment is outstanding, then the CMU should immediately acknowledge the uplink block just received. To achieve this, the CMU should respond with an ACK in the technical ACK/NAK field of a General Response downlink. The sequence is analogous to the SATCOM case, illustrated in Figure 10-4 of Attachment 10.

11.3.3.2 Uplink Acknowledgment Scenario 2, Pending Downlink

When the CMU receives an uplink block and there is no preceding downlink block, for which an acknowledgment is outstanding and there is a downlink block in the CMU downlink queue waiting to be transmitted, then the CMU has two alternatives for acknowledging the uplink block:

1. The CMU can respond with the UBI value of the received downlink ACK in the technical ACK/NAK field of a General Response downlink followed by the downlink block.

or

2. The CMU can respond with the queued downlink block containing an embedded ACK. If the downlink block is retransmitted, then it should retain the original UBI and contain a <NAK> (1/5) in the Technical Acknowledgment field. This option is preferred to option a.

The sequence is analogous to the SATCOM case, illustrated in Figure 11-2 of Attachment 11.

11.3.3.3 Uplink Acknowledgment Scenario 3, Criss-cross

If the CMU receives an uplink block, which does not positively acknowledge a preceding downlink block, for which an acknowledgment is outstanding, the CMU should immediately acknowledge the uplink block just received. To achieve this the CMU should respond with an ACK in the Technical Acknowledgment field of a General Response downlink to resolve the criss-cross condition. The ACK is sent in a General Response downlink rather than an immediate retransmission with an embedded ACK to facilitate quickest delivery over the AOA medium and to most effectively utilize available RF resources. The sequence is analogous to the SATCOM case, illustrated in Figure 11-3 of Attachment 11.

The downlink block is only retransmitted when VAT7 expires or a General Response <_DEL> uplink containing a NAK is received. The downlink block retransmission should retain the original DBI and contain a <NAK> (1/5) in the Technical Acknowledgment field.

A retransmission can only be used to deliver an ACK when the CMU receives an uplink block immediately prior to expiration of VAT7. In this case the CMU has the option of using the retransmitted downlink block or a General Response downlink to deliver the ACK. The sequence is analogous to the SATCOM case, illustrated in Figure 11-4 of Attachment 11.

11.3.4 VDR Link Management

The following subsections describe basic protocol exceptions to Section 5 of this document for ACARS traffic sent and received over the VHF Digital Link.

11.3.4.1 Functional Capability of the Airborne Sub-System

The CMU should establish and maintain a link across the VHF medium with the Data Link Service Provider's (DSP) system. In order to do this, it should use the ACARS message protocol defined in this specification.

Since the frequency over which VHF data communications is conducted can change, the CMU needs to have a frequency management capability. The CMU can be programmed with the different available frequencies and attempt link establishment on each frequency as described herein.

11.3.4.2 Permission to Send

Prior to any ACARS VHF downlink transmission the CMU should receive permission to send to ensure transmission on an authorized frequency for data communications. Channel access authorization is performed by the VDR and is obtained using procedures established under Medium Access Control as defined in ARINC Characteristic 750. See Section 11.6.6 for frequency acquisition procedures.

11.3.4.2.1 AOA Response to VDL Mode 2 Link Establishment

When a VDL Mode 2 link is established the avionics sends a Link Test message or other message waiting to be downlinked. When the acknowledgment is received, the avionics may send a Media Advisory message indicating that the AOA link is established.

When all AOA retries have been performed without receiving an ACARS ACK the avionics should react as described in Section 11.6.

11.3.4.2.2 AOA Response to VDL Mode 2 Link Handoff

When a VDL Mode 2 link hand off occurs (see ARINC Specification 631), the avionics should send a link test message or other message waiting to be downlinked. Two links exist during the handoff and only the new link should be used for sending downlinks. For example, if an uplink is received over the old link the ACARS ACK should be sent via the new link.

When all AOA retries have been performed without receiving an ACARS ACK then the avionics should react as described in Section 11.6.

11.3.4.3 Media Switching

Any multi-block message in progress when the avionics switches between AOA and any other media, including ACARS VHF, is re-started.

COMMENTARY

The multiblock message is re-started

1. because there may be a different service provider

2. because, even if it is the same service provider, the ground computers may not have the capability to combine partial messages or,
3. to maintain similarity with existing ACARS media management.

11.4 AOA Link Management Timers

The following subsections describe protocol exceptions to Chapter 5 of this document for ACARS traffic sent and received over the VHF Digital Link. Due to different throughput of the VDL channel, different timer and counter values are specified.

Timer and counter values have been determined to be consistent with the timers/counters and retransmission logic used at the VDL layers.

VGT1 has been determined to encapsulate the maximum duration between the sending of an AVLC frame and the receipt of its acknowledgment (note that the calculation is based on the default values found in ARINC Specification 631).

VAT7 has been determined to take into account VDL Handoff and the VDL retransmission logic.

The other timers and counters have been derived from VGT1 and VAT7 values using the relations between the different timers.

11.4.1 Ground-Based Timers

The ground-based timers are as follows:

TIMER	VALUE	TIMER NAME	NOTES
VGT1	35s	No ACK Timer	1
VGT2	70s	Message Reject Timer	2*VGT1
VGT3	20s	Incomplete Message Interval Timer	
VGT4	420s	Incomplete Downlink Message Timer	
VGT5	Variable	Q5 Timer	2
VGT6	N/A	Squitter Timer #1	
VGT7	N/A	Squitter Timer #2	
VGT8	600s	Temporary Suspension Timer	

Note 1: VGT1 = 2(N2*T1) + Tlatency (N2 and T1 definition refer to ARINC Specification 631).Values used to calculate VGT1: N2 = 3, T1 = 5s, Tlatency = 5s

Where: ‘T1’ and ‘T3’ are timers specified in ARINC Specification 631.

Note 2: This value is service provider dependent

Refer to Figure 19-1 of Attachment 19, for an illustration of the role of Timer T1, as defined in Section 7.6.1 of ARINC Specification 631, in uplink block transmissions.

11.4.2 Airborne Timers

The following timer values should be used.

TIMER	VALUE	TIMER NAME	NOTES
VAT1	N/A	Contact Timer	
VAT2	N/A	Scan Timer	
VAT3	N/A	Tracker Timer	
VAT4	80s	Message Assembly Timer	
VAT5	N/A	Interblock Timer	
VAT6	600s	NOCOMM Timer	
VAT7	45s	No ACK Timer	1
VAT8	600s	UBI Reset Timer	
VAT9	600s	Voice Mode Timer	
VAT10	1200s	Multiblock Message Timer	
VAT 11	User defined	Auto Return to Data Defined	
VAT12	600s	Inter-Media Switch Timer	
VAT13	300s	Debounce timer	

Note 1: VAT7 = (N2*T1) + (N2*T3) (N2, T1 and T3 refer to ARINC Specification 631) Values used to calculate VGT1: N2 = 3, T1 = 5s, T3 = 10s

11.4.2.1 Management of Inter-Media Switch Timer (VAT12) and Debounce Timer (VAT13)

The implementation of media switching between ACARS and VDL (AOA) uses a timer to prevent the overuse of the ACARS base frequency. This adopted approach implements a timer in the avionics to monitor the time it takes for the avionics to switch from ACARS to AOA and back to ACARS.

1. The timer that performs this function is the Inter- Media Switch Timer (VAT12).
2. **VAT12 should be initialized when the avionics tunes to the indicated AOA frequency.**
3. No action should be taken on the expiration of VAT12.
4. If the aircraft determines that AOA is not available, and VAT12 has expired, the aircraft falls back to the ACARS base frequency.
5. **If the aircraft determines that AOA is not available, and VAT12 has yet to expire, the aircraft falls back to the previously used ACARS frequency.**

A second timer, the Debounce Timer (VAT13) is implemented in the avionics to wait before attempting to reconnect to AOA after the avionics falls back to its initial frequency, due to disconnect from AOA.

1. The waiting time is defined as the debounce time.
2. VAT13 prevents the aircraft from bouncing between the two media (ACARS and AOA).
3. VAT13 is set when the avionics switches from AOA to ACARS.
4. VAT13 is cancelled upon entry into frequency acquisition.

11.4.3 Successful Switch from ACARS to AOA

A message sequence chart illustrating the successful switch from ACARS to AOA is included as Figure 18-3 of Attachment 18.

11.4.4 Fallback from AOA to ACARS Before VAT12 Expiration

A message sequence chart illustrating the fallback from AOA to ACARS before VAT12 has expired and is included as Figure 18-4 of Attachment 18.

1. This scenario illustrates the aircraft determining that AOA is unavailable before VAT12 has expired.
2. Aircraft switches back to original ACARS frequency.
3. VAT13 is initiated.

11.4.5 Fallback from AOA to ACARS After VAT12 Expiration

A message sequence chart illustrating the fallback from AOA to ACARS after VAT12 has expired is included as Figure 18-5 of Attachment 18.

1. This scenario illustrates the aircraft determining that AOA is unavailable after VAT12 has expired.
2. Aircraft switches back to base ACARS frequency.
3. VAT13 timer is initiated.

11.4.6 Ground Counters

The following counter value should be used.

COUNTER	VALUE	COUNTER NAME	NOTES
VGC1	2	Transmission Counter	

11.4.7 Airborne Counters

The following counter value should be used.

COUNTER	VALUE	COUNTER NAME	NOTES
VAC1	2	Transmission Counter	

11.5 Switching Between ACARS and AOA

11.5.1 ACARS to AOA (Normal)

There are several triggers for a CMU to switch from ACARS to AOA.

1. **Receipt of version 2 ACARS Squitters indicating AOA availability**
2. **Receipt of an ACARS to AOA VDL Retune command**

COMMENTARY

Other conditions such as Aircraft initiated switchover based on a-priori knowledge (e.g., Airline preference DSP Table) or NO COMM on ACARS could also lead to the switch to AOA.

11.5.1.1 ACARS to AOA Switchover Based on Squitters

ACARS squitters may be used to indicate when and where VDL Mode 2 is available. The squitter data can indicate whether only AOA is supported; only ATN is supported or both are supported. The Squitter data provides the VDL mode 2 frequency and optionally a list of VDL Mode 2 Ground Station address(es) that are expected to be within range on that frequency for each service (AOA/ATN) supported. See ARINC Specification 620 for the definition of the Squitter Version 2 uplink.

Squitter data should reflect real time availability of AOA and ATN. For example, if the AOA processor fails then the squitter data changes from indicating support for both to support for ATN only.

If the CMU chooses to disconnect from an ACARS VHF link to attempt to establish a VDL Mode 2 connection then the CMU should send a Label 5V downlink before leaving the ACARS VHF frequency. See ARINC Specification 620 for definition of Label 5V message. The Label 5V downlink is transmitted only once and the avionics does not expect any acknowledgement (similar to Label 5P).

Figure 18-6 of Attachment 18 and the following steps describe the data that is exchanged when an aircraft switch from ACARS to AOA communication mode is initiated in response to receiving a squitter uplink.

Step 1: ACARS Squitter (Version 2)

The aircraft receives an ACARS Squitter Version 2 indicating AOA support and containing a valid VHF frequency. There may also be a list of VDL mode 2 Ground Station address(es).

Step 1a: Determine if POA to VDL Mode 2 transition is appropriate.

If on-ground, compare the Squitter station ID (IATA or ICAO as appropriate) to the current CMU departure and destination stations. If a match is obtained, or no (departure or destination) station information is available, proceed to step 2, otherwise continue operation in POA.

COMMENTARY

It may be possible to receive squitter messages announcing VDL capability while operating POA when it is not possible to operate using VDL Mode 2. An example of this occurs with closely spaced airports (e.g. Miami (KMIA) – Fort Lauderdale (KFLL)). To avoid ground propagation issues it is better to maintain operation on POA until airborne if the VDL Mode 2 ground station is not located at the departure airport.

Step 2: Avionics transmits a Label 5V Switching services advisory ACARS downlink on the ACARS frequency.

Transmit an ACARS message to indicate the non-availability of the legacy ACARS RF link because the VHF radio is switching to the VDL mode.

Step 3a: Tune to VDL frequency

Upon frequency change, the avionics may use the proposed VDL Ground Station address(es) (if provided) to establish a link without waiting for collection of valid uplinks on the new frequency. This will improve the service continuity and optimize the time to switch to AOA. In such a case, go to Step 4.

If the VDL Ground Station address(es) is not provided or the CMU decides not to use the supplied one, then go to Step 3b.

Step 3b: VDL Uplink Traffic

Receipt by the aircraft of any VDL Uplink. The PECT Table is built for the chosen frequency. A Ground Station is chosen.

Step 4: Avionics transmits XID CMD LE per ARINC 631

Step 5: Ground transmits XID_RSP_LE per ARINC 631

Step 6: Avionics transmits AVLC INFO Frame containing an ACARS block (mandatory).

Following the Link Establishment, the aircraft should send an AVLC INFO Frame containing a Link test (Label Q0) or any other pending ACARS Downlink (except media advisory) message to update the CMU-ACARS DSP connectivity status.

Step 7: Ground transmits AVLC INFO Frame containing an ACARS ACK block. The ground system should transmit an ACARS block to acknowledge the downlink message sent in step 6.

Step 8: Avionics may transmit AVLC INFO Frame containing an ACARS Media Advisory block. When the aircraft receives the ACK of the previous ACARS downlink message, it may send an ACARS Media Advisory to advise of a change in ACARS link status.

For FANS1/A operation, whenever the switch from ACARS to AOA takes place on different Service Providers, then the CMU should send a Media Advisory.

If the switchover takes place on the same Service Provider then it is preferred that the CMU does not send a Media Advisory.

Every time the avionics performs VDL Mode 2 link establishment then a Link Test or other downlink message should be sent to establish the link with the ACARS DSP.

COMMENTARY

Having an AVLC link to the Ground Station does not mean the aircraft has a link to the ACARS DSP.

The proposed mechanism is similar to the one implemented for SATCOM Data-2, where the log-on to the GES is not sufficient to declare the link to a DSP is up and running. In SATCOM Data-2, and especially for FANS-1 operation, the transmission of an ACARS downlink after the log-on should be done.

The CMU should have non-ambiguous connectivity status information to the ACARS DSP, which is quite different from a link to the Ground Station.

The DSP uses the Link Test Q0 or other Downlink label to update its Tracking Table and map the 7 characters ACARS Aircraft Number with the ICAO 24-bit Aircraft address.

11.5.1.2 ACARS to AOA Switchover Based on VDL Retune Command

An ACARS to AOA VDL Retune (Label :}) is used to command an aircraft to change its operating frequency from ACARS to AOA. The DSP uses the ACARS to AOA VDL Retune to offload in a controlled manner its ACARS frequencies and ensure an optimal transition (i.e. minimize NO COMM condition). The ACARS to AOA VDL Retune provides at least the target VDL frequency and the DSP Id but may also indicate a list of proposed VDL Ground Station addresses. See ARINC 620-5 Specification for definition of the ACARS to AOA VDL Retune Label.

There might be situations where the ACARS to AOA switchover cannot be accepted by the CMU. If the CMU refused the switchover because the ACARS to AOA VDL Retune is not recognized then the CMU should send a Label QX downlink to advise that the VDL Retune has not been accepted. When the CMU recognizes the label but chooses not to comply for other reasons, the CMU should downlink a Label QV Autotune Reject message to advise that the VDL retune has not been accepted. If an airline wants to inhibit some or all of its fleet from being retuned to AOA, then the airline should make arrangements with the service providers to inhibit the uplinking of AOA VDL Retune messages to those aircraft.

If the CMU supports the AOA VDL Retune but is temporarily unable to act upon the VDL Retune uplink (multiblock uplink or downlink in progress for example), then the CMU should acknowledge the VDL Retune uplink. When the CMU has completed the downlink message, it should transmit a Label 5V message, and then switch to AOA.

If an ACARS to AOA VDL Retune is received and all conditions to switch to AOA are met, the Debounce Timer (VAT13) should be ignored. In other words, the aircraft should change its operating frequency from ACARS to AOA even if

VAT13 has not expired. Note that the Inter-Media Switch Timer (VAT12) should be started as usual (just like on Squitter switchover).

The different steps of the frequency switch triggered by the ACARS to AOA VDL Retune are described below:

Step 1: Ground transmits an AOA VDL Retune command. The VDL Retune command contains the new VDL frequency, which can be either the CSC or a DSP assigned VDL frequency, the DSP ID, and an optional list of Ground Stations.

Step 2: If the avionics supports and accepts AOA VDL Retune, it should first respond on the present legacy ACARS frequency with a technical acknowledgment message.

If the avionics is busy sending or receiving an air-ground message, then there will be a delay until the ongoing message is completed before the avionics actually switches to the AOA frequency.

The downlink label 5V is generated and sent to the ground station on the present legacy ACARS frequency when the avionics is ready. If the avionics is able to retune immediately, the Label 5V will contain the embedded acknowledgement for the VDL Retune uplink.

For subsequent steps, refer to section 11.5.1.1 step 3a through step 7. When using the ACARS to AOA VDL Retune, the CMU should not send any Media Advisories.

Note that, unlike the ACARS to ACARS autotune, an ACARS to AOA VDL Retune will cause a multiblock message (uplink or downlink) to restart if the switch occurs during a multiblock message per section 11.3.4.3. The avionics should try to complete the multiblock message before switching.

Note: The AOA VDL Retune uplink should only be used to switch avionics from POA to AOA. It should not be used to switch avionics from one AOA frequency to another AOA frequency.

11.5.2 AOA to ACARS (Normal)

There are several triggers for a CMU to switch from AOA to ACARS. One of them is a DSP initiated Autotune command.

COMMENTARY

Other conditions such as Aircraft initiated switchover based on a-priori knowledge (e.g., Airline preference DSP Table) or NO COMM on AOA could lead to the switch to ACARS.

The CMU may send an AVLC DISC to disconnect the VDL link prior to switch back to ACARS.

11.5.2.1 AOA to ACARS Switchover Based on Autotune Command

An AOA to ACARS Autotune (Label :;) is used to command an aircraft to change its operating frequency from AOA to ACARS. The DSP uses this Autotune to anticipate the loss of VDL frequency coverage, and avoid NO COMM situations. The first six characters in the AOA to ACARS Autotune are the same as for ACARS Autotune and only contain the target ACARS frequency. An optional four-digit field (character positions 7-10) can specify a new one shot value for the Debounce Timer (VAT13). This field will specify the debounce timer in seconds, with one second to 9999 seconds being valid. If a setting of zero is received in this field (0000), the message should be acknowledged, the frequency change will occur, and the default value for VAT 13 will be used.

If an AOA to ACARS Autotune is received and all conditions to switch to ACARS are met (message complete), the Inter-Media Switch Timer (VAT12) should be ignored. In other words, the aircraft should change its operating frequency from AOA to the ACARS frequency indicated in the Autotune whatever the VAT12 Timer state may be. If the optional characters for the VAT13 are present in the Autotune Command, then the VAT13 timer should be set to the value specified. Note that the Debounce Timer (VAT13) should be started as usual (just like on VDL frequency unavailability). When VAT13 expires, its value should be set to the default value.

There might be situations where the AOA to ACARS switchover cannot be accepted by the CMU. When the CMU chooses not to comply, the CMU should downlink a Label QV Autotune Reject message to advise that the autotune has not been accepted. If an airline wants to inhibit some or all of its fleet from being autotuned to POA then the airline should make arrangements with the service providers to inhibit the uplinking of autotune messages to those aircraft.

The different steps of the frequency switch triggered by the AOA to ACARS Autotune are described below:

Step 1: Ground transmits an AVLC INFO frame containing an AOA to ACARS Autotune. The Autotune command contains the target Legacy ACARS frequency.

Step 2: Avionics should transmit an AVLC INFO frame containing an ACARS General Response Acknowledgement (Label _DEL) message, or alternatively an autotune reject (Label QV) message.

If the avionics is going to comply with the Autotune command, the avionics should first respond on the present VDL operating frequency with a technical acknowledgment message.

Subsequent steps apply when the avionics is going to switch to the specified legacy ACARS frequency.

Step 2a: Complete any message in progress if possible.

Step 2b: **Avionics should transmit an AVLC DISC frame to the VDL link.**

Step 3: **Tune to the ACARS frequency received in the Autotune uplink.**

Step 3a: **Avionics transmits an ACARS downlink message.**

The avionics should immediately send a Link Test (Label Q0) message or any other pending ACARS downlink message.

Step 4: **Ground acknowledges the downlink block. The ground system should transmit an ACARS block to acknowledge receipt of the downlink message sent in step 3b.**

When using the AOA to ACARS Autotune, the CMU should not send any Media Advisories.

11.5.2.2 AOA to ACARS Switchover Without Autotune Command

The steps for switchover from AOA to ACARS without an Autotune command are identical to those of Section 11.5.2.1, with an additional step described below:

Step 5: **The CMU may transmit a Media Advisory block.**

When the aircraft receives the ACK of the previous ACARS downlink message, it may send an ACARS Media Advisory to advise of a change in AOA link status.

For FANS1/A operation, whenever the switch from AOA to ACARS takes place on different Service Providers, then the CMU should send a Media Advisory.

If the switchover takes place on the same Service Provider then it is preferred that the CMU does not send a Media Advisory, especially if the CMU sends an AVLC DISC prior to leaving the VDL frequency.

Note that, unlike the ACARS to ACARS autotune, an AOA to ACARS autotune will cause a multiblock message (uplink or downlink) to restart if the switch occurs during a multiblock message per section 11.3.4.3. The avionics should try to complete the multiblock message before switching.

11.5.3 Exceptions

The following paragraphs describe exceptions and fault handling procedures.

11.5.4 Connectivity Loss with ACARS Processor

If a VDL ground station supporting AOA loses its connection to its ACARS processor, the AOA bit in the Ground Station Information Frame (GSIF) may be reset. Any connected aircraft may also be disconnected at this time. Subsequent connections requesting AOA service are refused with cause code 0x03 (indicating loss of terrestrial connection).

11.5.5 Unsupported Handoffs

The following paragraphs describe the procedures for handling unsupported handoffs.

11.5.5.1 Handoffs to a Ground Station That Does Not Support AOA

The stations that support AOA indicate their capability in the GSIF. When an aircraft conducts handoff to a new ground station, it searches its PECT for the best station. The aircraft checks the AOA bit to confirm that the station supports AOA. If aircraft utilizing AOA attempts to establish a link or handoff to a ground station that does not support AOA or is currently disconnected from the ACARS system, the connection is refused with XID_RSP_LCR. The associated cause code (0x07) indicates that the ground station does not have a link to the ACARS system.

11.5.5.2 Handoffs Between Service Providers

Handoffs between service providers are not supported. Instead a new link connection is established in accordance with ARINC Specification 631. If the system mask shows that the preferred ground station handing off the connection is serviced by a different service provider, the aircraft initiates a new connection using XID_CMD_LE to establish the link. The aircraft disconnects from its current service provider after the new link has been established. If the aircraft issues an XID_CMD_HO, the proposed service provider rejects the handoff.

11.6 ACARS – VHF Manager

Note: Sections 11.6 through 11.6.3 contain the current text of ARINC Specification 618-5. This material is included for information only.

The ACARS-VHF manager may be considered as part of the VME/LME function. See Section A10.2 of Attachment 10 to ARINC Characteristic 750. Its purpose is to manage the operating mode of the VDR by selecting when to transition into AOA while operating in an ACARS environment or when to transition to ACARS from an AOA environment.

11.6.1 AVLC Startup

The CMU may command AVLC operation upon any of the following situations:

1. Label SQ uplink advertisement on ACARS channel (See ARINC Specification 620). Any outstanding message traffic is allowed to be completed prior to leaving the frequency. Being connected in ACARS VHF is not a pre-requisite for switching to AOA.
2. Apriori knowledge of service. The CMU can use any additional information available (e.g., current position and bearing) to assist in the decision to invoke AOA operation.
3. Command mode invocation. The CMU may utilize either uplinked information or pilot intervention to enable AOA operation. In this case, if no operating frequency is explicitly specified, operation begins on the CSC.

11.6.2 AVLC Shut Down

Decision to fall back to ACARS vs. to proceed on VDL Mode 2 is based on CMU dependent logic. This logic is predicated on airlines specified preferences (which may for instance specify either a preference for continuous contact regardless of subnet or a desire to maximize VDL Mode 2 operation). When the CMU determines that AOA operation is no longer possible, the CMU returns to the original operating frequency if the Intra-Media Switch timer (IST) has not expired. If the IST has expired, the CMU returns to an ACARS base frequency as determined by its internal frequency search characteristics.

11.6.3 Frequency Switch

If the CMU has knowledge of frequencies broadcast by the ground LME via an uplink XID, these frequencies should be tried (subject to airline policy) prior to returning to ACARS operation. If no additional frequency support has been announced, the CMU may attempt to communicate using the CSC prior to returning to Plain old ACARS operation.

COMMENTARY

If ACARS operation is restored upon loss of VDL Mode 2 operation, squitters can advertise the availability of VDL Mode 2 services. Return to AOA operation may be delayed until reception of the Label SQ squitter broadcast and expiration of the debounce timer. Conversely, attempting additional VDL frequencies directly may cause the delay of the TG1 dwell timer on each frequency attempted. Airline policy determines specific implementation preferences.

11.6.4 Voice/Data Switching

The VDR may be switched at any time to operate in Voice mode. VAT9 should be started at the transition into Voice. If Data mode is restored prior to the expiration of VAT9, operation resumes using the same frequency and mode of operation as prior to the switch.

If Data mode is restored in VDL Mode 2, a XID_CMD_LE is expected to establish **the** link.

If VAT9 has expired when Data mode is restored, **then the CMU should enter frequency acquisition starting with Base mode and frequency.**

Note: Base mode means the first mode (Mode A or Mode 2) selected when entering frequency acquisition with a given service provider.

11.7 AVLC Requirements

ACARS Over AVLC uses the services provided by the AVLC and VME/LME functions as defined in ARINC Specification 631. These functions are a subset of the VDL Mode 2 subnetwork as defined in ARINC Specification 631. The ISO 8208 layer is not operated within AOA, but some services specific to AOA to be provided by AVLC are also identified (a specific function of AOA is to interface to ACARS 618 and not to the VDL 8208 subnetwork layer).

AOA thus interfaces directly with AVLC/VME, and uses the services provided by AVLC (connection oriented frame transfer), and those provided by VME/LME (VDL Mode 2 link management).

COMMENTARY

The VDL Mode 2 provisions defined in ARINC Specification 631 will be extended to service ATN. Therefore commonality between operation (AOA and ATN) should be ensured. Simultaneous operations in AOA with one service provider and in ATN with another should be possible. Therefore, the AVLC options defined or negotiated for AOA operations should be compatible with ATN operation. See ARINC Specification 631 for more details.

11.7.1 Conditions for Proper Operation of AOA

The following AVLC parameters support proper VHF AOA operation:

1. Frame size (N1-downlink and N1-uplink as defined in ARINC Specification 631).

   Frame size is variable and can be negotiated between airborne and ground AVLCs. The frame size ranges from 1144 bits to 16504 bits with a default value of 8312 bits. Proper operation of VHF AOA expects the N1 parameter to be set at least to 2008 bits (251*8, i.e., the maximum current ACARS block size: 220 characters of free text). Smaller N1 values may result in lower performances than currrent ACARS subnetworks.

   Bigger N1 values can be set for VHF AOA operation. N1 should be adjusted by the service providers depending on the environment (frequency occupancy, number of stations, etc.).

   The VHF AOA is informed by AVLC of the N1 values applicable to the current link and uses this information to properly insert downlink messages into AVLC frames.

   In the case where N1 is under the minimum acceptable value, the ACARS VHF Manager may decide to stop AOA/AVLC operations and eventually switch back to VHF ACARS.

2. Expedited subnetwork connection

   There is no subnetwork function in AOA. Therefore, the capability to expedite the subnetwork connection does not exist. The VHF AOA protocol should wait for completion of a handoff before sending a Q0 downlink.

3. VDL Mode 2 subnetwork specific ground DTE address.

   The VDL Mode 2 subnetwork specific ground DTE address field is not used for AOA. Selection of the service provider is only performed according to the value of the service provider ID.

4. AVLC specific options

   AOA operation is selected if the AOA bit (bit 6 of AVLC specific options parameters) is set to 1 (in both Ground and Airborne XID frames).

   AVLC determines if this condition is met before establishing the connection with the ground.

11.7.2 Services Provided by AVLC/VME

These services are divided into two main categories, Data transfer services and VDL Mode 2 Link management services.

VHF AOA uses the frame exchange services to exchange AOA frames with the ground DSP and the VDL Mode 2 link management services to determine when operations over AVLC are possible or not, and which actions should be undertaken if the link is not available (See VHF frequency management, Section 5.6).

VDL Mode 2 subnetwork (AVLC and VME/LME) should provide the following services to VHF AOA.

11.7.2.1 Data Transfer Services

11.7.2.1.1 Downlink Request

This service allows the transmission by AVLC of a downlink frame.

11.7.2.1.2 Uplink Indication

This service allows delivery of valid uplink frames to the VHF AOA.

11.7.2.2 VDL Mode 2 Link Management Services

VHF AOA uses the services described hereafter to manage the AOA (VDL Mode 2) logical link.

COMMENTARY

Management of the VHF frequency/service provider's selection is implementation specific and may be allocated to the VME/LME and/or ACARS VHF management function.

11.7.2.2.1 VDL Service Start Up Request

Activation of this service allows the VME to initialize the VDL Mode 2 service.

11.7.2.2.2 VDL Link Establishment Indication

AVLC/VME informs VHF AOA that communication is now possible on an established VDL Mode 2 link. This service is activated upon initial AVLC link establishment.

The primitive associated with this service may convey the negotiated N1 values for uplinks and downlinks and the active service provider.

11.7.3 VDL Ground Station Switch Indication

AVLC/VME informs the VHF AOA that a handoff was performed on an established VDL Mode 2 link. The primitive associated with this service conveys the negotiated N1 values for uplinks and downlinks.

11.7.4 VDL Service Unavailable Indication

AVLC/VME can inform the VHF AOA, through this service, of the non-availability of the VDL Mode 2 service.

COMMENTARY

AVLC should specify the cause of the non-availability, in order to allow the ACARS-VHF manager to decide to switch back to ACARS or to stay in VDL Mode 2.

Possible causes of service disruption include link disconnected (DISC frame received, no handoff possible, no activity from ground stations, etc.

11.7.4.1 VDL Service Shutdown Request

This service allows complete shutdown of the VDL Mode 2 function.

11.7.5 AOA Channel Management

Refer to Figure 18-7 of Attachment 18 for a block diagram depicting the AOA Channel Management process.

VHF AOA uses the above-specified services to:

1. Determine when AVLC is available for data transfer
2. Determine when AVLC is not available to indicate a NO COMM condition
3. Disconnect VDL Mode 2 and switch back to VHF ACARS.

11.7.5.1 Start VDL Operation

When the ACARS VHF management function activates VDL Mode 2 VHF, AOA should activate ‘VDL service start up request’, then enter VDL acquisition state.

If the ACARS VHF management function switches back to ACARS VHF, then VHF AOA should go to ‘End VDL operation’ state.

11.7.5.2 VDL Acquisition

When in VDL Acquisition State, VHF AOA should wait for ‘Permission to Send’ (see Section 11.7.5.6 for a definition of permission to send) before entering the Logical channel establishment state and being able to transfer AOA frames by using the frame exchange services.

The VDL VME may try to contact one or several VDL service providers before the AVLC link is successfully established. If a NOCOMM caused the VHF AOA to go back to the ‘VDL Acquisition’ state, the ACARS VHF manager may decide:

1. To try to establish a link with another VDL service provider. When the link is established, then ‘Permission to send’ is granted (see Section 11.7.6).
2. To reestablish the link with the same service provider when Permission to send is granted.

3. To stay logged on (if the link is still available) to the same VDL service provider and try to reestablish the AOA link.

If the ACARS VHF management function switches back to ACARS VHF, then the VHF AOA should go to ‘End VDL Operation’ state.

11.7.5.3 AOA Logical Channel Establishment

When ‘Permission to Send’ (see Section 11.7.5.6) is granted or if a VDL Mode 2 ground station switch indication (VHF ground station handoff) is reported by AVLC, the VHF AOA should try to establish an AOA logical link by sending a Q0 label or any pending downlink. When this downlink is acknowledged, VHF AOA should consider that the AOA logical channel is established and enter Logical channel maintenance.

Upon ‘NO COMM’ condition (see Section 11.7.6), VHF AOA should go back to VDL acquisition state.

If the ACARS VHF management function switches back to ACARS VHF, then VHF AOA should activate ‘VDL link disconnect request’, and go to the ‘End VDL operation’ state when the VDL service is declared unavailable.

COMMENTARY

A logical channel is re-established every time the ground station, to which the AVLC/LME is connected, changes.

11.7.5.4 AOA Logical Channel Maintenance

The AOA link is available for transmission/reception of ACARS blocks when entering ‘logical channel maintenance’ state.

AOA may send a media advisory downlink (only when entering ‘Logical Channel Maintenance’ upon ‘Permission to Send’) to indicate to the service provider that the VDL Mode 2 medium is available for data transfer.

VHF AOA can thus exchange AOA blocks with the service provider by using Data transfer services provided by AVLC.

Upon NO COMM condition (see Section 11.7.6), VHF AOA should go back to ‘VDL acquisition’ state.

If a ground station switch indication is reported, VHF AOA should go back to ‘logical channel establishment’ state.

If the VHF frequency management function switches back to VHF ACARS, then VHF AOA should activate ‘VDL link disconnect request’, and go to ‘End VDL operation’ state when the VDL service is declared unavailable.

11.7.5.5 End VDL Operation

VDL Mode 2 operations are terminated. VHF AOA activates the ‘VDL service shutdown request’.

11.7.5.6 Permission to Send

Prior to any AOA downlink transmission, the CMU should receive 'Permission to send' to ensure the transmission on an authorized AVLC link for data communications.

Permission to send is provided automatically when:

AOA receives an indication from AVLC that VDL Mode 2 link status changes from 'not established' to 'Established'.

Permission to send is also provided when:

1. Upon manual request from the aircrew (optionally)
2. An error free uplink is received
3. Other options are possible.

11.7.6 NO COMM

A number of events result in AOA declaring to the ACARS router that it is in a NO COMM situation.

COMMENTARY

> Upon NO COMM situation, the ACARS router may decide to route downlink messages to alternate media (HF or SATCOM).

The state is considered to be 'IN COMM' when a downlink has been acknowledged (after permission to send has been granted). This is a precursor to entry into 'logical channel maintenance state'.

A NO COMM is declared when:

1. The max number of retries at VHF AOA level is exceeded for a given downlink (Transmission counter VAC1 expires) without acknowledgment.
2. The VDL service is declared unavailable due to link disconnection (by the AVLC layer or consecutive to a 'VDL service shutdown request from ACARS-VHF manager). This link disconnection can be accidental or may result from a decision of the ACARS VHF manager to change VDL service provider.
3. VDR is declared as failed.
4. VHF is in Voice mode.
5. VDR Label 270 data word Bits 11 and 14 indicate that the VDR is not in the 'Protocol Set' state (as defined in ARINC Specification 750).

ATTACHMENT 1
AIR/GROUND COMMUNICATIONS

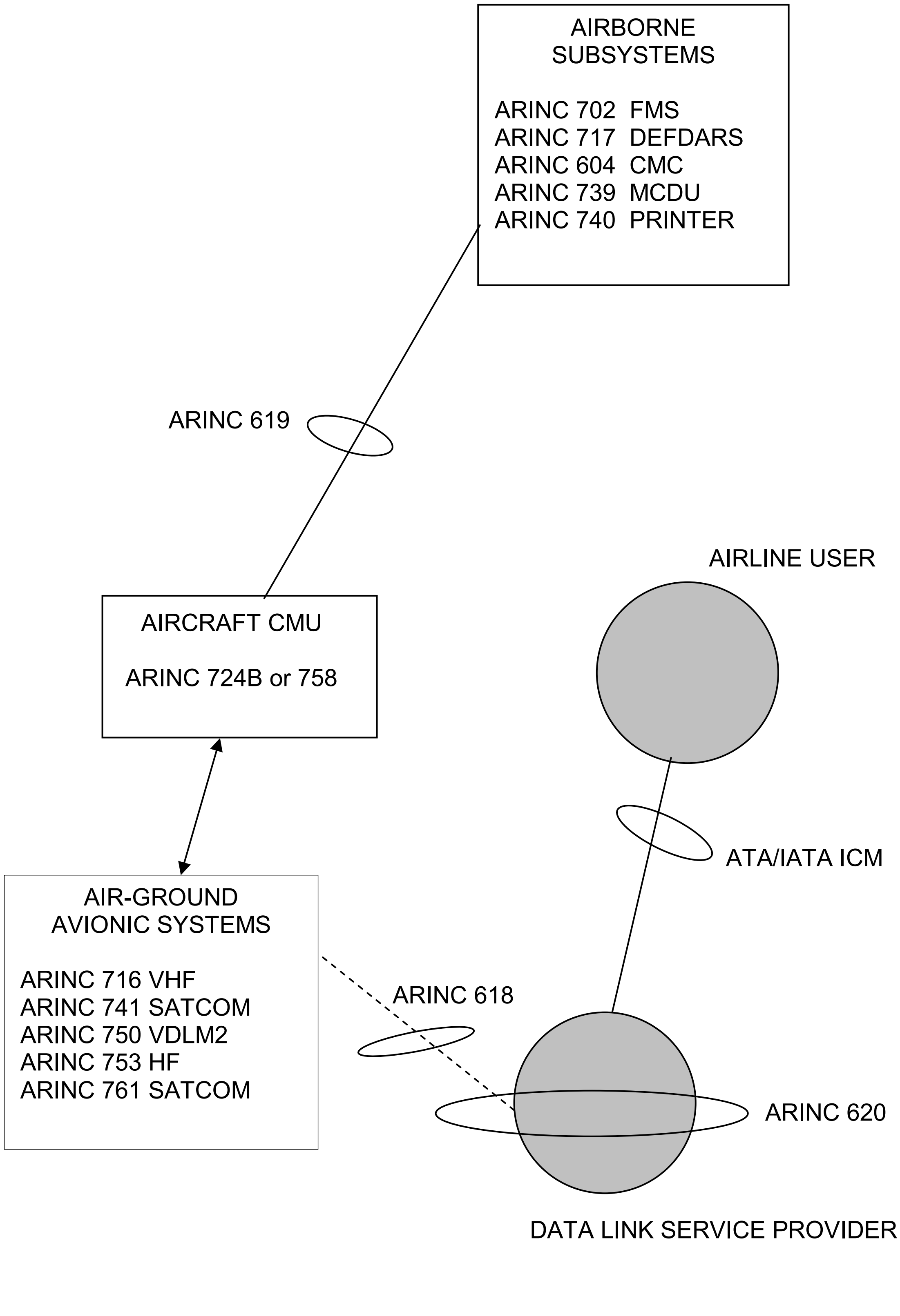


Figure 1-1 ACARS Documentation

ATTACHMENT 2
FREQUENCY MANAGEMENT DIAGRAMS

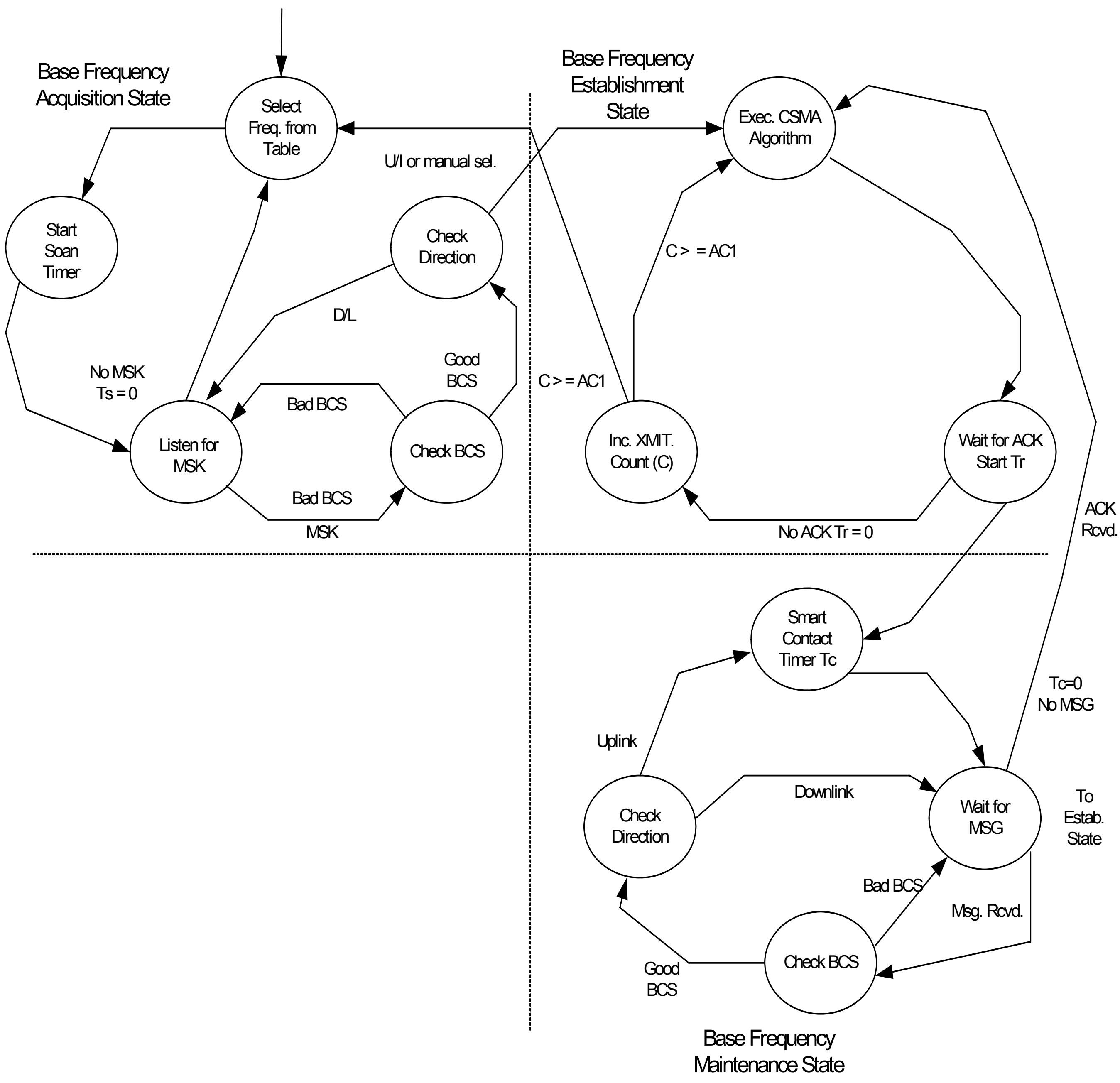
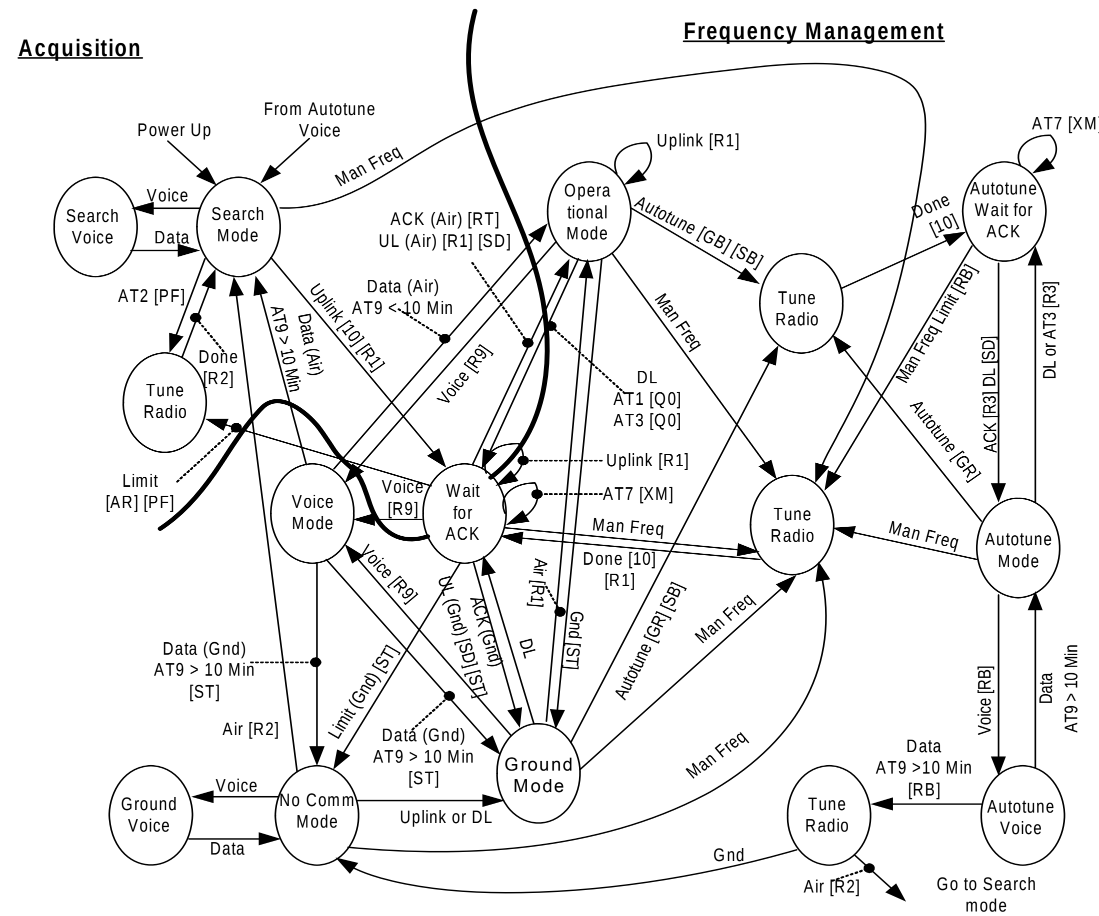


Figure 2-1 – Simplified State Program

ATTACHMENT 2
FREQUENCY MANAGEMENT DIAGRAMS



ACTIONS

[10] Generate downlink
[Rn] Reset ATn Timer
[GR] Send General Response
[XM] Xmit Msg. Reset AT7, Increment Retry Counter
[SB] Save Base Frequency
[RB] Restore Base Frequency
[PF] Pick Frequency from Table
[SD] Save Current Downlink (Q0 is not saved)
[ST] Stop AT1 and AT3 Timers

DEFINITIONS

AT1: Contact Timer
AT2: Scan Timer
AT3: Tracker Timer
AT7: No ACK Timer
AT9: Voice Mode Timer
Air: Airplane is Airborne
Gnd: Airplane is on the ground
DL: Dowlink to Send
UL: Uplink for Aircraft

Voice: Select Voice Mode
Data: Select Data Mode
Man Freq: Manual Frequency Changes
Uplink: Any Uplink with Valid BCS
ACK: Uplink for aircraft with ACK
Autotune: Autotune uplink
Limit: AT7 Retry Timer Expires and Retry Counter Limit

Note: This example is not fully comprehensive. Many other state diagram configurations could be delveloped to satisfy the provisions of this specification in response to the stated desire of the user.

Figure 2-2 – Example State Diagram

ATTACHMENT 2
FREQUENCY MANAGEMENT DIAGRAMS

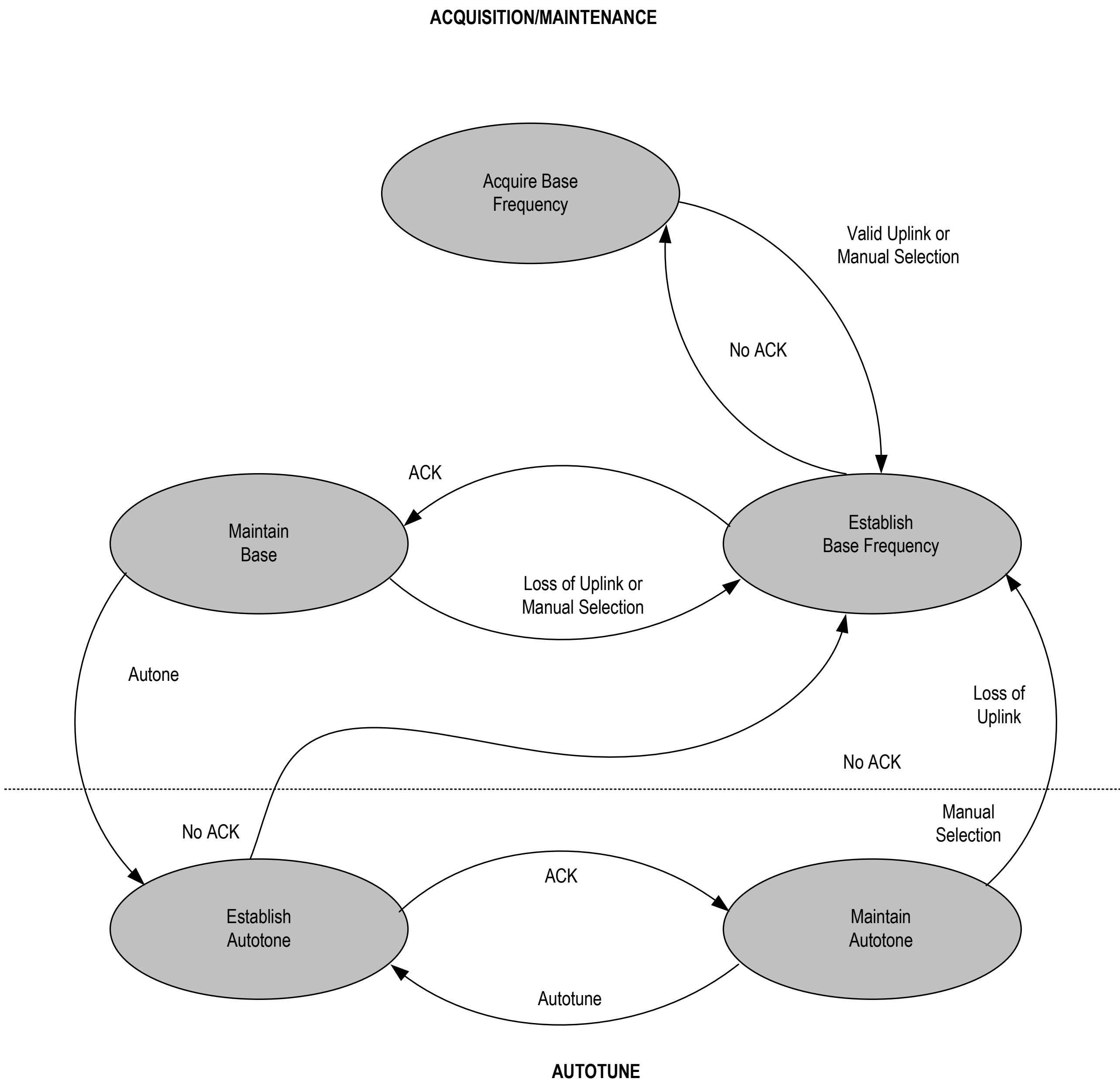


Figure 2-3 – Base Frequency

ATTACHMENT 2
FREQUENCY MANAGEMENT DIAGRAMS

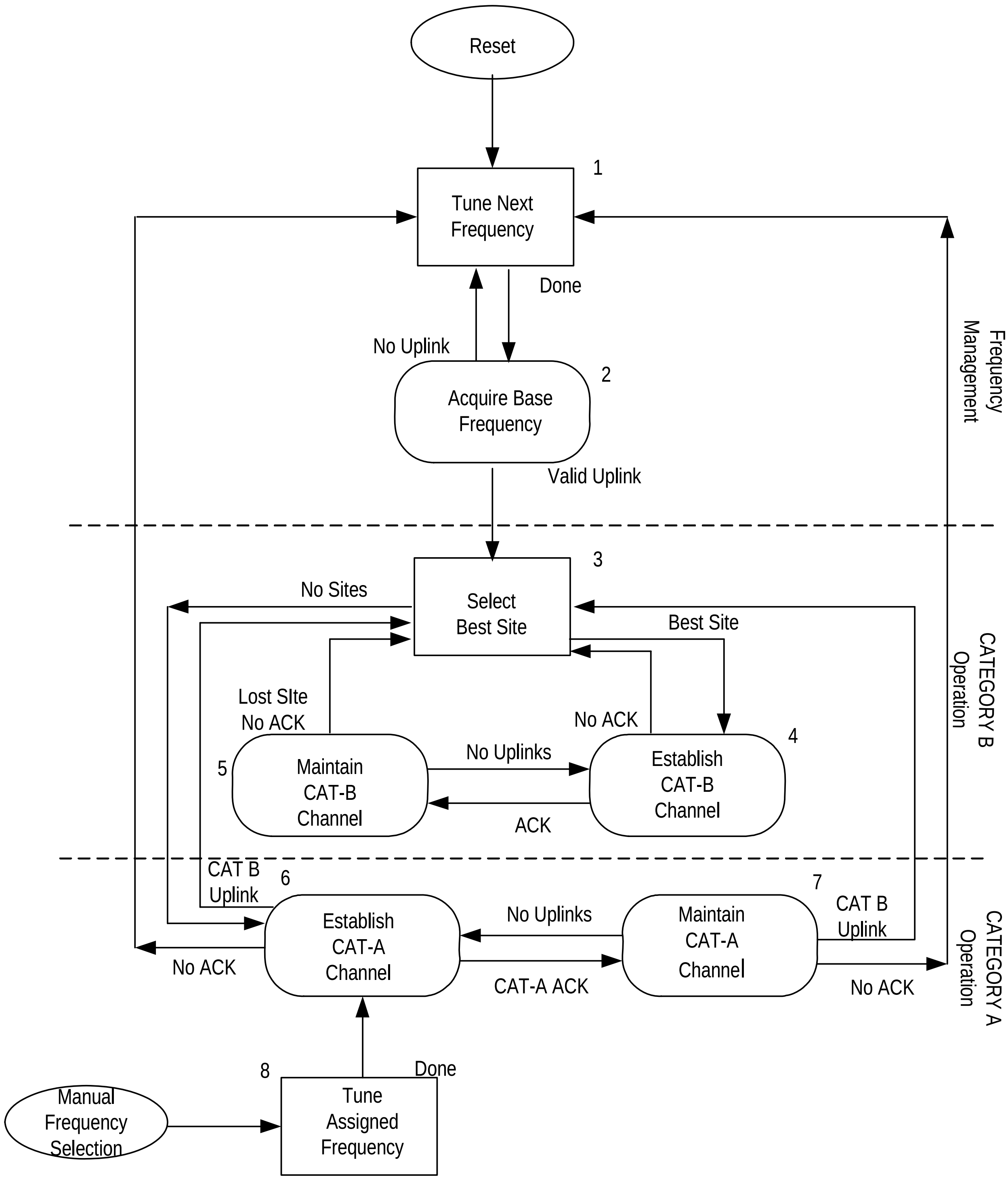


Figure 2-4 – Logical Channel Management

1. <u>TUNE NEXT FREQUENCY</u>

Command the transceiver to tune to the next frequency found in the user-defined primary frequency table. Go to 2.

2. <u>ACQUIRE BASE FREQUENCY</u>

Listen for a valid uplink.

Go to 3 if valid uplink detected.

Go to 1 if none detected after Timer AT2 expires.

3. <u>SELECT BEST SITE</u>

Evaluate reception performance of each ground station site.

Go to 4 with best site.

Go to 6 if no sites are acceptable.

4. <u>ESTABLISH CAT-B CHANNEL</u>

Transmit a message in queue or link test using selected site for mode character and wait for acknowledgment.

Retransmit at AT7 intervals until acknowledgment is received.

Go to 5 when ACK received.

Go to 3 after AC1 attempts have failed.

5. <u>MAINTAN CAT-B CHANNEL</u>

Normal Category B operation.

Go to 3 if no ACK received for a message after AC1 attempts, or if timer AT2 expires due to lack of uplink traffic from selected site.

Go to 4 (optional) if timer AT1 expires due to lack of any uplink traffic.

6. <u>ESTABLISH CAT-A CHANNEL</u>

Transmit a message in queue or link test using mode character “2” and wait for acknowledgment.

Retransmit up to AC1 times at AT7 intervals until acknowledgment is received.

Go to 7 when CAT-A ACK received (Mode Char “2”).

Go to 3 if acceptable Category B uplink detected.

Go to 1 after AC1 attempts have failed.

7. <u>MAINTAIN CAT-A CHANNEL</u>

Normal Category A operation.

Go to 1 if no ACK received for a message after AC1 attempts.

Go to 3 if acceptable Category B uplink detected.

Go to 6 (optional) if timer AT1 expires due to lack of uplink traffic.

Go to 8 if uplink autotune command received.

8. <u>TUNE ASSIGNED FREQUENCY</u>

Enter this state directly when frequency manually entered.

Command the transceiver to tune to the assigned frequency.

Go to 6.

Figure 2-4a – Logical Channel Management State Description

ATTACHMENT 3
ISO 5 CHARACTERS

Table 3-1 – Limits to ASCII (ISO #5) Code Set

BIT 7-------------------------------------->					**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**
BIT 6-------------------------------->					**0**	**0**	**1**	**1**	**0**	**0**	**1**	**1**
BIT 5----------------------->					**0**	**1**	**0**	**1**	**0**	**1**	**0**	**1**
BIT 4	BIT 3	BIT 2	BIT 1	Col → Row ↓	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
0	0	0	0	**0**	00 NUL	10 DLE	20 SP	30 0	40 @	50 P	60 `	70 p
0	0	0	1	**1**	01 SOH	11 DC1	21 !	31 1	41 A	51 Q	61 a	71 q
0	0	1	0	**2**	02 STX	12 DC2	22 "	32 2	42 B	52 R	62 b	72 R
0	0	1	1	**3**	03 ETX	13 DC3	23 1 #	33 3	43 C	53 S	63 c	73 s
0	1	0	0	**4**	04 EOT	14 DC4	24 $	34 4	44 D	54 T	64 d	74 t
0	1	0	1	**5**	05 ENQ	15 NAK	25 %	35 5	45 E	55 U	65 e	75 u
0	1	1	0	**6**	06 ACK	16 SYN	26 &	36 6	46 F	56 V	66 f	76 v
0	1	1	1	**7**	07 BEL	17 ETB	27 '	37 7	47 G	57 W	67 g	77 w
1	0	0	0	**8**	08 BS	18 CAN	28 (	38 8	48 H	58 X	68 h	78 x
1	0	0	1	**9**	09 HT	19 EM	29)	39 9	49 I	59 Y	69 i	79 y
1	0	1	0	**10**	0A LF	1A SUB	2A *	3A :	4A J	5A Z	6A j	7A z
1	0	1	1	**11**	0B VT	1B ESC	2B +	3B ;	4B K	5B [	6B k	7B {
1	1	0	0	**12**	0C FF	1C FS	2C ,	3C <	4C L	5C \	6C l	7C ¦
1	1	0	1	**13**	OD CR	1D GS	2D -	3D =	4D M	5D]	6D m	7D }
1	1	1	0	**14**	0E SO	1E RS	2E 1 .	3E >	4E N	5E ^	6E n	7E ~
1	1	1	1	**15**	0F SI	1F US	2F 1 /	3F ?	4F O	5F _	6F o	7F 4 DEL

Hex value → 04 ← Note

Character → EOT

Shading indicates that the character is not recommended in the Free Text portion of either Uplink or Downlink Messages.

Notes:

1. See Section 2.2.8 for guidance on usage.
2. The ESC character will pass through the SITA network.
3. The BEL character will pass through the ARINC network.
4. The DEL character is reserved.

ATTACHMENT 3
ISO 5 CHARACTERS

Table 3-2 – Baudot Character Set

BIT 4	BIT 3	BIT 2	BIT 1	Col → Row ↓	0	1	2	3	4	5	6	7
BIT 7					0	0	0	0	1	1	1	1
BIT 6					0	0	1	1	0	0	1	1
BIT 5					0	1	0	1	0	1	0	1
0	0	0	0	**0**	00 NUL	10 DLE	20 SP	30 0	40 @	50 P	60 `	70 p
0	0	0	1	**1**	01 SOH	11 DC1	21 !	31 1	41 A	51 Q	61 a	71 q
0	0	1	0	**2**	02 STX	12 DC2	22 "	32 2	42 B	52 R	62 b	72 R
0	0	1	1	**3**	03 ETX	13 DC3	23 [1] #	33 3	43 C	53 S	63 c	73 s
0	1	0	0	**4**	04 EOT	14 DC4	24 $	34 4	44 D	54 T	64 d	74 t
0	1	0	1	**5**	05 ENQ	15 NAK	25 %	35 5	45 E	55 U	65 e	75 u
0	1	1	0	**6**	06 ACK	16 SYN	26 &	36 6	46 F	56 V	66 f	76 v
0	1	1	1	**7**	07 BEL	17 ETB	27 ´	37 7	47 G	57 W	67 g	77 w
1	0	0	0	**8**	08 BS	18 CAN	28 (	38 8	48 H	58 X	68 h	78 x
1	0	0	1	**9**	09 HT	19 EM	29)	39 9	49 I	59 Y	69 i	79 y
1	0	1	0	**10**	0A LF	1A SUB	2A *	3A :	4A J	5A Z	6A j	7A z
1	0	1	1	**11**	0B VT	1B ESC	2B +	3B ;	4B K	5B [	6B k	7B {
1	1	0	0	**12**	0C FF	1C FS	2C ,	3C <	4C L	5C \	6C l	7C ¦
1	1	0	1	**13**	OD CR	1D GS	2D -	3D =	4D M	5D]	6D m	7D }
1	1	1	0	**14**	0E SO	1E RS	2E [1] .	3E >	4E N	5E ^	6E n	7E ~
1	1	1	1	**15**	0F SI	1F US	2F [1] /	3F ?	4F O	5F _	6F o	7F [4] DEL

Hex value → 04 ← Note
Character → EOT

Shading indicates that the character is not recommended in the Free Text portion of either Uplink or Downlink Messages.

Notes:

1. See Section 2.2.8 for guidance on usage.
2. The ESC character will pass through the SITA network.
3. The BEL character will pass through the ARINC network.
4. The DEL character is reserved.

ATTACHEMENT 4
MULTIBLOCK TIMING DIAGRAMS

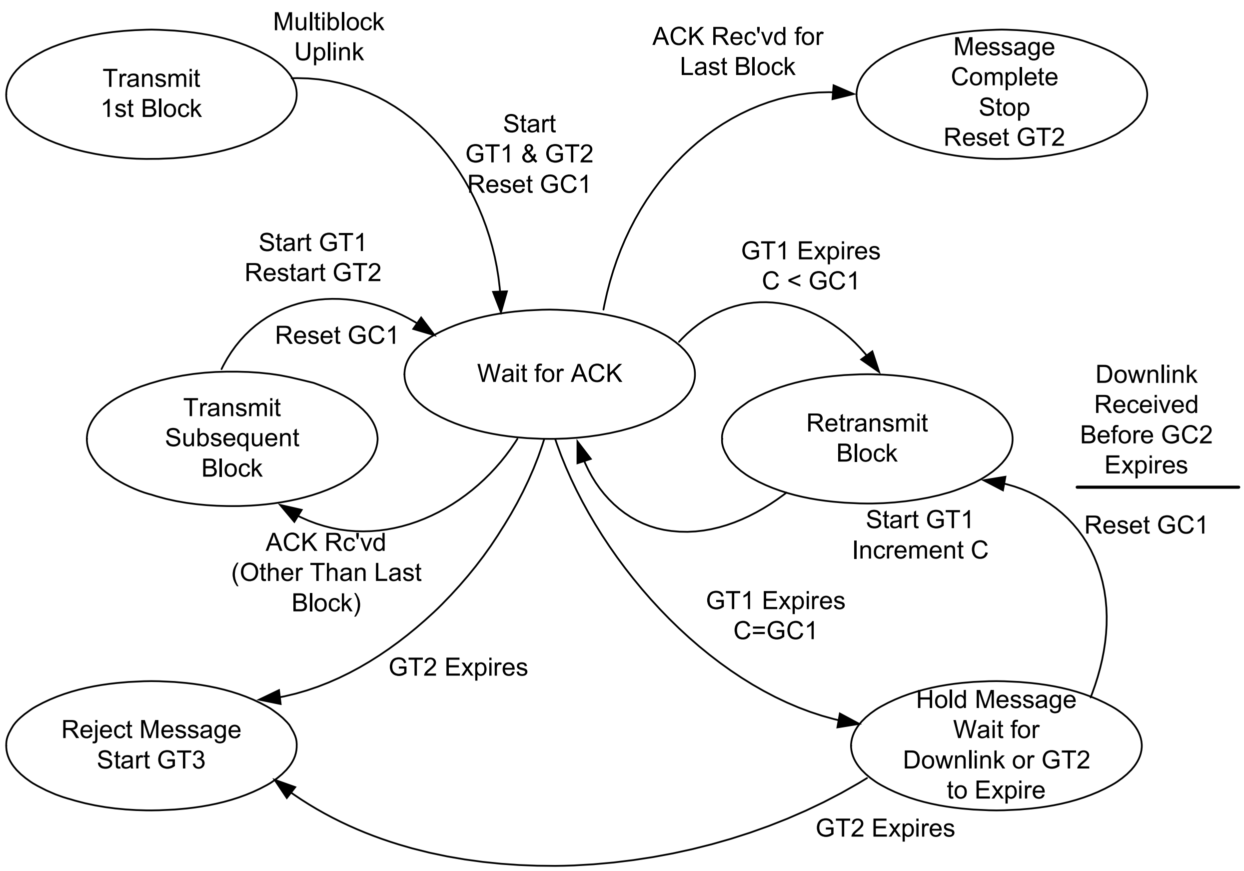


Figure 4-1 - Ground-Based Timers for Multiblock Uplinks

ATTACHMENT 4
MULTIBLOCK TIMING DIAGRAMS

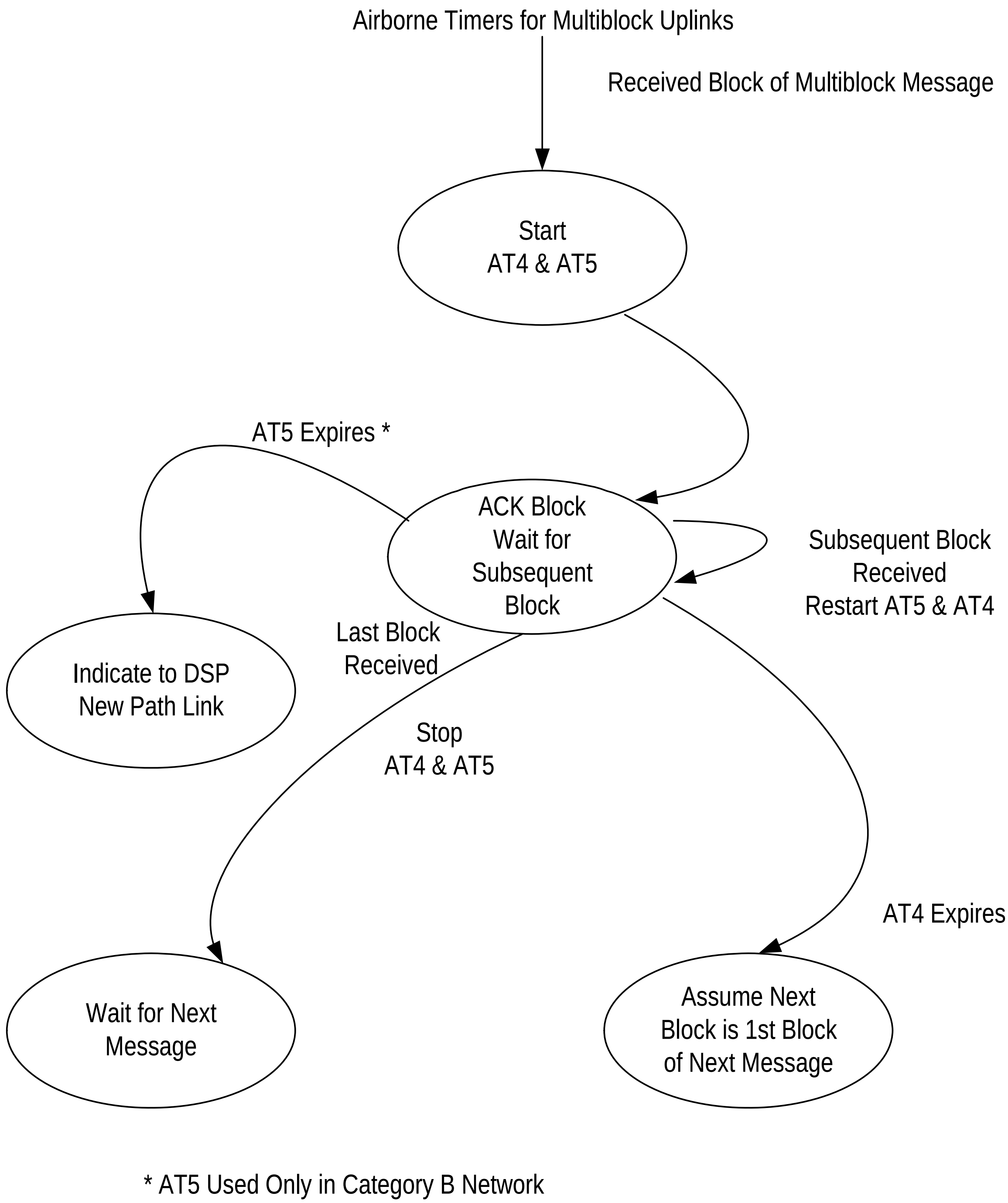


Figure 4-2 – Airborne Timers for Multiblock Uplinks

ATTACHEMENT 4
MULTIBLOCK TIMING DIAGRAMS

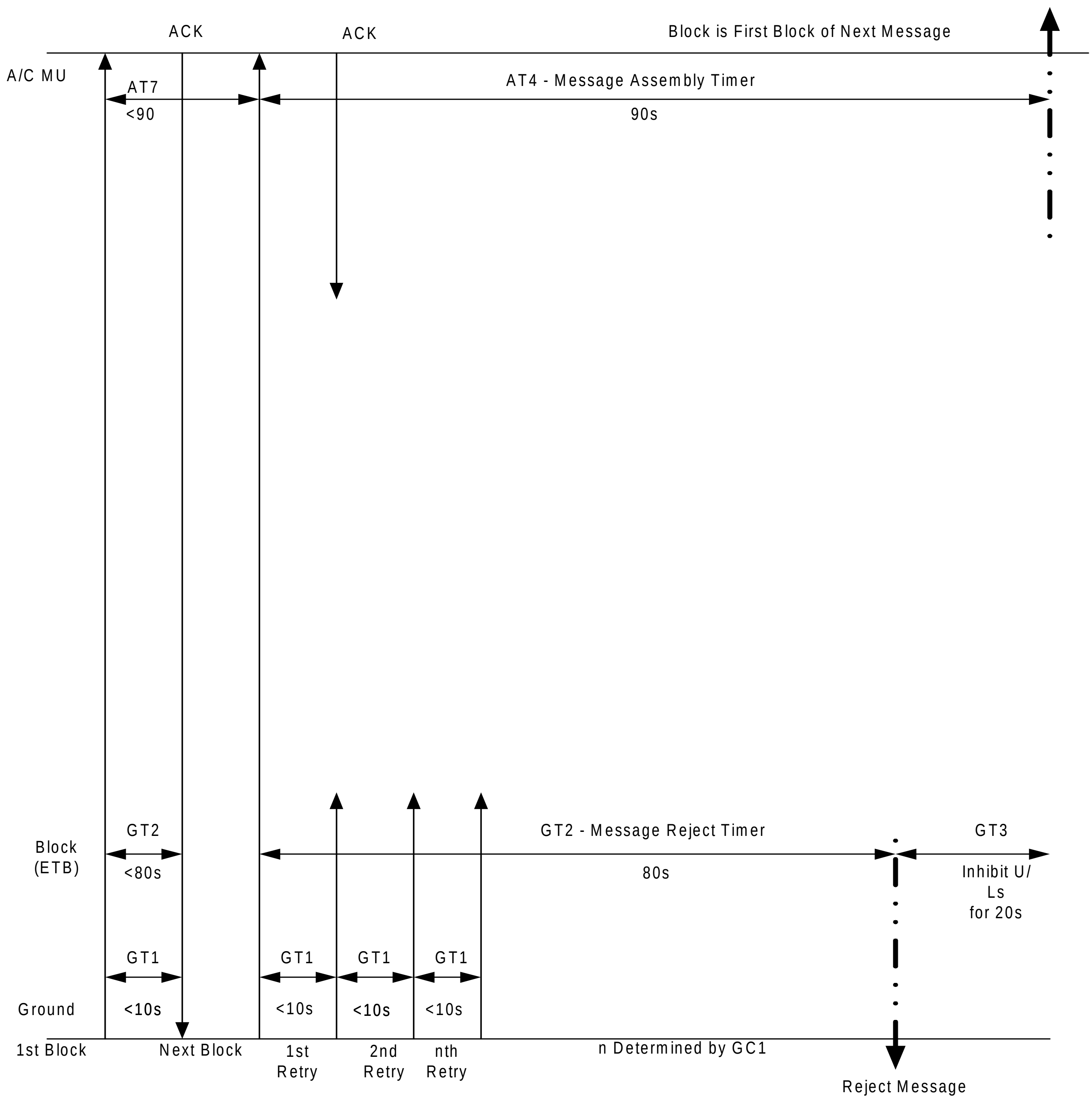


Figure 4-3 – Category A VHF Multiblock Uplink Procedure

ATTACHMENT 4
MULTIBLOCK TIMING DIAGRAMS

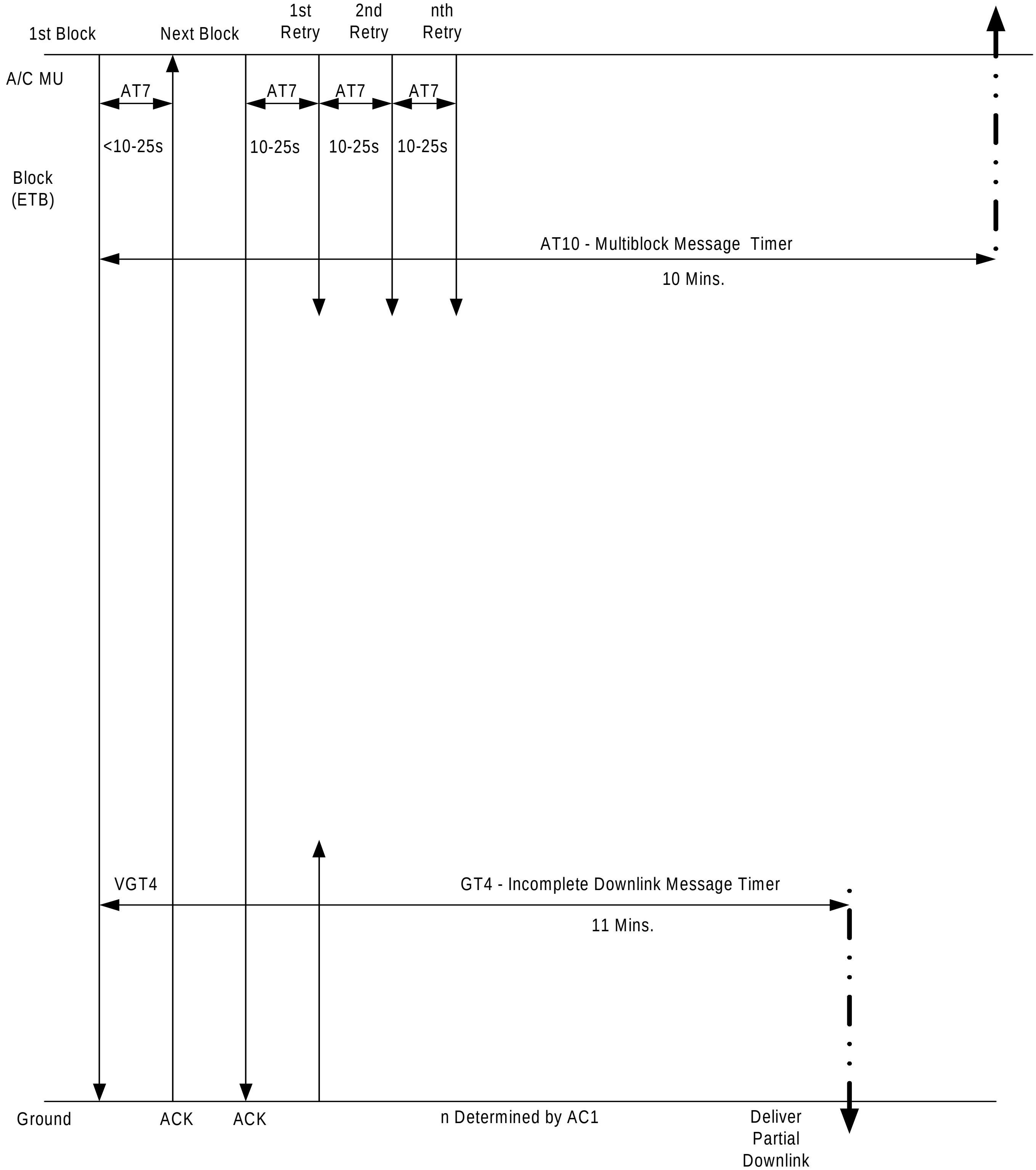


Figure 4-4 – Category A VHF Multiblock Downlink Procedure

ATTACHEMENT 4
MULTIBLOCK TIMING DIAGRAMS

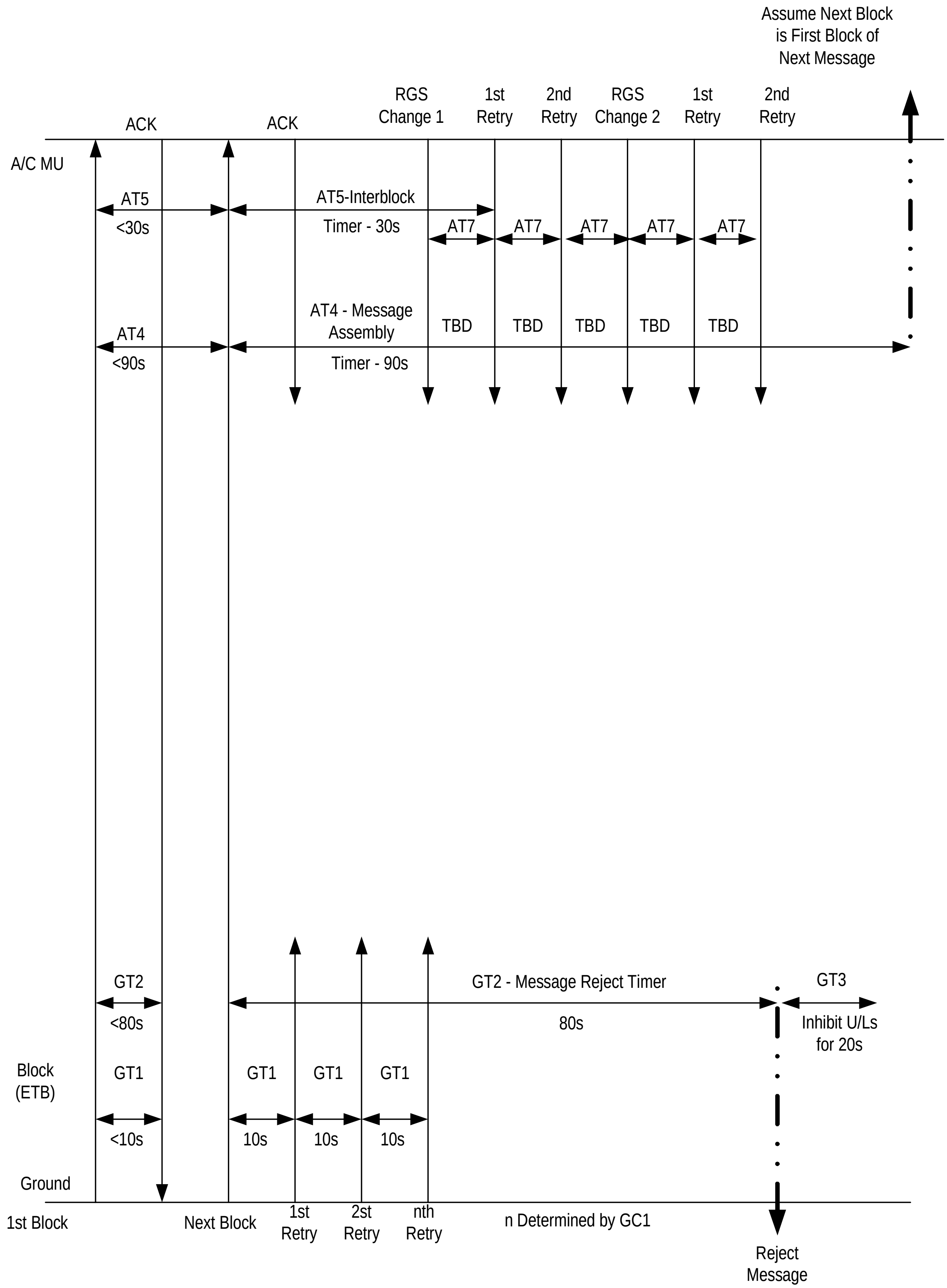


Figure 4-5 – Category B VHF Multiblock Uplink Procedure

ATTACHMENT 4
MULTIBLOCK TIMING DIAGRAMS

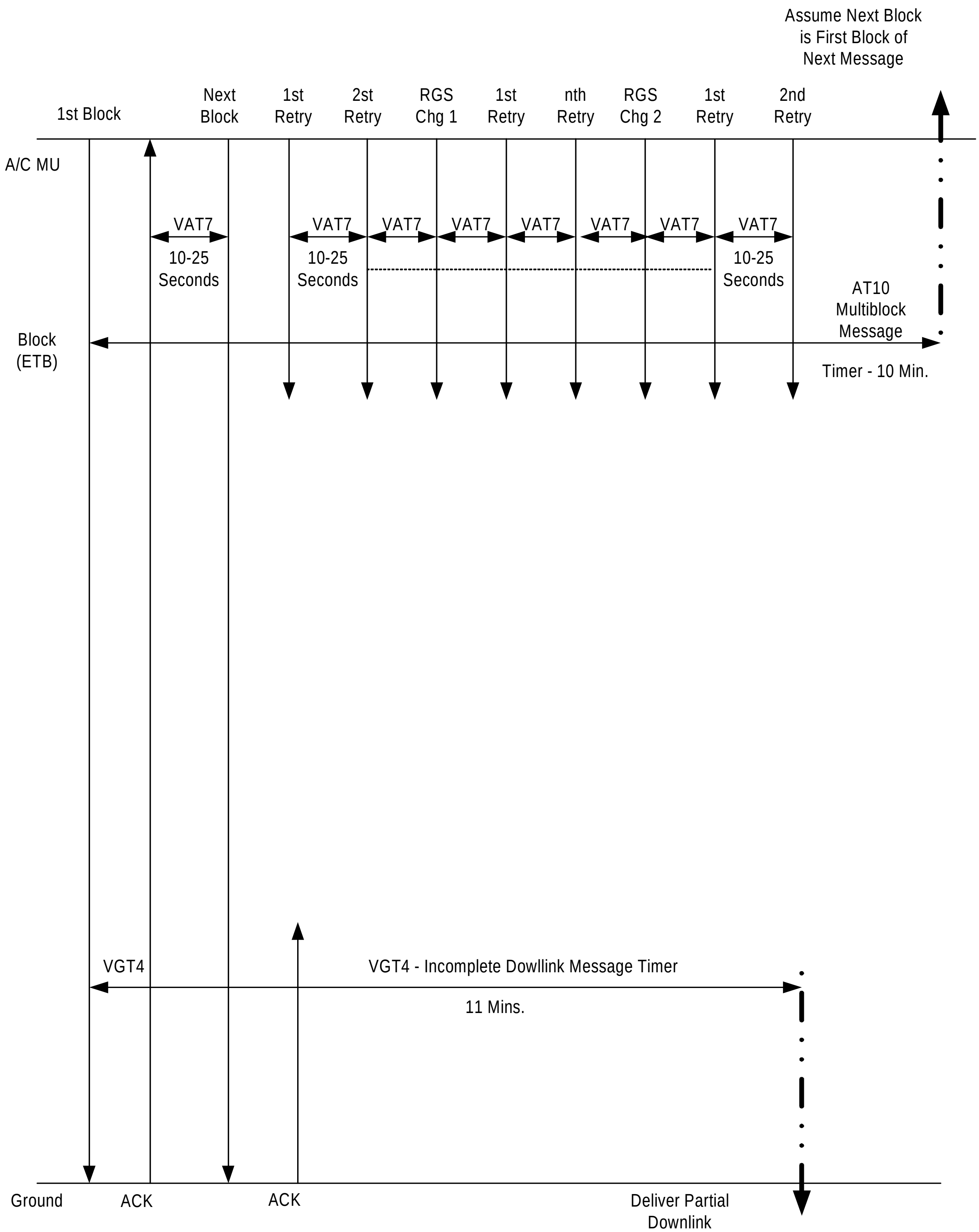


Figure 4-6 – Category B VHF Multiblock Downlink Procedure

ATTACHEMENT 4
MULTIBLOCK TIMING DIAGRAMS

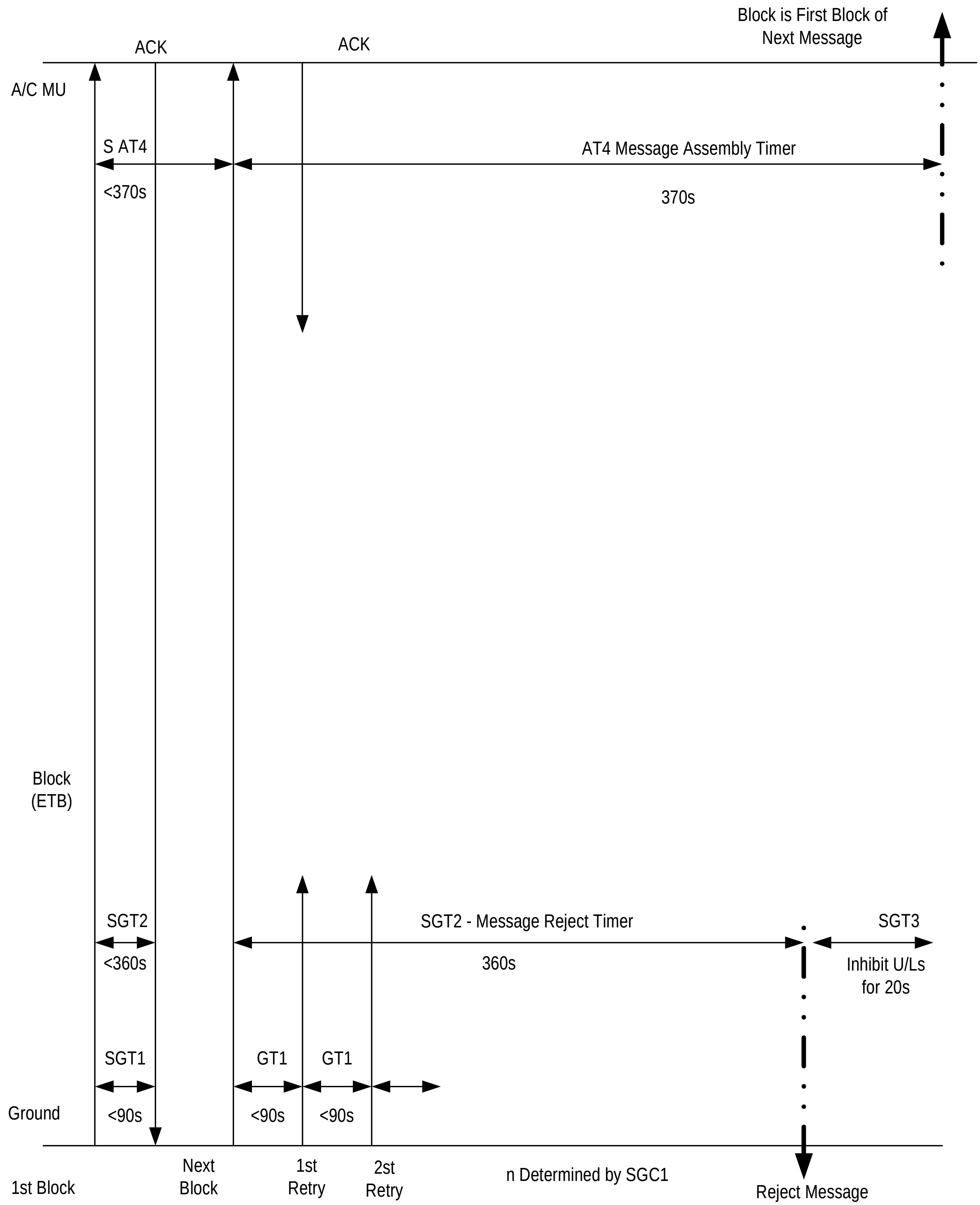


Figure 4-7 – SATCOM Uplink Procedure

ATTACHMENT 4
MULTIBLOCK TIMING DIAGRAMS

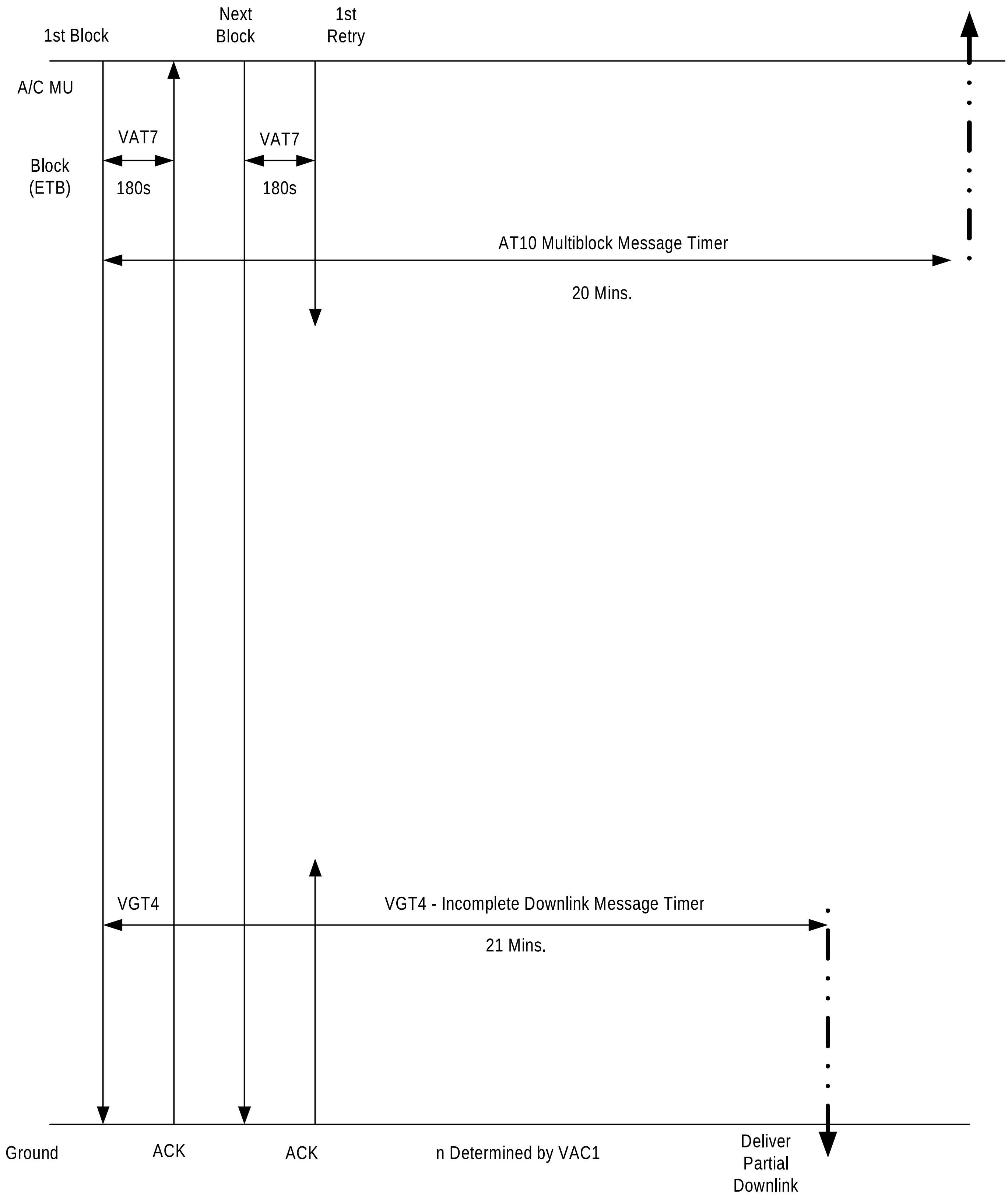


Figure 4-8 – SATCOM Multiblock Downlink Procedure

ATTACHMENT 5
MSK WAVEFORMS

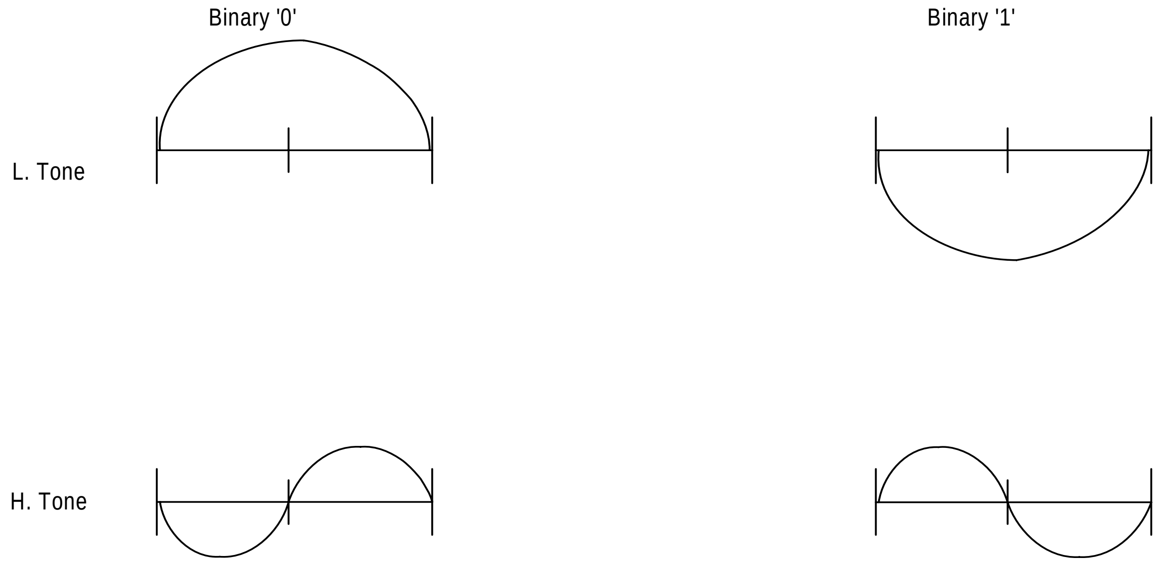


Figure 1 – Sub-Carrier Signal Types

Bit Order	1	2	3	4	5	6	7	8	9	10	11
Message	0	1	0	0	1	1	1	0	0	1	0

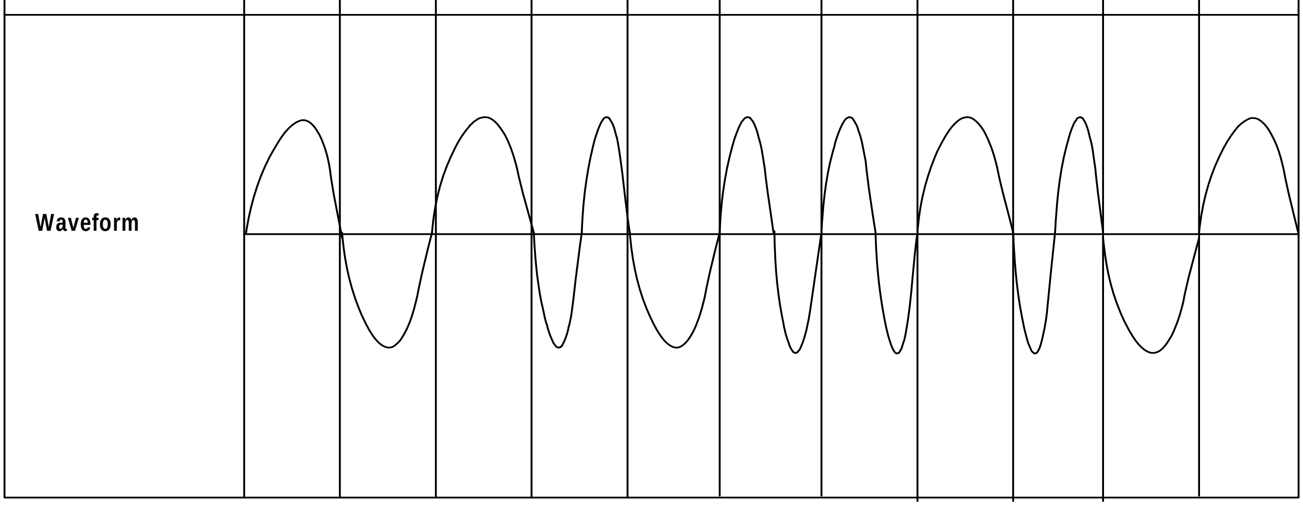


Figure 2 – Encoded Sub-Carrier Waveform

ATTACHMENT 6
MODE CHARACTER

CATEGORY A

0 0 1 1 0 0 1 0 ISO code "2"
Transmitted bi-directional
No Preferred Air/Ground Data Path Selected

CATEGORY B - CATEGORY B MODE CHARACTER SET

AIR TO GROUND	ISO #5	GROUND TO AIR	ISO #5	ACCESS CODE	SATELLITE
(bit pattern) 8 7 6 5 4 3 2 1	CODE (CHAR)	(bit pattern) 8 7 6 5 4 3 2 1	CODE (CHAR)	LOGICAL PATH (GROUND STATION)	SERVICE PROVIDER
0 1 0 0 0 0 0 0	@	1 1 1 0 0 0 0 0	`	#0	
1 1 0 0 0 0 0 1	A	0 1 1 0 0 0 0 1	a	#1	ARINC
1 1 0 0 0 0 1 0	B	0 1 1 0 0 0 1 0	b	#2	
0 1 0 0 0 0 1 1	C	1 1 1 0 0 0 1 1	c	#3	AIR CANADA
1 1 0 0 0 1 0 0	D	0 1 1 0 0 1 0 0	d	#4	
0 1 0 0 0 1 0 1	E	1 1 1 0 0 1 0 1	e	#5	
0 1 0 0 0 1 1 0	F	1 1 1 0 0 1 1 0	f	#6	
1 1 0 0 0 1 1 1	G	0 1 1 0 0 1 1 1	g	#7	
1 1 0 0 1 0 0 0	H	0 1 1 0 1 0 0 0	h	#8	
0 1 0 0 1 0 0 1	I	1 1 1 0 1 0 0 1	i	#9	
0 1 0 0 1 0 1 0	J	1 1 1 0 1 0 1 0	j	#10	AVICOM
1 1 0 0 1 0 1 1	K	0 1 1 0 1 0 1 1	k	#11	
0 1 0 0 1 1 0 0	L	1 1 1 0 1 1 0 0	l	#12	ALLIEDSIGNAL
1 1 0 0 1 1 0 1	M	0 1 1 0 1 1 0 1	m	#13	
1 1 0 0 1 1 1 0	N	0 1 1 0 1 1 1 0	n	#14	
0 1 0 0 1 1 1 1	O	1 1 1 0 1 1 1 1	o	#15	
1 1 0 1 0 0 0 0	P	0 1 1 1 0 0 0 0	p	#16	
0 1 0 1 0 0 0 1	Q	1 1 1 1 0 0 0 1	q	#17	
0 1 0 1 0 0 1 0	R	1 1 1 1 0 0 1 0	r	#18	
1 1 0 1 0 0 1 1	S	0 1 1 1 0 0 1 1	s	#19	SITA
0 1 0 1 0 1 0 0	T	1 1 1 1 0 1 0 0	t	#20	
1 1 0 1 0 1 0 1	U	0 1 1 1 0 1 0 1	u	#21	
1 1 0 1 0 1 1 0	V	0 1 1 1 0 1 1 0	v	#22	
0 1 0 1 0 1 1 1	W	1 1 1 1 0 1 1 1	w	#23	
0 1 0 1 1 0 0 0	X	1 1 1 1 1 0 0 0	x	#24	
1 1 0 1 1 0 0 1	Y	0 1 1 1 1 0 0 1	y	#25	
1 1 0 1 1 0 1 0	Z	0 1 1 1 1 0 1 0	z	#26	
0 1 0 1 1 0 1 1	[	1 1 1 1 1 0 1 1	{	#27	
1 1 0 1 1 1 0 0	\	0 1 1 1 1 1 0 0	|	#28	
0 1 0 1 1 1 0 1	]	1 1 1 1 1 1 0 1	}	#29	

Figure 6-1 – Mode Character Sets

ATTACHMENT 7
VOICE/DATA NOTIFICATION

AUTO/MAN	DEDICATED/ SHARED RADIO	MU ACTION	NOTES
Auto	Dedicated	Send F3; do not auto switch to VOICE mode.	1
Manual	Dedicated	Send F3; stay in DATA mode.	1
Auto	Shared	Send F3 of 5P. Switch to VOICE mode.	1, 2, 3
Manual	Shared	Send F3. Stay in DATA mode.	1

Notes:

1. Receipt of F3 will disable Temporary Suspension (GT8) timer.
2. If a 5P downlink is generated to identify the transition to VOICE mode, a Q6 downlink should be generated to advise the DSP that a return to Data mode has occurred.
3. If the MU cannot send the F3 (or 5P) downlink within 2 seconds, the MU should not attempt transmission.

ATTACHMENT 8
DATA RECORD CONTENTS AND FORMAT

A8-1 Data Recording

Table 8-1 below defines the format of an individual Data Record. A record is started when contact is established with a VHF ground station, and is terminated by a change in a parameter identified by NOTE 1.

Table 8-1 – Data Record Format

DATA FIELD	SIZE	DEFINITION	RANGE	NOTES
Frequency	4	VHF frequency in use for the statistics captured in this record. Note that the MSD and LSD are assumed (i.e. MSD="1", LSD="0" or "5"	1800 to 3697 (118000 to 136975)	1
Ground Station	1	Mode character in use	A to Z, 2, @, [, \,]	1
OOOI State	1	OOOI state when record is opened.	1=OUT 2=OFF 3=ON 4=IN	1
Time contact established	4	Time contact established (HHMM)	0000 - 2359	
Time contact broken	4	Time contact broken (HHMM)	0000 - 2359	
Reason for leaving this logical channel or frequency	1	A=uplinked Autotune command N=communications lost on channel (NO COMM) M=manual – pilot command L=RGS logic S=automatic frequency selection logic	A, L, M, N, S	
Downlink messages transmitted	2	Number of Downlink messages transmitted. Only messages requiring an acknowledgement are counted (i.e. not general response, Q5, QX, etc). This count includes retransmissions.	00 to 99	2
Downlink blocks transmitted	3	Number of downlink blocks transmitted. Only blocks requiring an acknowledgement are counted (i.e. not general response, Q5, QX, etc). This count includes retransmissions.	000 to 999	2
Uplink messages received	2	Number of uplink messages received. Only messages requiring an acknowledgement are counted (i.e. not general response, autotune, etc). Duplicate messages are counted.	00 to 99	2
Uplink blocks received	3	Number of uplink blocks received. Only blocks requiring an acknowledgement are counted (i.e. not general response, autotune, etc). Duplicate blocks are counted.	000 to 999	2
Blocks ACKed on 1st transmission	3	Number of blocks acknowledged on the first transmission.	000 to 999	2
Blocks ACKed on 2nd transmission	2	Number of blocks acknowledged on the second transmission	00 to 99	2
Blocks ACKed on 3rd transmission	2	Number of blocks acknowledged on the third transmission.	00 to 99	2
Blocks ACKed on 4th or more transmission	2	Number of blocks acknowledged on the fourth or subsequent transmission.	00 to 99	2

ATTACHMENT 8
DATA RECORD CONTENTS AND FORMAT

DATA FIELD	SIZE	DEFINITION	RANGE	NOTES
NAKS received in response to downlink blocks transmitted	1	Number of uplink NAKs received in response to a downlink transmission.	0 to 9	2
VAC1 limit reached	1	Number of times Retransmission counter VAC1 limit reached due to no response.	0 to 9	2
VAT10 expirations	1	Number of times downlink multiblock message timer VAT10 expired.	0 to 9	2
duplicate uplink blocks	2	Number of duplicate uplink blocks received	00 to 99	2
NAK'd uplink blocks	2	Number of NAKs transmitted in response to uplink blocks containing errors	00 to 99	2
VAT4 expirations	1	Number of times uplink Message Assembly timer (VAT4) expired	0 to 9	2

Note 1: When the value of any one of these parameters changes or VHF NOCOMM occurs, then the ACARS MU will close the present record and prepare to start a new record when VHF COMM occurs.

Note 2: If the maximum value is reached then the value of the field will remain at the maximum value and not wrap around to 0. Fields filled with 9's (i.e. 9, 99, 999) should be considered to be in an overflow state.

A8-2 Data Recording

Table 8-2 below defines the format of a Summary Report. The first column identifies each data field within a record. The second column defines the size (in octets) of each field within a record and the third column defines the range of each field. The summary data consists of the summation of the corresponding detailed data captured during each OOOI state. Detailed data will be captured continuously during normal operation. Summary data will be created on demand by processing the previously captured detail data.

Table 8-2 – Summary Report

PHASE OF FLIGHT	IN DATA FIELD (Number of:)	SIZE	RANGE	NOTES
IN	Downlink messages transmitted while IN (excluding General Response, Q5, QX etc)	3	000 to 999	2
IN	Downlink blocks transmitted while IN (including duplicate blocks)	3	000 to 999	2
IN	Uplink messages received while IN (excluding General Response, autotune etc)	3	000 to 999	2
IN	Uplink blocks received while IN (including duplicate blocks)	3	000 to 999	2
IN	Blocks ACKed on 1st transmission while IN	3	000 to 999	2
IN	Blocks ACKed on 2nd transmission while IN	2	00 to 99	2
IN	Blocks ACKed on 3rd transmission while IN	2	00 to 99	2
IN	Blocks ACKed on 4th or more transmission while IN	2	00 to 99	2
IN	NAKS received in response to downlink blocks transmitted while IN	1	0 to 9	2
IN	Times Retransmission counter (VAC1) limit reached because of no response while IN	1	0 to 9	2
IN	Times downlink Multiblock Message timer (VAT10) expired while IN	1	0 to 9	2

ATTACHMENT 8
DATA RECORD CONTENTS AND FORMAT

PHASE OF FLIGHT	IN DATA FIELD (Number of:)	SIZE	RANGE	NOTES
IN	Duplicate uplink blocks received while IN	2	00 to 99	2
IN	NAKs transmitted in response to uplink blocks containing errors while IN	2	00 to 99	2
IN	Times uplink Message Assembly timer (VAT4) expired while IN	1	0 to 9	2
OUT	Downlink messages transmitted while OUT (excluding General Response, Q5, QX etc)	3	000 to 999	2
OUT	Downlink blocks transmitted while OUT (including duplicate blocks)	3	000 to 999	2
OUT	Uplink messages received while OUT (excluding general response, autotune etc)	3	000 to 999	2
OUT	Uplink blocks received while OUT (including duplicate blocks)	3	000 to 999	2
OUT	Blocks ACKed on 1st transmission while OUT	3	000 to 999	2
OUT	Blocks ACKed on 2nd transmission while OUT	2	00 to 99	2
OUT	Blocks ACKed on 3rd transmission while OUT	2	00 to 99	2
OUT	Blocks ACKed on 4th or more transmission while OUT	2	00 to 99	2
OUT	NAKs received in response to downlink blocks transmitted while OUT	1	0 to 9	2
OUT	Times Retransmission counter (VAC1) limit reached because of no response while OUT	1	0 to 9	2
OUT	Times downlink Multiblock Message timer (VAT10) expired while OUT	1	0 to 9	2
OUT	Duplicate uplink blocks received while OUT	2	00 to 99	2
OUT	NAKs transmitted in response to uplink blocks containing errors while OUT	2	00 to 99	2
OUT	Times uplink Message Assembly timer (VAT4) expired while OUT	1	0 to 9	2

PHASE OF FLIGHT	OFF DATA FIELD (Number of:)	SIZE	RANGE	NOTES
OFF	Downlink messages transmitted while OFF (excluding General Response, Q5, QX etc)	3	000 to 999	2
OFF	Downlink blocks transmitted while OFF (including duplicate blocks)	3	000 to 999	2
OFF	Uplink messages received while OFF (excluding General Response, autotune etc)	3	000 to 999	2
OFF	Uplink blocks received while OFF (including duplicate blocks)	3	000 to 999	2
OFF	Blocks ACKed on 1st transmission while OFF	3	000 to 999	2
OFF	Blocks ACKed on 2nd transmission while OFF	2	00 to 99	2
OFF	Blocks ACKed on 3rd transmission while OFF	2	00 to 99	2
OFF	Blocks ACKed on 4th or more transmission while OFF	2	00 to 99	2
OFF	NAKs received in response to downlink blocks transmitted while OFF	1	0 to 9	2
OFF	Times retransmission counter (VAC1) limit reached because of no response while OFF	1	0 to 9	2
OFF	Times downlink Multiblock Message timer (VAT10) expired while OFF	1	0 to 9	2
OFF	Duplicate uplink blocks received while OFF	2	00 to 99	2

ATTACHMENT 8
DATA RECORD CONTENTS AND FORMAT

PHASE OF FLIGHT	OFF DATA FIELD (Number of:)	SIZE	RANGE	NOTES
OFF	NAKs transmitted in response to uplink blocks containing errors while OFF	2	00 to 99	2
OFF	Times uplink Message Assembly timer (VAT4) expired while OFF	1	0 to 9	2
ON	Downlink messages transmitted while ON (excluding general response, Q5, QX etc)	3	000 to 999	2
ON	Downlink blocks transmitted while ON (including duplicate blocks)	3	000 to 999	2
ON	Uplink messages received while ON (excluding general response, autotune etc)	3	000 to 999	2
ON	Uplink blocks received while ON (including duplicate blocks)	3	000 to 999	2
ON	Blocks ACKed on 1st transmission while ON	3	000 to 999	2
ON	Blocks ACKed on 2nd transmission while ON	2	00 to 99	2
ON	Blocks ACKed on 3rd transmission while ON	2	00 to 99	2
ON	Blocks ACKed on 4th or more transmission while ON	2	00 to 99	2
ON	NAKs received in response to downlink blocks transmitted while ON	1	0 to 9	2
ON	Times Retransmission counter (VAC1) limit reached because of no response while ON	1	0 to 9	2
ON	Times downlink Multiblock message timer (VAT10) expired while ON	1	0 to 9	2
ON	Duplicate uplink blocks received while ON	2	00 to 99	2
ON	NAKs transmitted in response to uplink blocks containing errors while ON	2	00 to 99	2
ON	Times uplink Message Assembly timer (VAT4) expired while ON	1	0 to 9	2

Note 1: (deleted)

Note 2: If the maximum value is reached then the value of the field will remain at the maximum value and not wrap around to 0. Fields filled with 9’s (i.e. 9, 99, 999) should be considered to be in an overflow state.

ATTACHMENT 9
MEDIA ADVISORY LOGIC

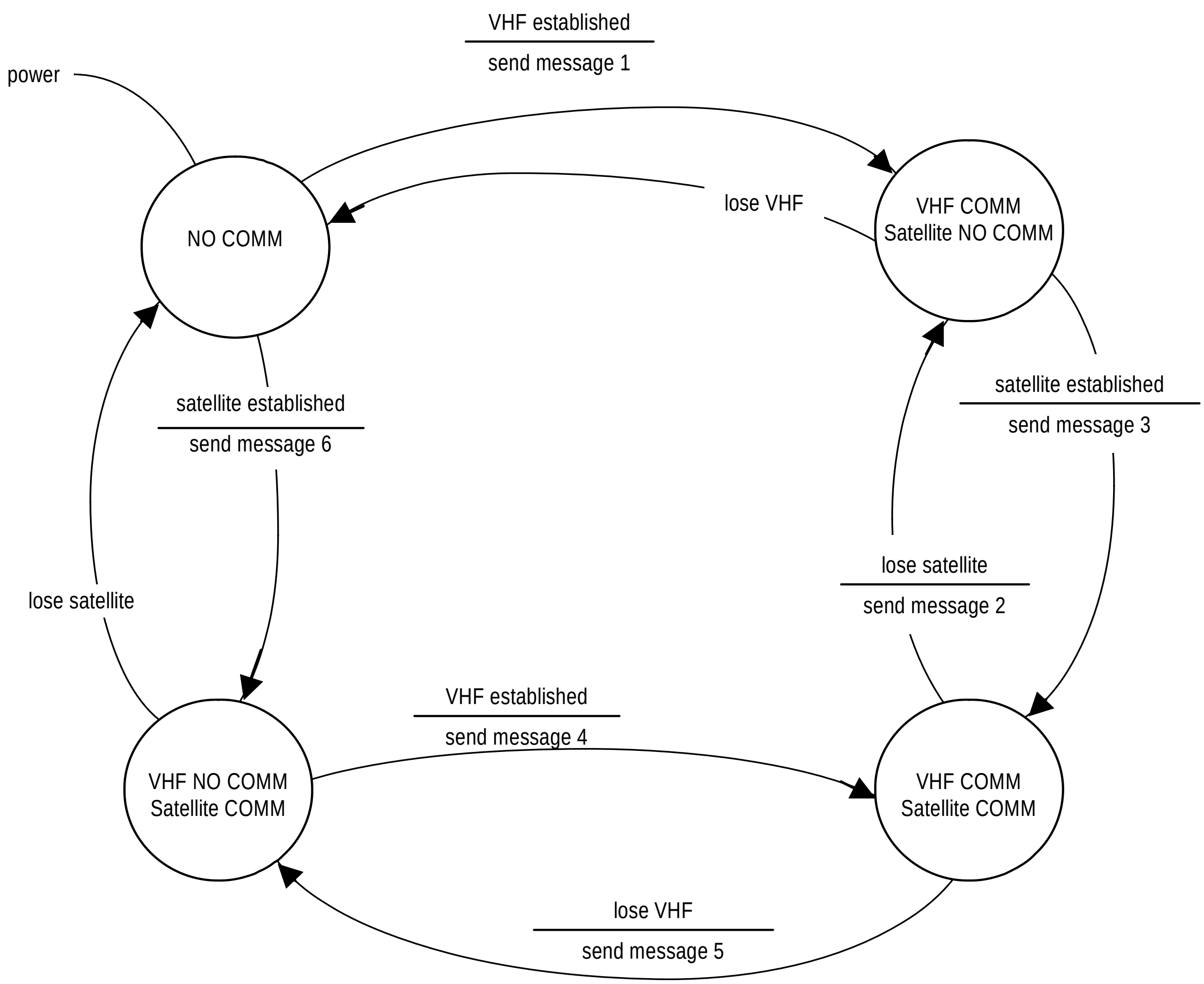


Figure 9-1 – Example of Media Advisory Logic for an Aircraft Equipped Only withVHF and SATCOM Datalink

Notes:

1. Simultaneous or near simultaneous transitions should be considered by the designer when implementing the Media Advisory logic.
2. The contents of each message identified in this example is defined in Table 9-1.

ATTACHMENT 9
MEDIA ADVISORY LOGIC

Table 9-1 – Examples of the Contents of the Media Advisory Messages Referenced by Figure 9-1

Message	Establishment/Loss Flag	Media Identification	Media Status	Routing
1	E	V	V	V
2	L	S	V	V
3	E	S	VS	S
4	E	V	VS	V
5	L	V	S	S
6	E	S	S	S

ATTACHMENT 9
MEDIA ADVISORY LOGIC

Table 9-2 – Example of Media Advisory Logic for an Aircraft Equipped with VHF and SATCOM and HF Datalink

state N			event			state N+1						
VHF Status	HFDL Status	SATCOM Status	VHF	HFDL	SATCOM	VHF Status	HFDL Status	SATCOM Status	Establishment /Loss Flag	Media Ident. Field Value	Media Status	Media Advisory Downlink Routing
no comm	no comm	no comm	comm	none	none	comm	no comm	no comm	E	V	V	V
no comm	no comm	no comm	none	comm	none	no comm	comm	no comm	E	H	H	H
no comm	no comm	no comm	none	none	comm	no comm	no comm	comm	E	S	S	S
no comm	no comm	comm	comm	none	none	comm	no comm	comm	E	V	VS	V
no comm	no comm	comm	none	comm	none	no comm	comm	comm	E	H	HS	H
no comm	no comm	comm	none	none	no comm	no comm	no comm	nocomm	L	S		
no comm	comm	no comm	comm	none	none	comm	comm	no comm	E	V	VH	V
no comm	comm	no comm	none	no comm	none	no comm	no comm	no comm	L	H		
no comm	comm	no comm	none	none	comm	no comm	comm	comm	E	S	HS	S
no comm	comm	comm	comm	none	none	comm	comm	comm	E	V	VHS	V
no comm	comm	comm	none	no comm	none	no comm	no comm	comm	L	H	S	S
no comm	comm	comm	none	none	no comm	no comm	comm	no comm	L	S	H	H
comm	no comm	no comm	no comm	none	none	no comm	no comm	no comm	L	V		
comm	no comm	no comm	none	comm	none	comm	comm	no comm	E	H	VH	H
comm	no comm	no comm	none	none	comm	comm	no comm	comm	E	S	VS	S
comm	no comm	comm	no comm	none	none	no comm	no comm	comm	L	V	S	S
comm	no comm	comm	none	comm	none	comm	comm	comm	E	H	VHS	H
comm	no comm	comm	none	none	no comm	comm	no comm	no comm	L	S	V	V
comm	comm	no comm	no comm	none	none	no comm	comm	no comm	L	V	H	H
comm	comm	no comm	none	no comm	none	comm	no comm	no comm	L	H	V	V
comm	comm	no comm	none	none	comm	comm	comm	comm	E	S	VHS	S
comm	comm	comm	no comm	none	none	no comm	comm	comm	L	V	HS	HS
comm	comm	comm	none	no comm	none	comm	no comm	comm	L	H	VS	VS
comm	comm	comm	none	none	no comm	comm	comm	no comm	L	S	VH	VH

ATTACHMENT 10

MESSAGE SEQUENCE CHARTS FOR DOWNLINK ACKNOWLEDGMENT ON SATCOM/HFDL

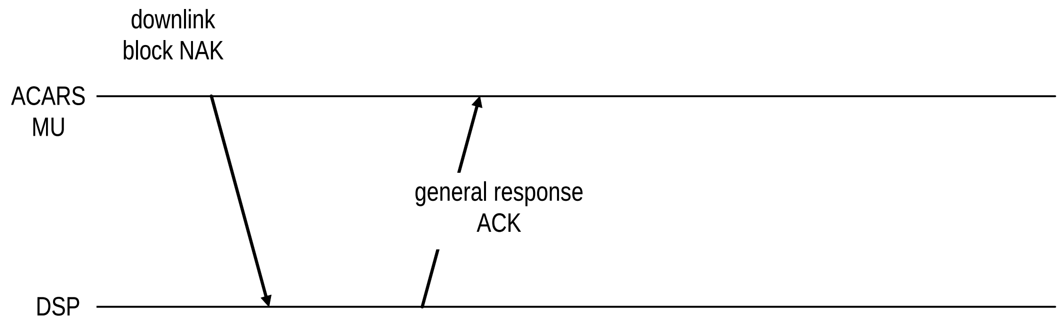
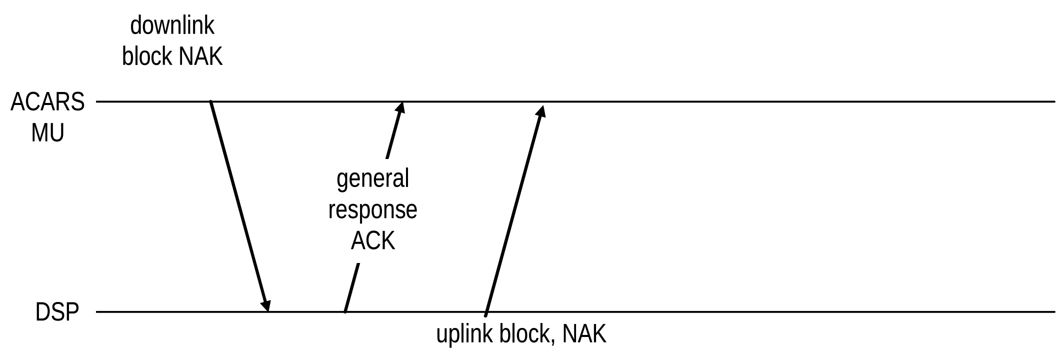


Figure 10-1 – Acknowledgment of a Downlink Block, Scenario 1, Simple Case



or

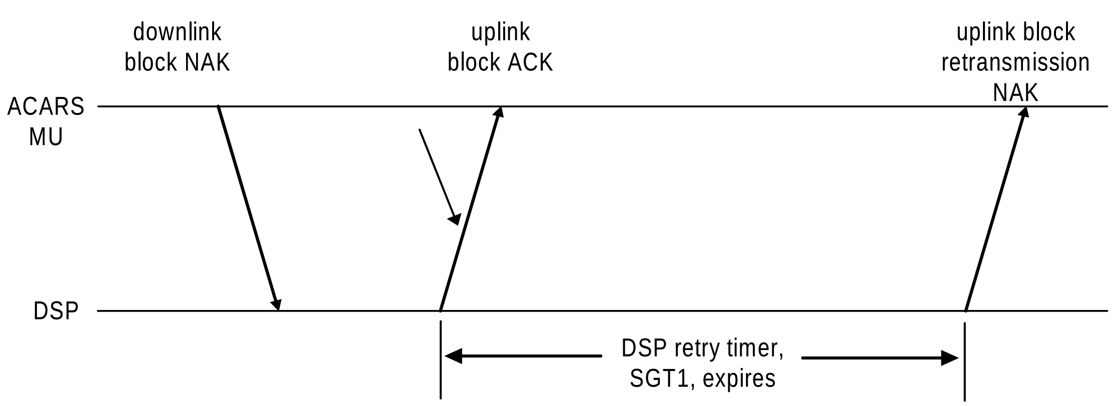


Figure 10-2 – Acknowledgment of a Downlink Block, Scenario 2, Pending Uplink

ATTACHMENT 10
MESSAGE SEQUENCE CHARTS FOR DOWNLINK ACKNOWLEDGMENT ON SATCOM/HFDL

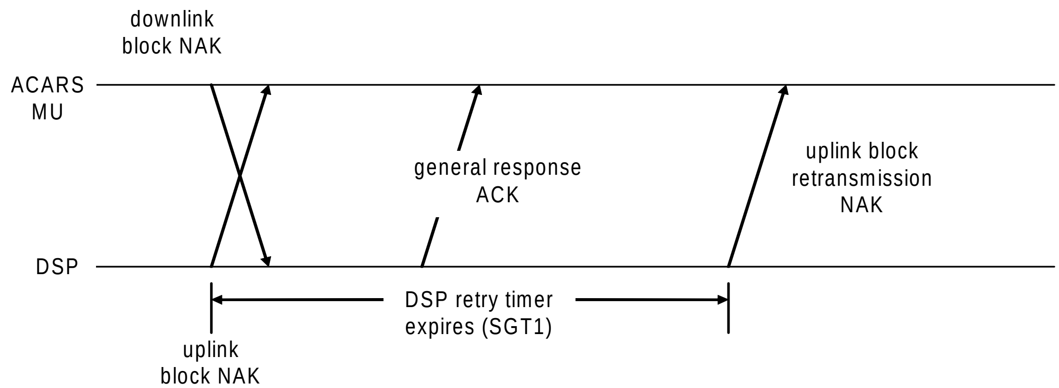
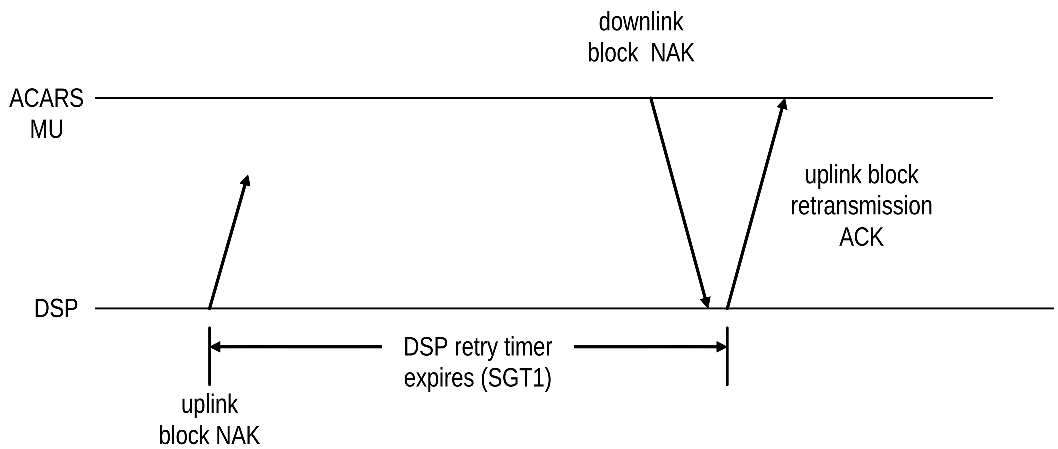


Figure 10-3 – Acknowledgment of a Downlink Block, Scenario 3, Criss-Cross



or

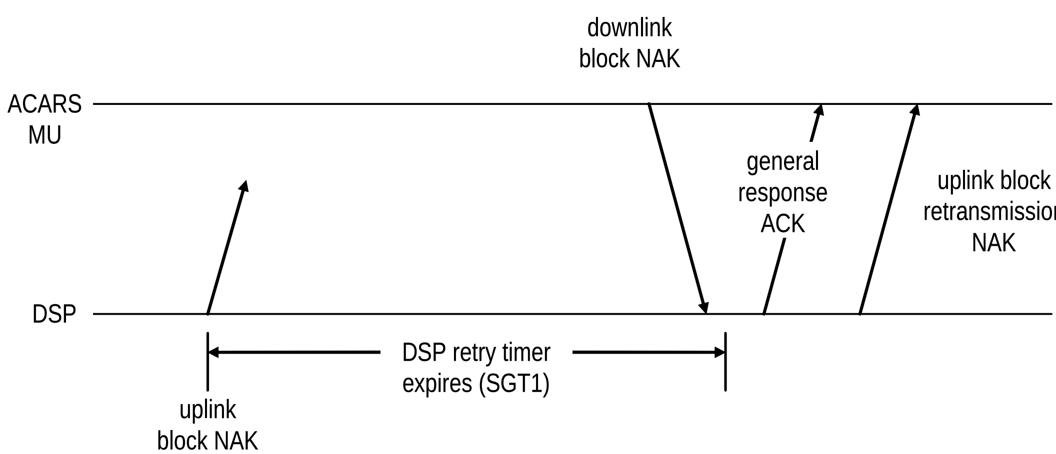


Figure 10-4 – Acknowledgment of a Downlink Block, Scenario 3 Criss-Cross and Retransmission

ATTACHMENT 11
MESSAGE SEQUENCE CHARTS FOR UPLINK ACKNOLWEDGMENT ON SATCOM

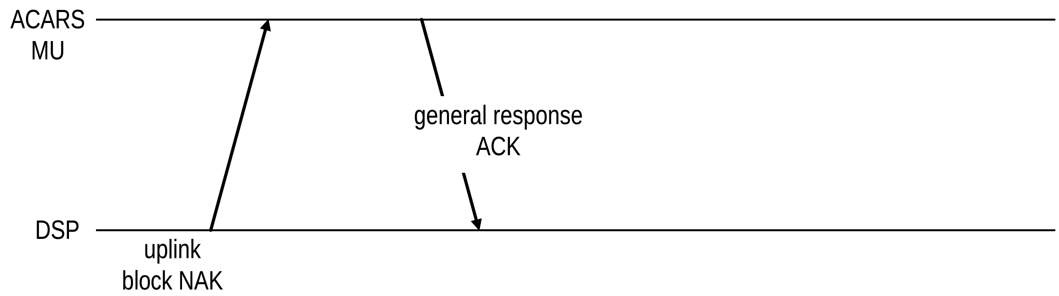
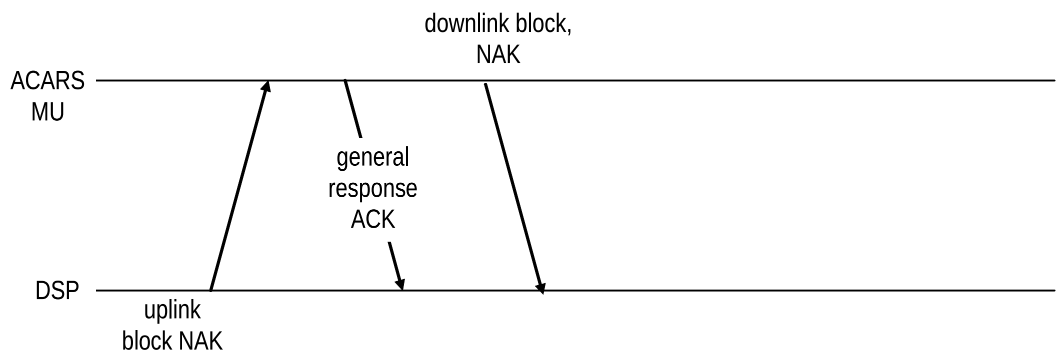


Figure 11-1 – Acknowledgment of an Uplink Block, Scenario 1, Simple Case



or

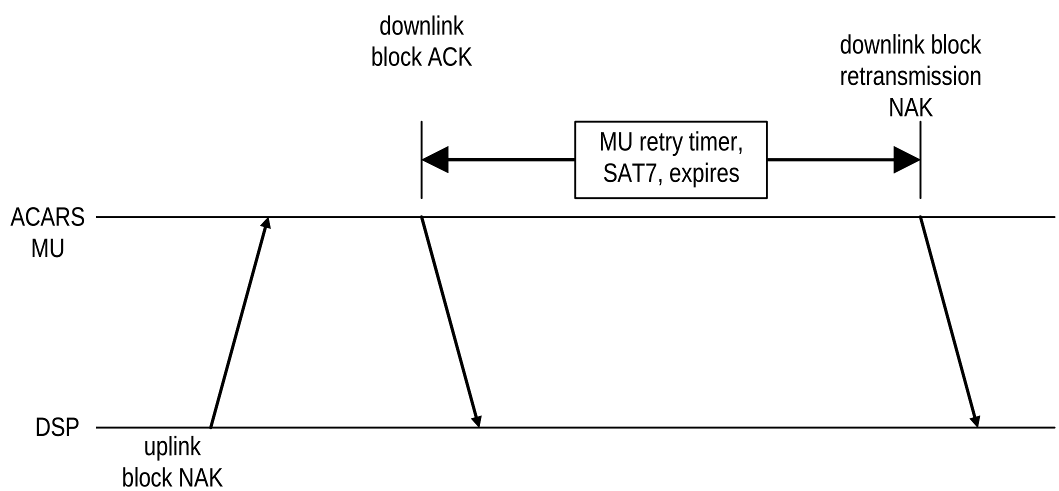


Figure 11-2 – Acknowledgment of an Uplink Block, Scenario 2, Pending Downlink

ATTACHMENT 11
MESSAGE SEQUENCE CHARTS FOR UPLINK ACKNOWLEDGMENT ON SATCOM/HFDL

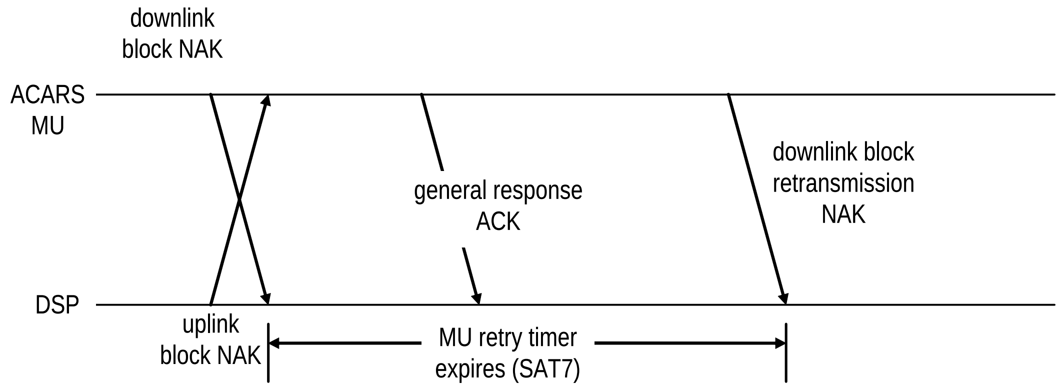
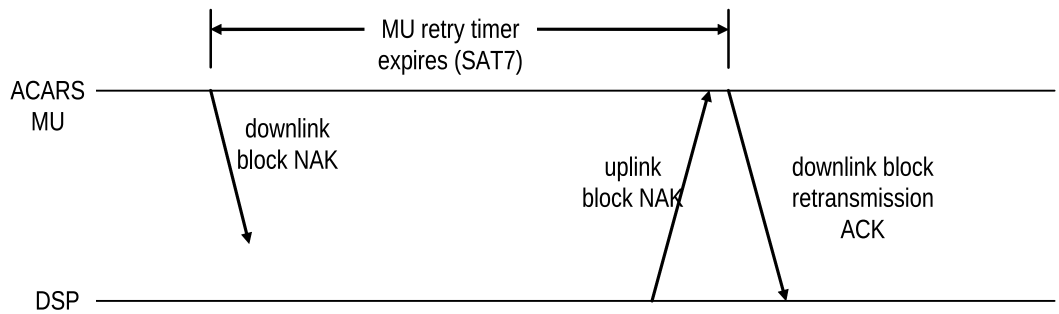


Figure 11-3 – Acknowledgment of an Uplink Block, Scenario 3, Criss-Cross



or

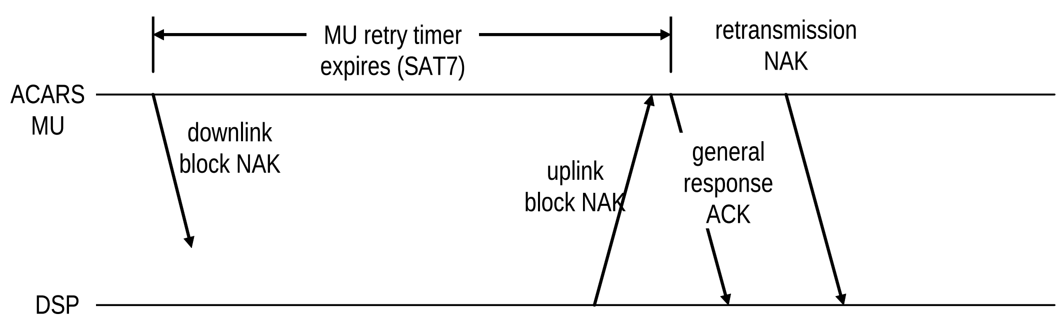


Figure 11-4 – Acknowledgment of an Uplink Block, Scenario 3 Criss-Cross and Retransmission

ATTACHMENT 12
NESTED MULTIBLOCK TIMING DIAGRAMS

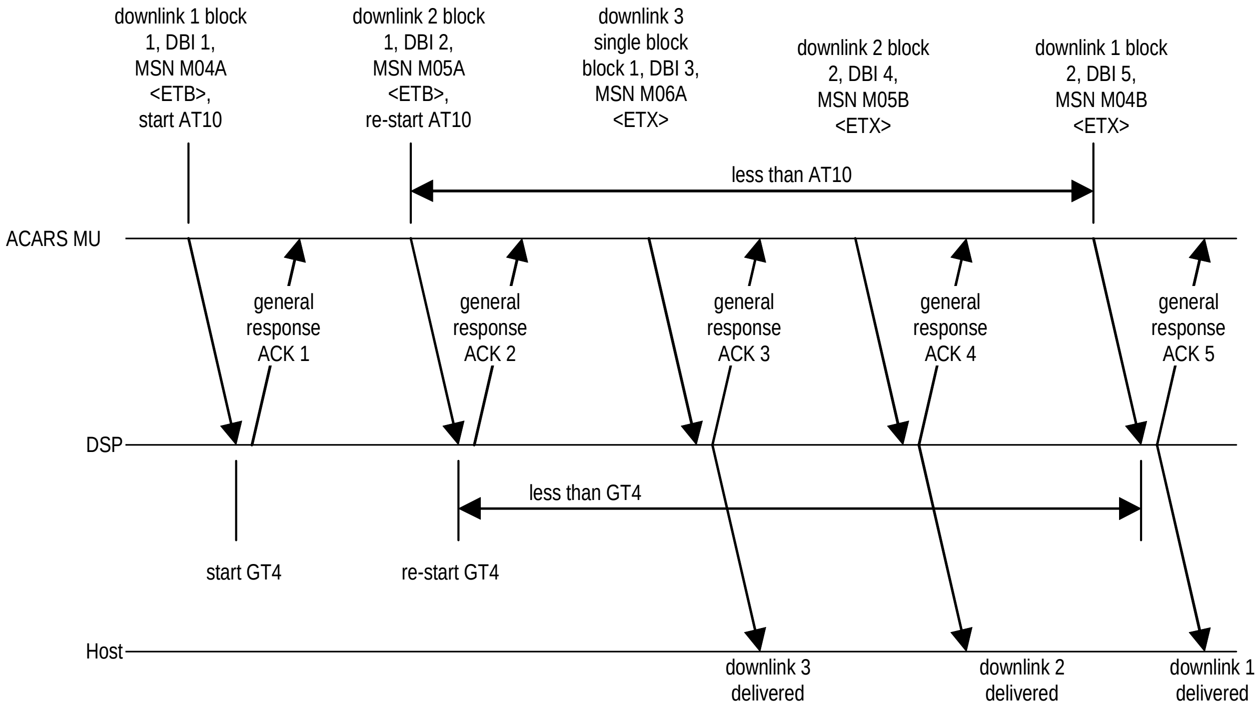


Figure 12-1 – Example of Multiblock Downlink Nesting, Normal Operation

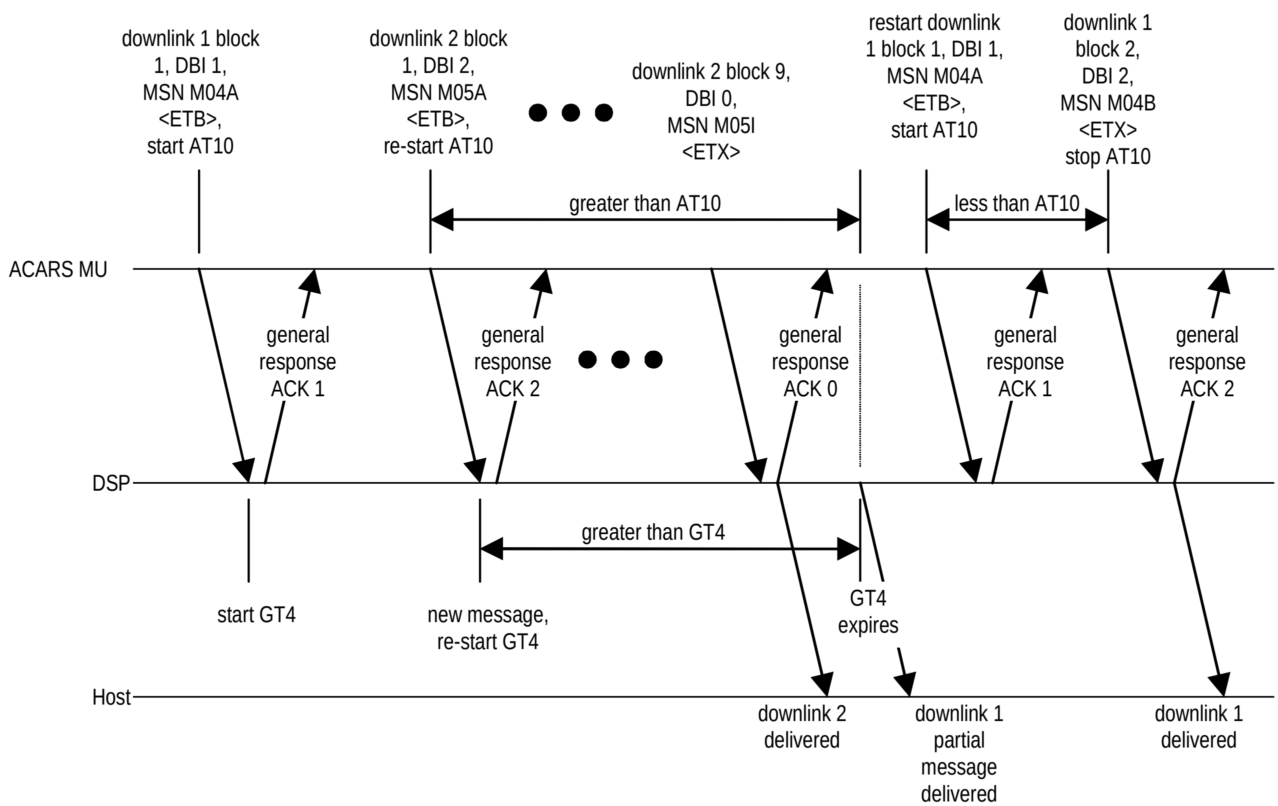


Figure 12-2 – Example of Multiblock Downlink Nesting, AT10 Expires Before Downlink 1 is Completed

ATTACHMENT 13
MU-VDR PROTOCOL NEGOTIATION MESSAGE SEQUENCE CHART EXAMPLES

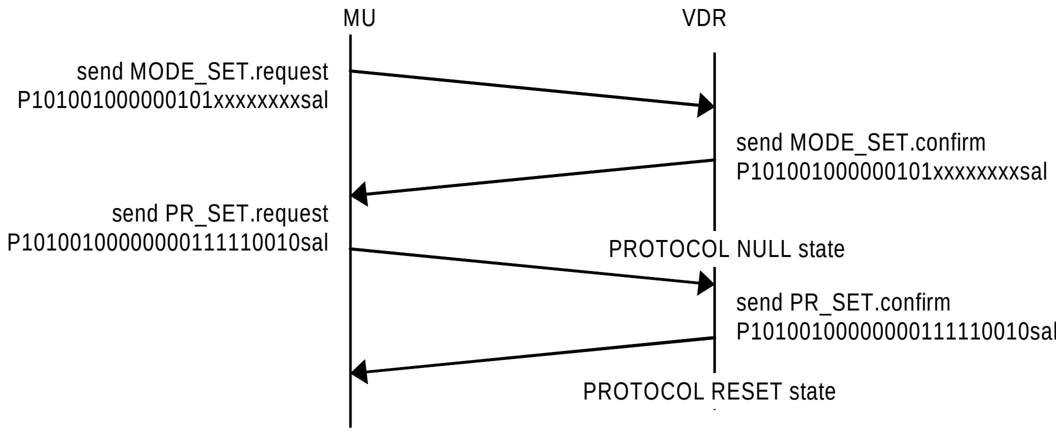


Figure 13-1 – MU Sets Protocol without Querying VDR

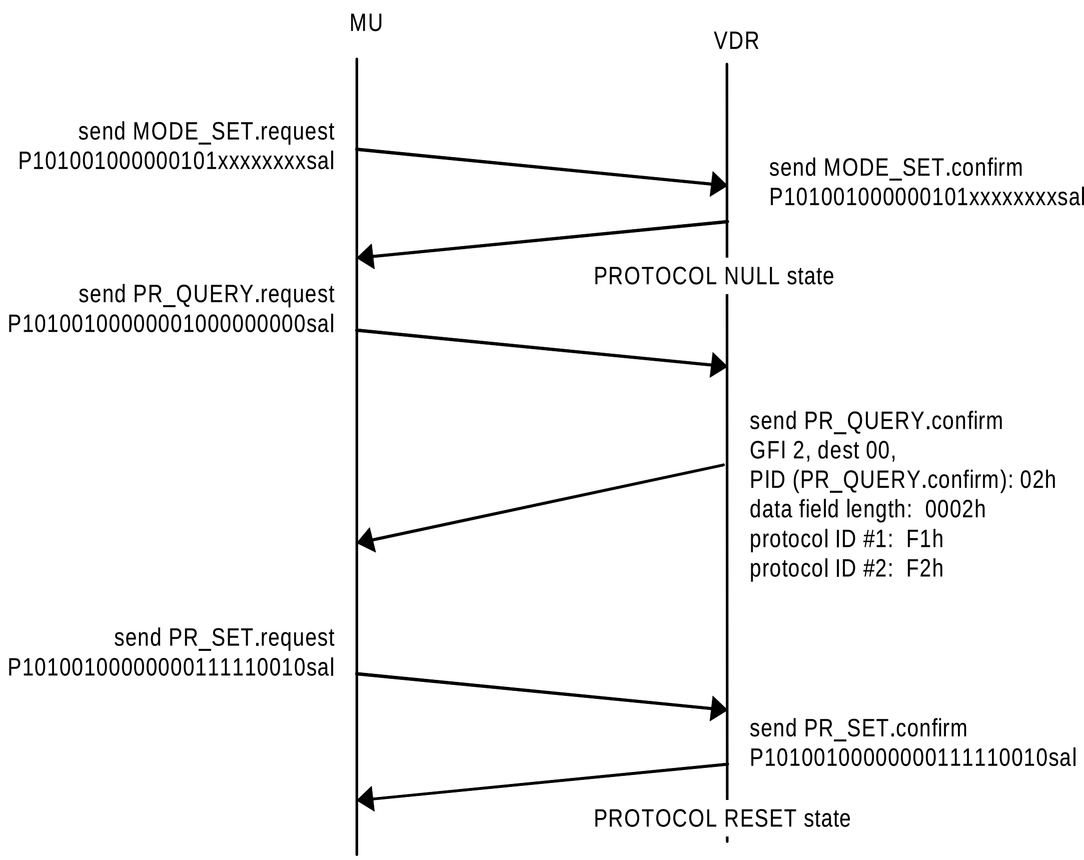


Figure 13-2 – MU Queries VDR and then Sets Protocol

ATTACHMENT 13
MU-VDR PROTOCOL NEGOTIATION MESSAGE SEQUENCE CHART EXAMPLES

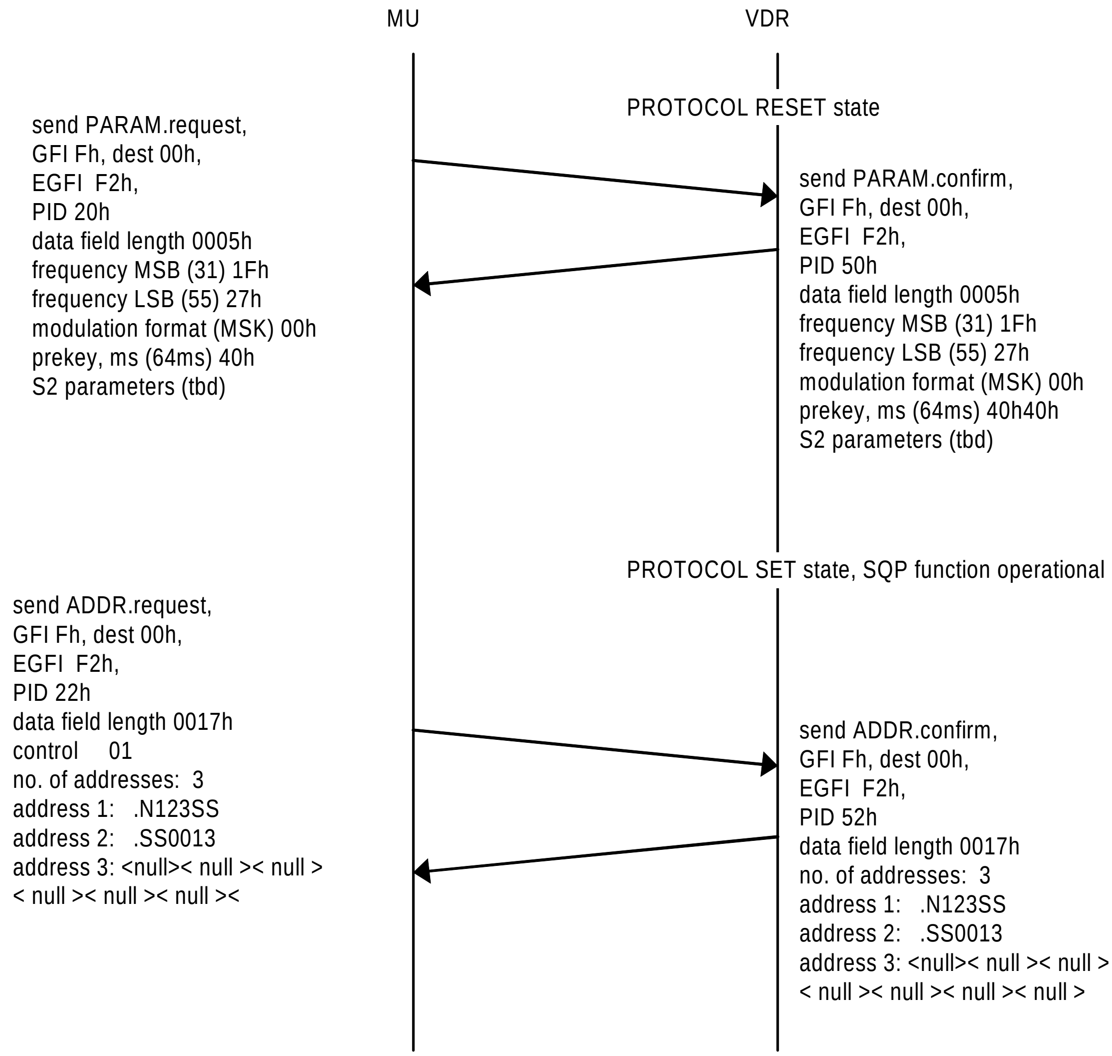


Figure 13-3 – MU Sends ACARS Protocol Initialization Data to VDR

ATTACHMENT 13
MU-VDR PROTOCOL NEGOTIATION MESSAGE SEQUENCE CHART EXAMPLES

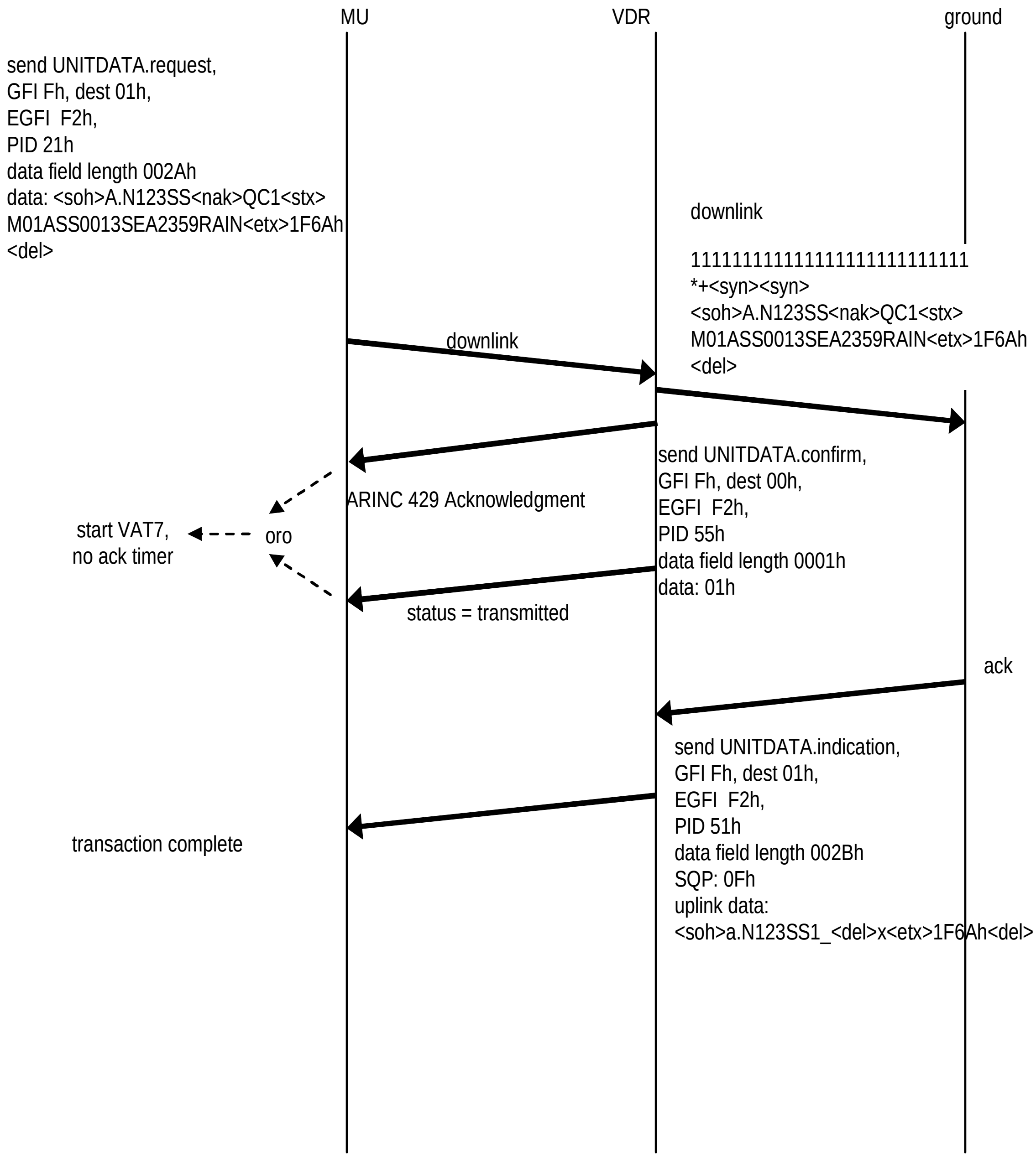


Figure 13-4 – Typical MU-VDR Downlink Scenario

ATTACHMENT 14
PROPAGATION DELAY

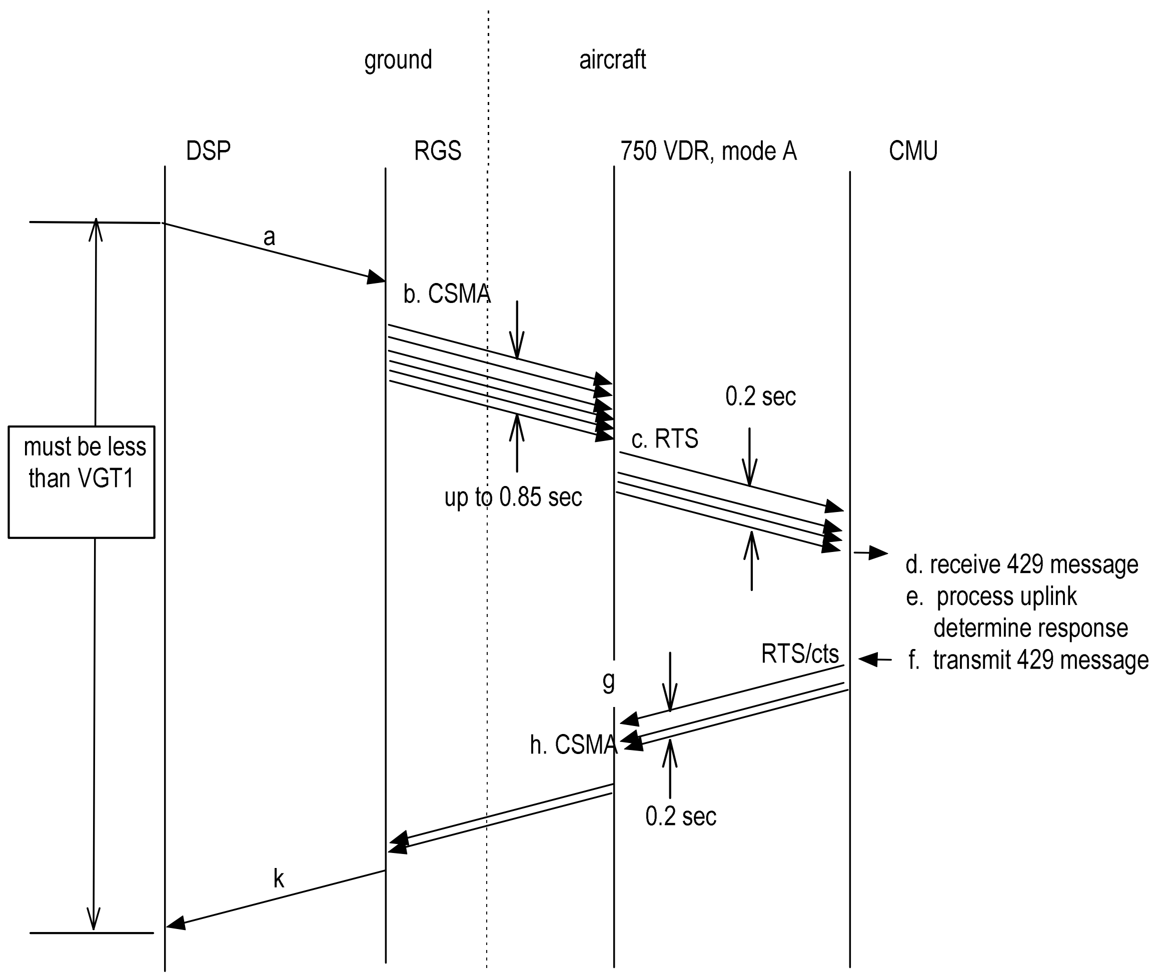


Figure 14-1 – Mode A Uplink Propagation Message Sequence Diagram

ATTACHMENT 14
PROPAGATION DELAY

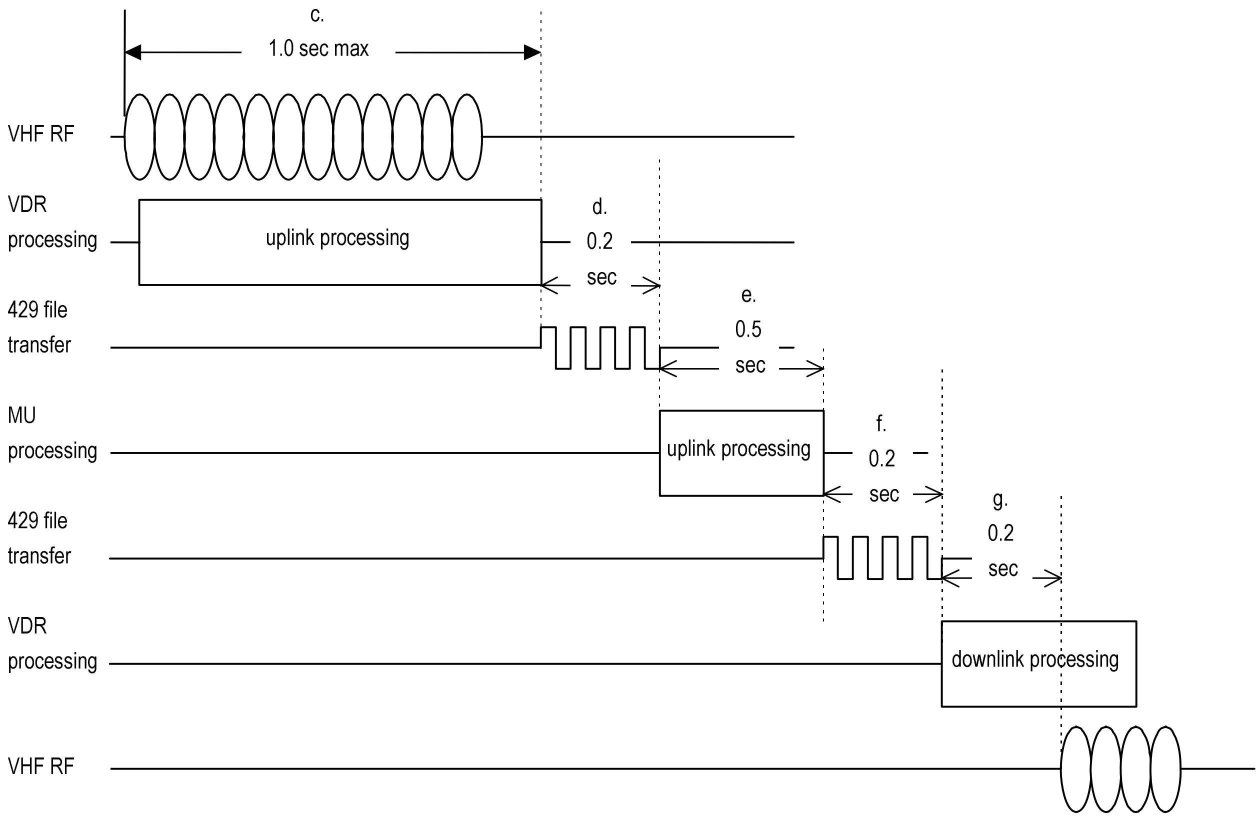


Figure 14-2 – Mode A Uplink Propagation Delay Components

ATTACHMENT 14
PROPAGATION DELAY

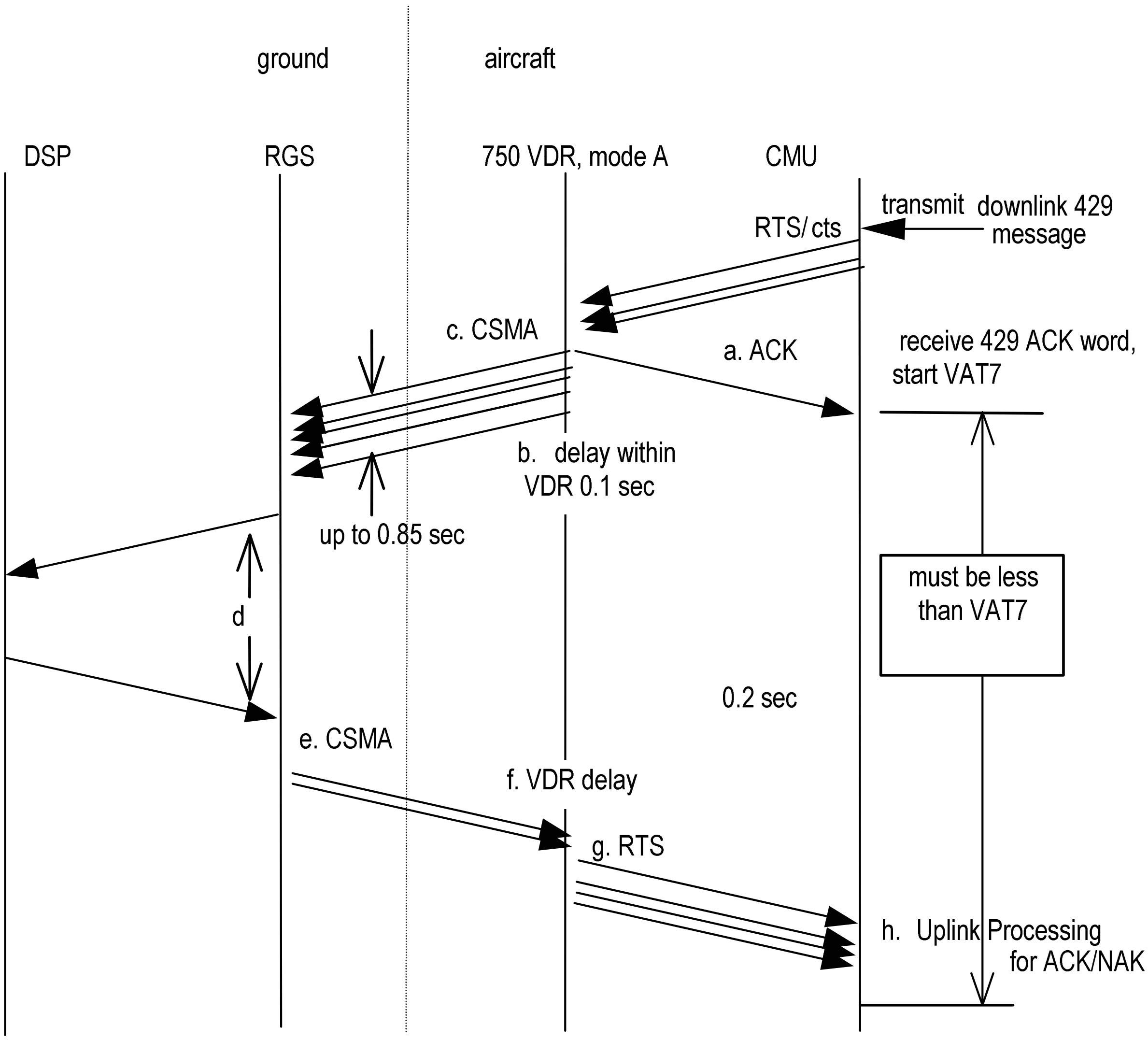


Figure 14-3 – Mode A Downlink Propagation Delay Components

ATTACHMENT 15
GENERAL FORMAT OF AIR/GROUND DOWNLINK AND UPLINK MESSAGES

Table 15-1 – General Format of Air/Ground Downlink Message

Name	SOH	Mode	Aircraft Registration Number	TAK	Label	DBI	STX	MSN	Flight ID
Size	1	1	7	1	2	1	1	4	6
Example	<SOH>	2	.N123XX		5Z	2	<STX>	M01A	XX0000

Application Text
0-210

Suffix	BCS	BCS Suffix
1	2	1
<ETX>		<DEL>

ATTACHMENT 15
GENERAL FORMAT OF AIR/GROUND DOWNLINK AND UPLINK MESSAGES

Table 15-2 – General Format of Ground/Air Uplink Message

NAME	SOH	Mode	Aircraft Registration or Flight ID	TAK	Label	UBI	STX
Size	1	1	7	1	2	1	1
Example	<SOH>	2	.N123XX	<NAK>	10	A	<STX>

Application Text
0-220

Suffix	BCS	BCS Suffix
1	2	1
<ETX>		<DEL>

ATTACHMENT 16
AOA PROTOCOL ARCHITECTURE

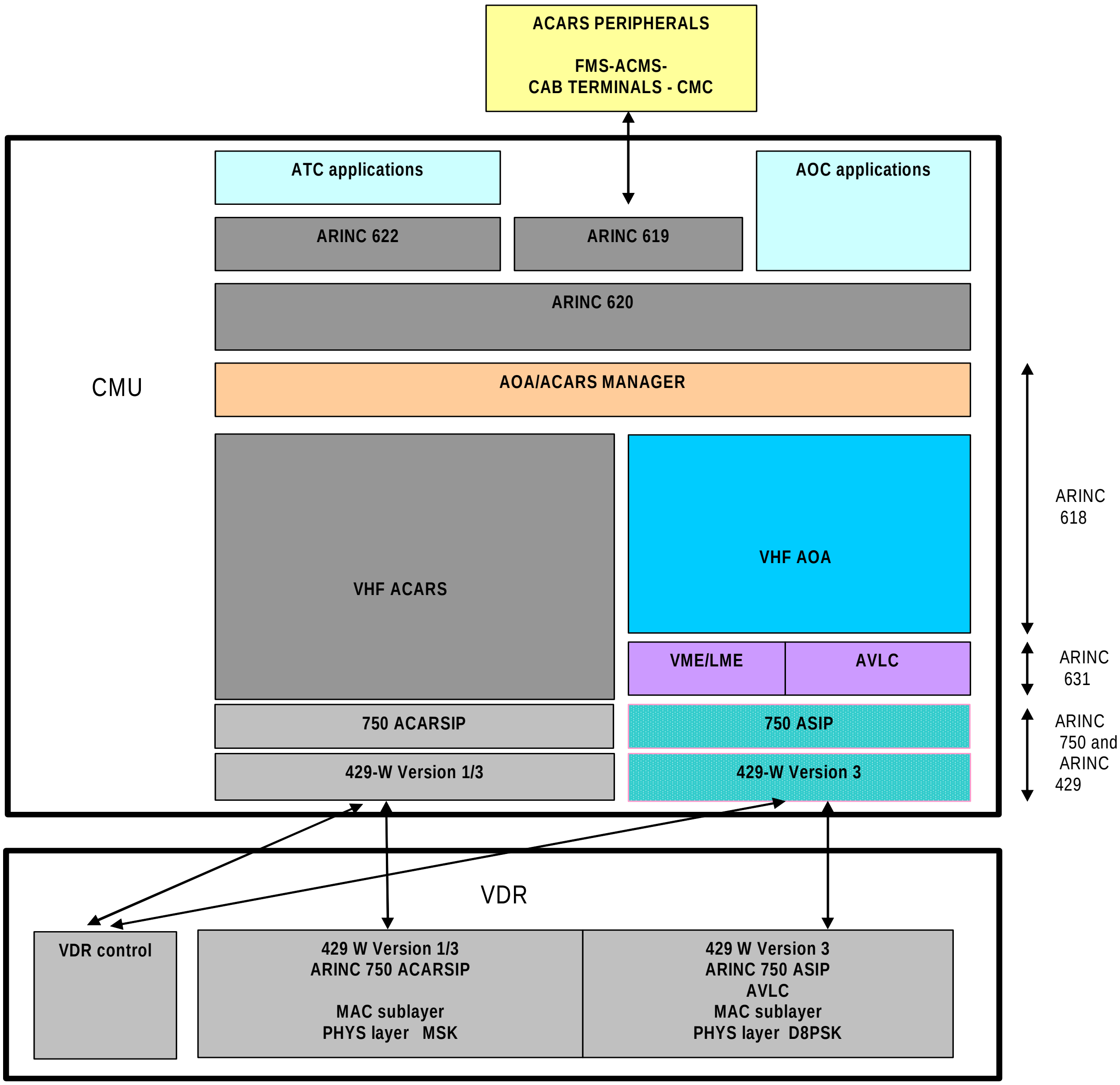
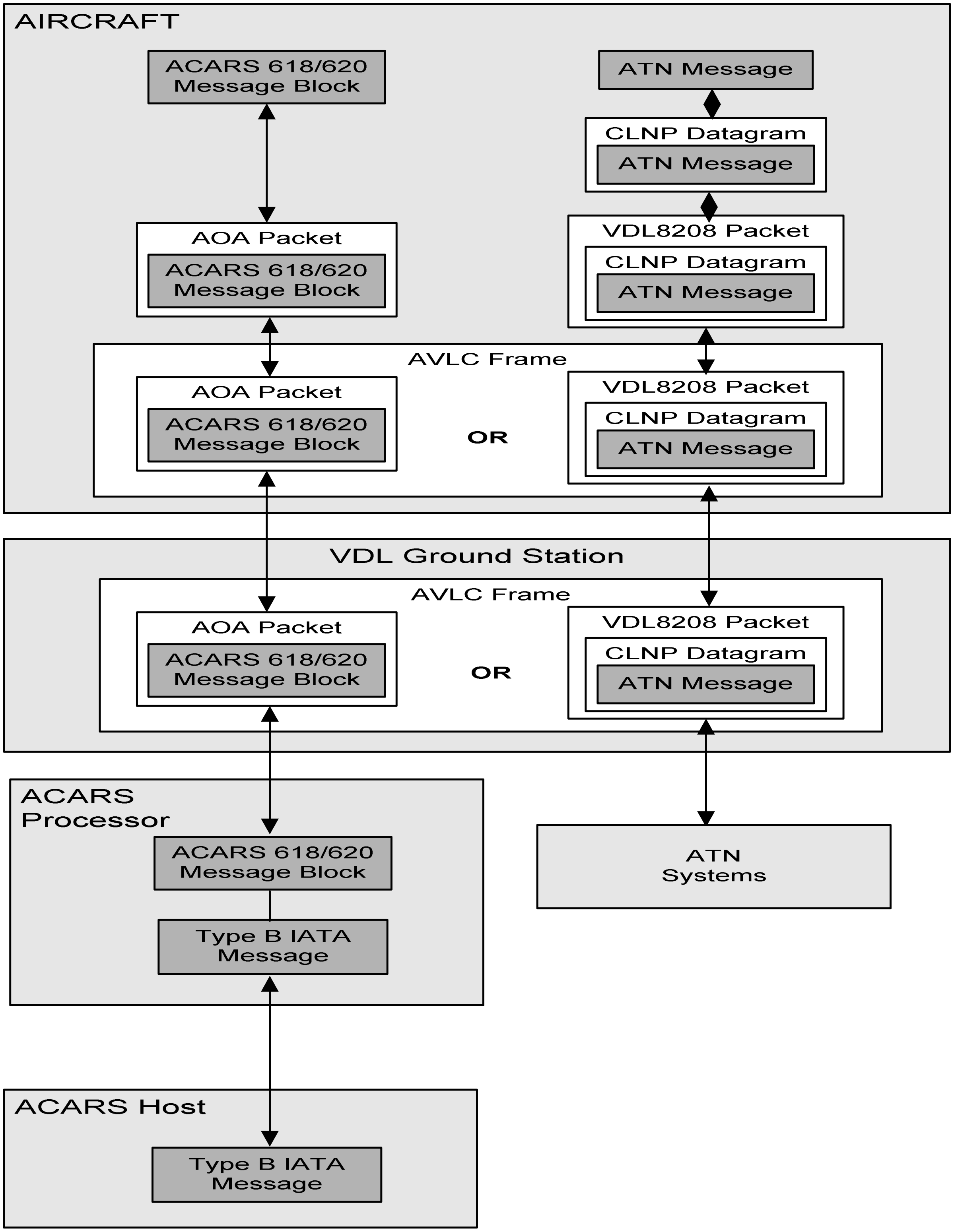


Figure 16-1 – General Airborne Communication Architecture

ATTACHMENT 16
AOA PROTOCOL ARCHITECTURE



Note: VDL 8208 is ISO 8208 as modified by ICAO VDL SARPs. Refer to ARINC Specification for implementation details.

Figure 16-2 – ACARS Over AVLC Interface

ATTACHMENT 17
AVLC FRAME STRUCTURE

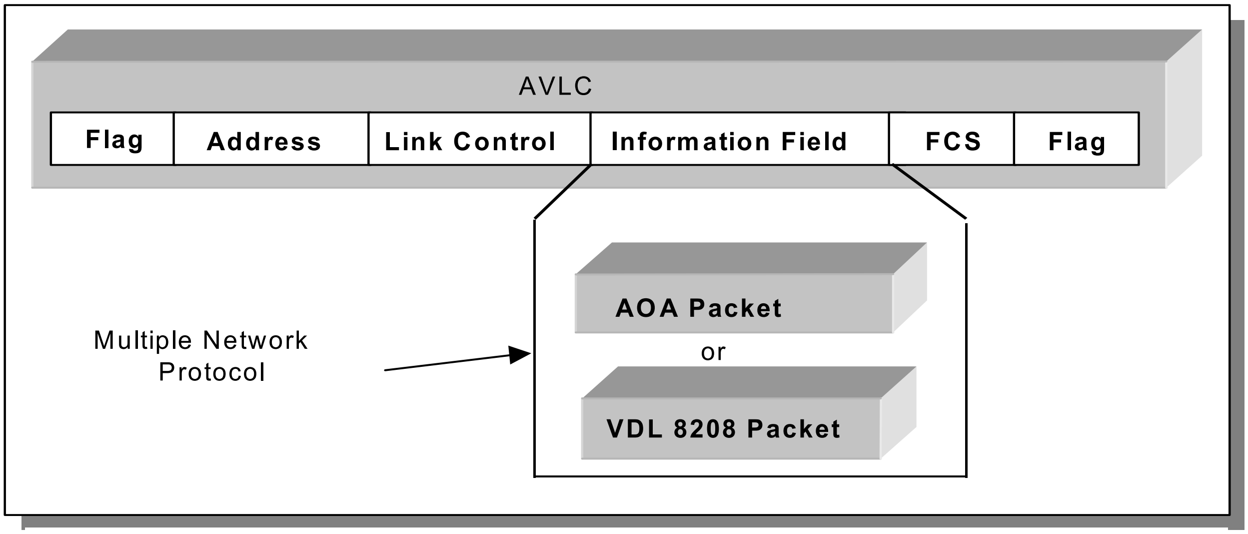


Figure 17-1 – Multiple Network Layer Protocols

ATTACHMENT 17
AVLC FRAME STRUCTURE

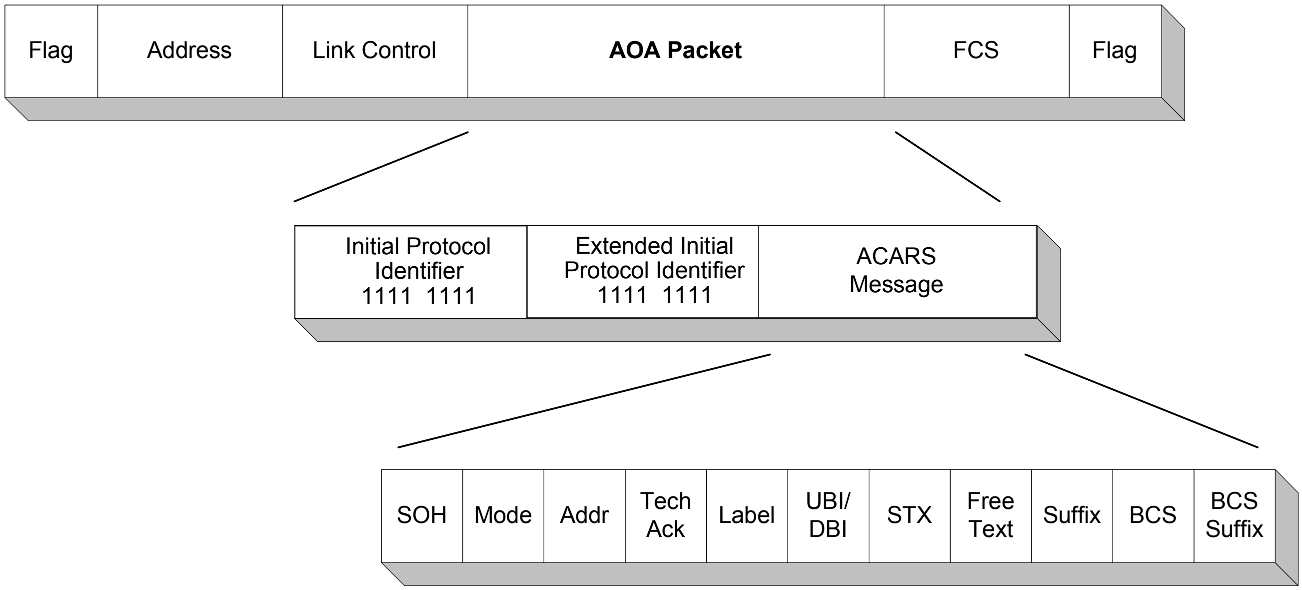


Figure 17-2 – IPI, Extended IPI and ACARS Block within AVLC Frame

ATTACHMENT 18
AOA MESSAGE SEQUENCE CHARTS AND FLOW DIAGRAMS

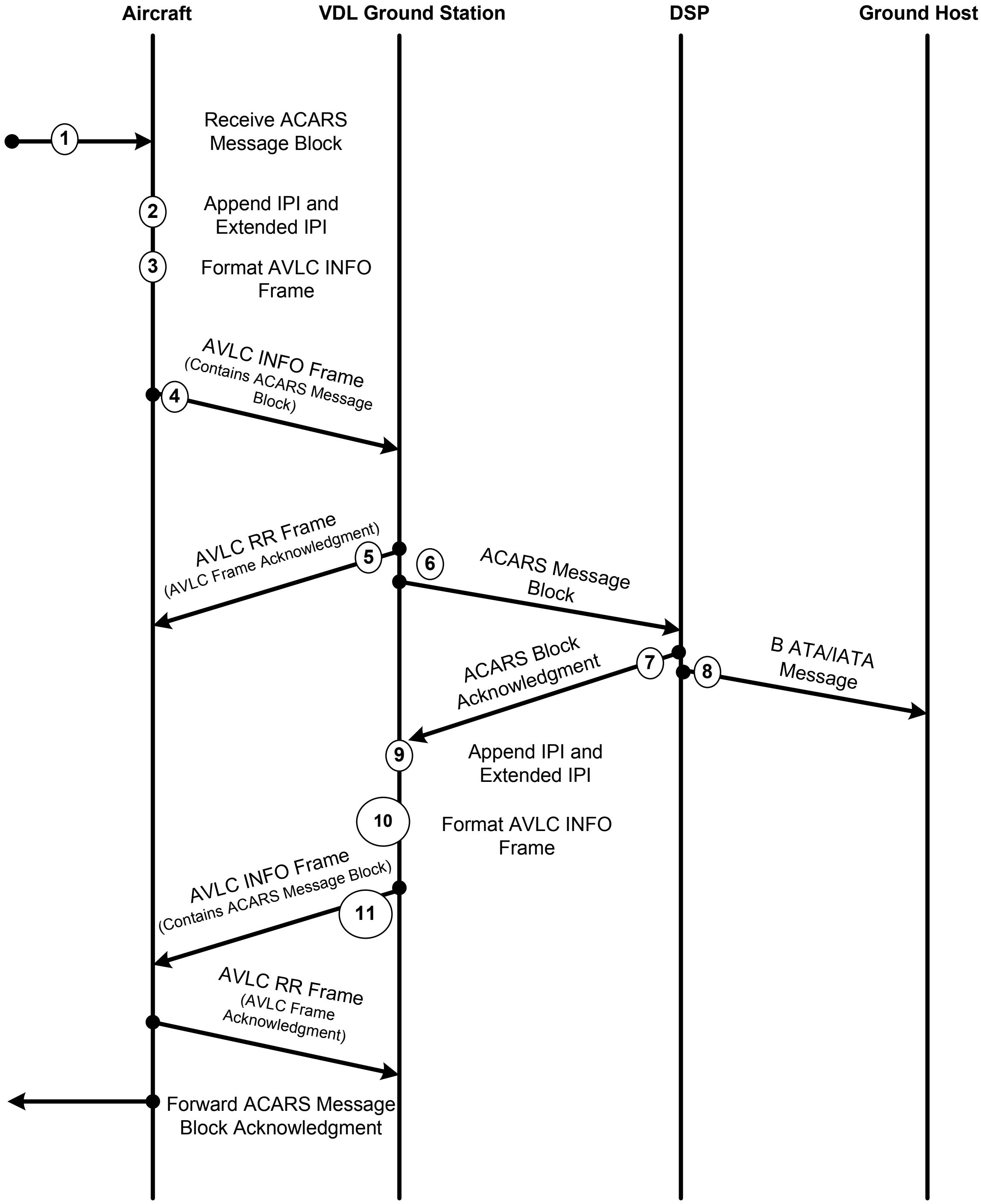


Figure 18-1 – AOA Downlink Processing

Note: Prior to Step 4, Aircraft sends INFO Frame containing ACARS Block to Ground Station, AVLC link establishment procedures have been accomplished as per the VDL SARPs.

ATTACHMENT 18
AOA MESSAGE SEQUENCE CHARTS AND FLOW DIAGRAMS

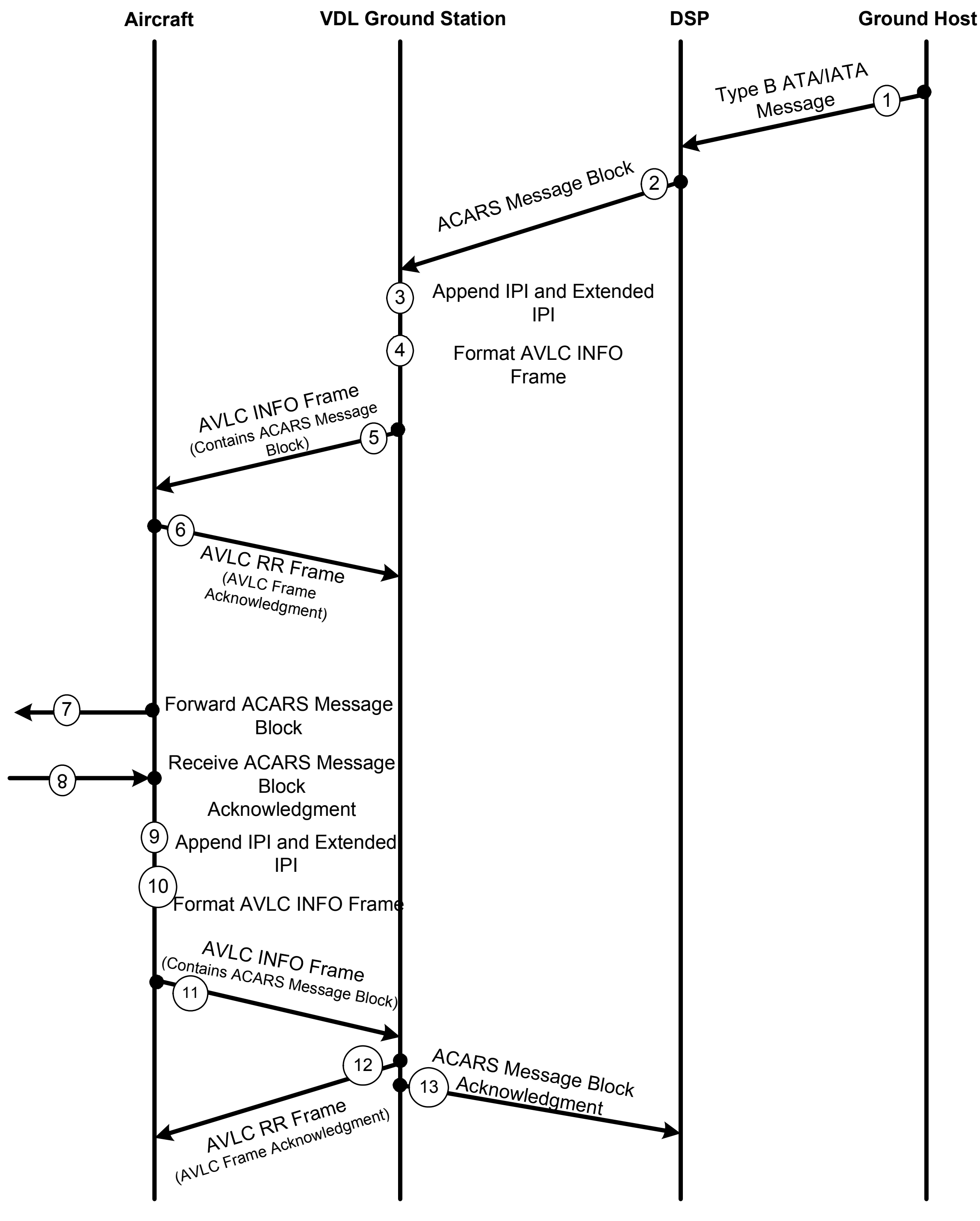


Figure 18-2 – AOA Uplink Processing

ATTACHMENT 18
AOA MESSAGE SEQUENCE CHARTS AND FLOW DIAGRAMS

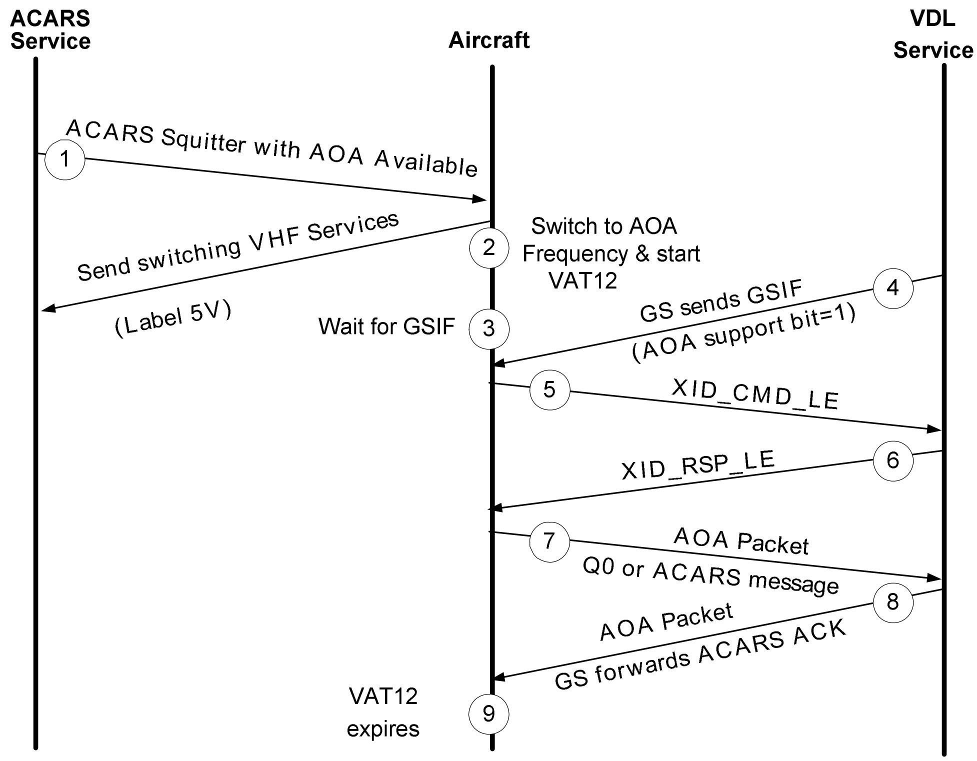


Figure 18-3 – Successful Switch from ACARS to AOA Based on Ground Station Announcement of AOA Availability

ATTACHMENT 18
AOA MESSAGE SEQUENCE CHARTS AND FLOW DIAGRAMS

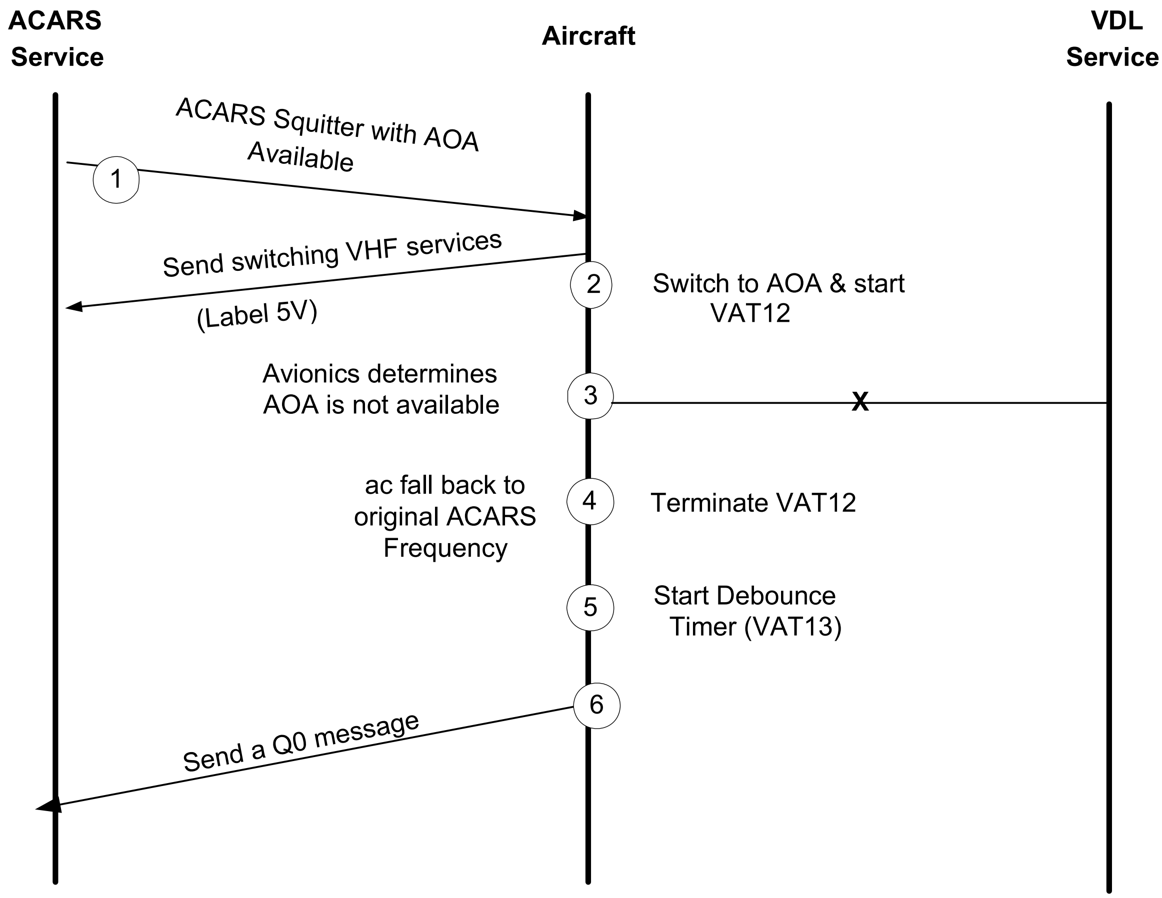


Figure 18-4 – Fallback from AOA to ACARS (Before VAT12 Expires)

ATTACHMENT 18
AOA MESSAGE SEQUENCE CHARTS AND FLOW DIAGRAMS

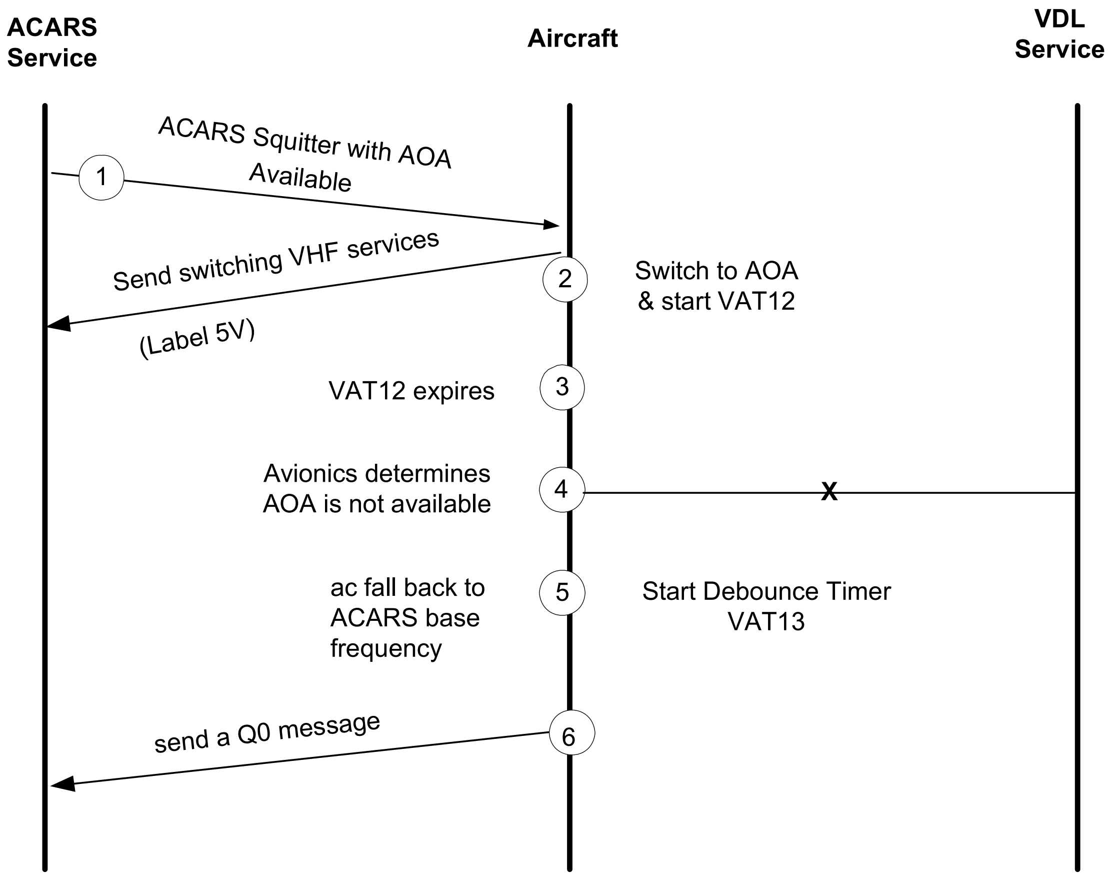


Figure 18-5 – Fallback from AOA to ACARS (After VAT12 Expires)

ATTACHMENT 18
AOA MESSAGE SEQUENCE CHARTS AND FLOW DIAGRAMS

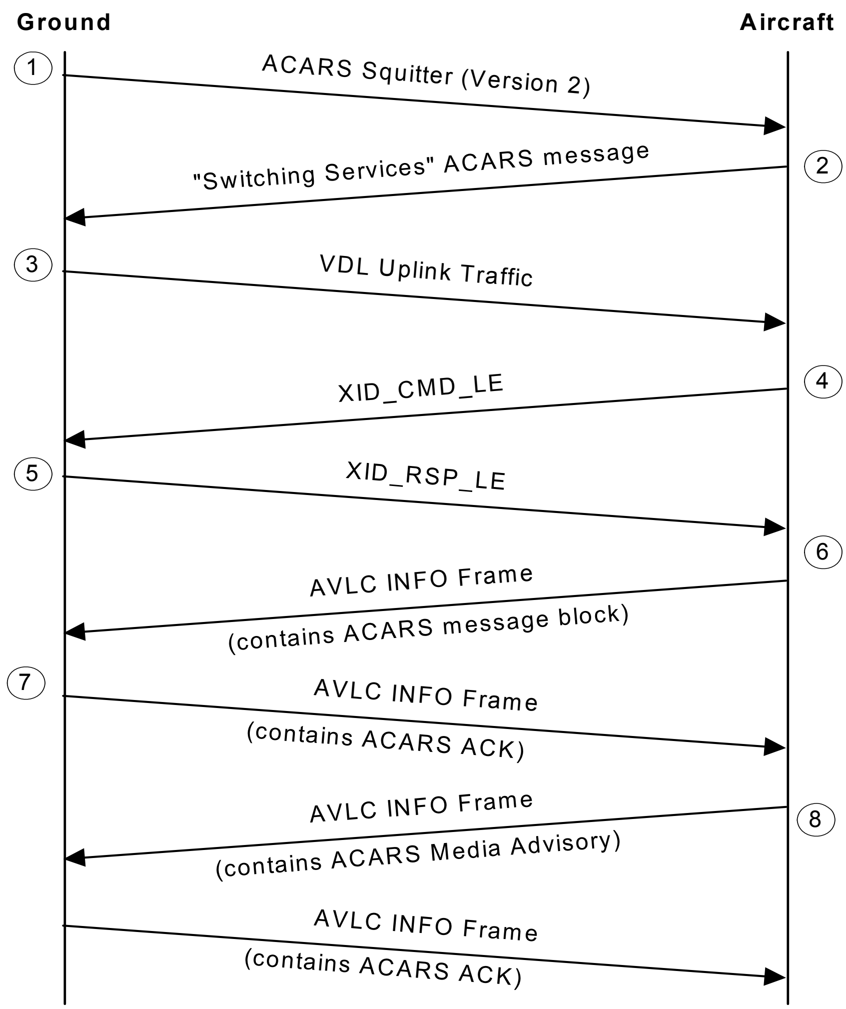


Figure 18-6 – ACARS to AOA Switch Advisory Followed by AOA Operation

ATTACHMENT 18
AOA MESSAGE SEQUENCE CHARTS AND FLOW DIAGRAMS

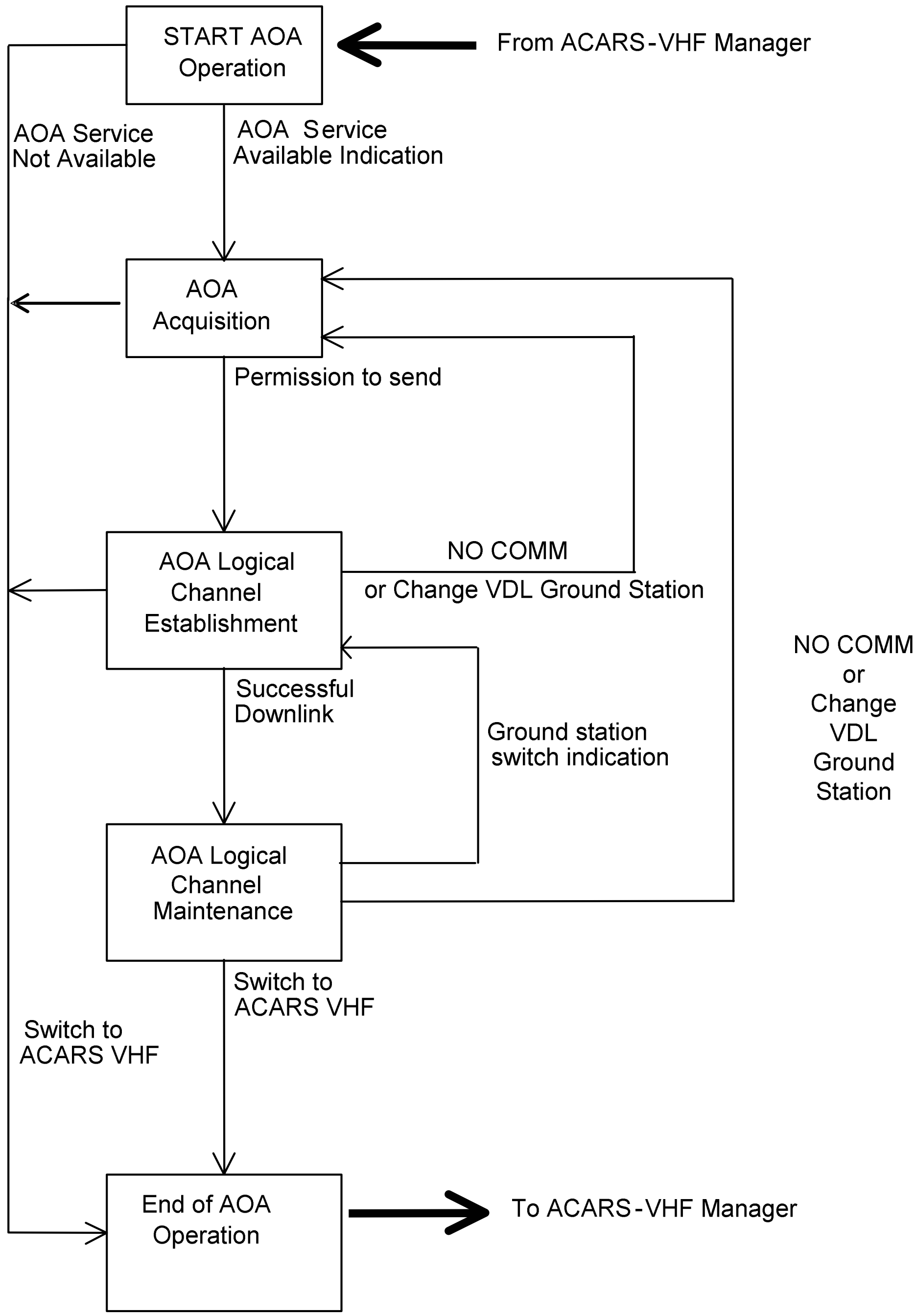


Figure 18-7 – AOA Channel Management

Note: Refer to Section 11.6 for policy options for switching from AOA to ACARS.

ATTACHMENT 19
AOA TIMING DIAGRAMS

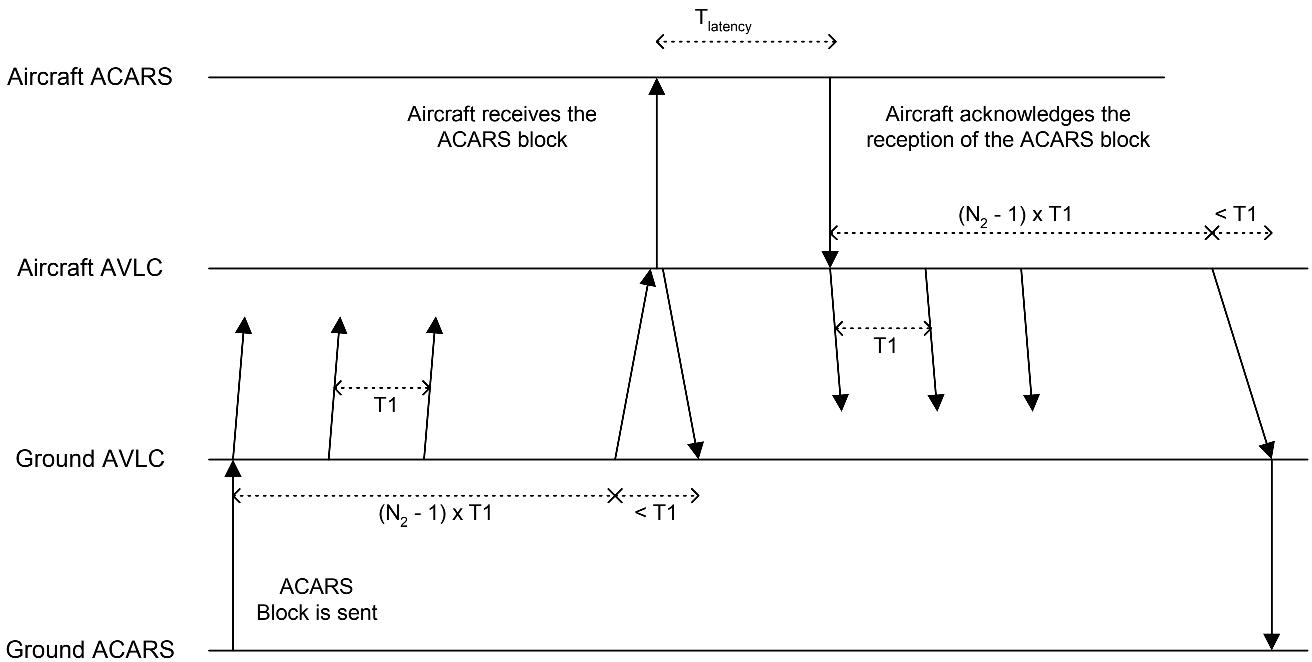


Figure 19-1 – Uplink Block Transmission Over AOA – No ACK Timer (VGT1) Role

APPENDIX A
PROTOCOL HISTORY

The VHF Air/Ground Interface has been developed and enhanced over a number of years. This appendix provides a historical record of that process.

A1.1 The Early Days and ARINC 597

VHF ACARS was introduced into operation in 1976 and its initial configuration operated on a single frequency 131.550 MHz operated by ARINC in the domestic United States.

The airborne configuration typically consisted of an ACARS 597 MU, a dedicated ACARS CU, and a 546/566 VHF transceiver that was typically a shared VOICE/DATA installation.

In addition since the VHF transceiver were at the time used only for VOICE purposes, no special design considerations had been put forth to support a DATA.

Initial applications were primarily limited to provide aircraft movement messages. Very little uplink traffic existed.

A1.2 On-Board Expansion

The next step in the evolution of ACARS involved additional interfacing to on-board systems. This advancement was driven by the potential of downlinking engine/performance data via an OAT and providing uplink messages to the crew to a Cockpit Printer. A printer was necessary due to display limitations.

A1.3 ARINC 724 Configuration

With the introduction of 1st generation digital aircraft (B757, B767, A300) a new characteristic was generated in 1979. The MU/VHF interface was changed to support an ARINC 716 VHF Transceiver and expanded peripheral capabilities were added such as a DFDAU and FMC using ARINC 429 file transfer protocols. CMUs would pass frames as received and forward.

A1.4 Frequency Management

As domestic carriers were unable to have Data Link service in many of their international routes and as international airlines became interested in Data Link and its potential services, additional Service Providers emerged on alternate frequencies. At the same time traffic on the ARINC network was increasing in some geographic areas to the point of secondary frequencies being needed.

To complicate this operation a new approach to manage frequencies was needed to satisfy inadvertent transmissions in unauthorized frequencies.

Frequency Management was created to properly manage multiple frequency ACARS operation.

A1.5 Category B Operation

As new service providers emerged, a new air/ground protocol developed that allowed the aircraft to manage ground station handoffs because, in their networks, this could simplify ground/ground communications.

A1.6 ARINC 724B Configuration

With the introduction of 2nd generation digital aircraft (B747-400, MD-11, A320) a new characteristic was generated in 1986. Many new interfaces were added at this time including MCDUs, Multiple Input Printer, Maintenance Computers, Digital OOOI sources, and the use of General Purpose ARINC 429 Data Bus interfaces.

A1.7 Multiblock Downlinks

A1.7.1 Background

The first definition of multiblock transmission only allowed the Datalink Service Provider (DSP) to recognize whether a block was not the last block of a message. This was accomplished by using the End of Block <ETB> character (1/7) to end the block and the End of Transmission <ETX> character (0/3) to designate the end of the message. The service provider kept on reassembling the ETB blocks until an ETX block was received, at which point the message was sent to the user.

The above system worked well if a multiblock message could be sent through a single ground station with no collisions, etc. Problems started arising once the transmission was interrupted for whatever reason. For example, while an aircraft is downlinking a multiblock message, the MU may need to move its point of connection from one Ground Station to another. Also, the MU may need to interleave another message with the multiblock message. In spite of these interruptions, the service provider needs to reassemble the different blocks into a whole message before delivering it to the user.

Since the message contained no indication to the DSP of what order the blocks were to be reassembled, it sometimes lead to messages being reassembled with blocks out of sequence or missing. This problem was exacerbated by each vendor and service provider having their own private definitions of when to time out on a message and whether or not to continue with the last block which had not gotten through or to start again with the first block of the message.

The first step forward was the introduction of the Positive Acknowledgment protocol. With this, at least the aircraft could tell when each block was being acknowledged. But the DBI still does not always enable the service provider to interpret the order of the blocks so many problems remained.

Other problems arise when aircraft using Category B logical channels change ground station during multiblock transmission. The definition was that logical channel changeover should lead to the message being continued.

The solution to the problems described above was to redefine the 4 character Message Sequence Number field to indicate which message a block belongs to (Message Number) and the position in the sequence of that message's blocks

(Block Letter). The Message Sequence Number (MSN) may either be entered by the ACARS MU or the originator avionics system.

The new definition of the MSN solves all the problems experienced with downlink multiblock messages. Since the service provider can identify which message a block belongs to and where it should be in the message, the reassembly task becomes elementary. The service provider can ensure that messages are reassembled with the blocks in the right order and can even tell when a block is missing.

This system removes the requirement for any restart timers and fixed definition of whether a message must be restarted on logical channel changeover since the MSN indicates whether the aircraft has continued with the last block received or restarted the transmission with a new message number.

A1.7.2 Positive Acknowledgment

There are two different formats for messages, original and Positive Acknowledgment. They apply both to air-to-ground messages and ground-to-air messages. There are no provisions for air-to-air messages.

The original format provides for the use of a single ISO #5 character to identify an uplink message. This character was designated the Uplink Block Identifier (UBI). There is no provision for a complementary character in the downlink message.

Later, when the Positive Acknowledgment Protocol was devised, the original/new assignments were necessary to distinguish between the two formats.

The new format, provides for the single UBI character defined for the uplink to be limited to the alphabet (letters A-Z). In downlinks, a single character Downlink Block Identifier (DBI), immediately following the Label field, is used as well. The DBI is limited to numbers (0-9).

The new format also uses the Technical Acknowledgment field in a different way than original format in certain messages. Assume the airborne subsystem has correctly received an uplink message, containing an UBI. The MU should enter this UBI, in place of the positive acknowledgment character (ACK), of its responding downlink message. The MU should continue to report incorrectly received uplink messages with the negative acknowledgment character (NAK) in the Technical Acknowledgment field.

Except for the above mentioned differences in the use of the block identifiers and Technical Acknowledgment fields, the two formats are identical.

Original format uplink and downlink messages and new format uplink and downlink, should be constructed as follows:

Technical Acknowledgment implemented in the Original format is structured to support an acknowledgment with the use of the ACK (0/6) control character.

The MSN and the Downlink Block Identifier (DBI) were used by the DSP to detect such duplicate downlink transmissions. See Section 2.2.6 for a description of the DBI. The DSP should examine the MSN of each downlink block in order to determine whether or not the downlink is a retransmission of the block immediately preceding it. Detection of any non-valid DBI character should result in the block being discarded.

The DSP should compare the MSN of the incoming block with the MSN of the preceding block and compare the DBI of the incoming block with the character found in the DBI position with a reference character. Normally, the reference character should be the character contained in the DBI character position of the immediately preceding downlink block. However, if the DBI Reset timer (GT8) expires, the reference DBI character should be set to the control character <NUL>. If the two MSN values and the two DBI characters match, then the downlink should be deemed a duplicate and discarded.

A1.8 Original Format Description

COMMENTARY

> The original format is included in this specification to document systems which were built before the definition of the Positive Acknowledgment Protocol format and have not been reprogrammed.

The original definition of ACARS air-ground messages included a one-character field designated uplink block identifier, or UBI, in messages sent from the ground to the aircraft. The airborne equipment used the contents of the UBI field to identify duplicate transmissions only.

In 1988 the industry asked that a downlink block identifier be defined to improve downlink multi-block handling, resulting in the definition of a new message format.

In the original definition, a downlink block identifier (DBI) was not considered to be necessary. Therefore the DBI field was omitted in the definition of messages sent from the aircraft to the ground.

Technical Acknowledgment implemented in the Original format is structured to detect an acknowledgment with the use of the ACK (0/6) control character alone in the Technical Acknowledgment field of the uplink.

The Standardized Acknowledgment format provides for the use of a single character to identify an uplink message. This character is referred to as an uplink block identifier (UBI), and enables the aircraft to detect duplicate messages.

A downlink message in the standardized acknowledgment format does not contain a similar downlink block identifier (DBI). The Standardized Acknowledgment format is obsolete. It is recommended that the Correlated Acknowledgment defined in Section 3.5.2 be used.

DSPs assign a UBI to all uplink transmissions using one of the following schemes:

a. Each new block uplinked to a given aircraft is assigned a new UBI, even for general responses to downlink retransmissions. The following sequence will be used:

A, B, C, D... Y, Z, A, B, ... etc.

The first UBI of all new sequences is an “A”.

b. The first block uplinked to a new aircraft is assigned a UBI identical to the datalink service provider’s logical channel identifier (mode character) and is represented in lowercase: a, b, c ... x, y, or z.

All subsequent blocks will have UBIs which alternate between lowercase and uppercase. For example, if the first UBI is “s”, the sequence starting with the second UBI is:

S, s, S, s, S, s, ... etc.

COMMENTARY

This implementation has proven to be limiting and should not longer be used.

Retransmitted blocks retain their original UBIs, except when the retransmission is caused by the aircraft transmitting one of the labels Q5, CA, CB, CC, CD, CE, CF.

Note: A new aircraft is one that did not use the ground station for a period of “x” (see Appendix D) minutes.

The correlated acknowledgment format provides for the use of alphabetical characters to identify uplink messages, and numeric characters to identify downlink messages. Under the correlated acknowledgment format, one byte is added to the downlink header. This byte contains a DBI (‘0’ to ‘9’) that uniquely identifies a downlink block. The technical acknowledgment field of the uplink acknowledgment block contains the DBI being acknowledged or a negative acknowledgment (NAK). In addition, for an uplink block correctly received by the avionics, the correlated downlink block contains the UBI (‘A’ to ‘Z’) being acknowledged or a NAK in the technical acknowledgment field. Uplink blocks remain the same except for the technical acknowledgment field. Refer to section 3.1.1.2.1 for the assignment of UBIs for uplink messages.

A DBI is a single character located after the label field at the beginning of text, and is provided in all downlinks in the correlated acknowledgment format. Its function is to enable DSPs to detect duplicate messages or message blocks. Airborne sub-systems change the bit pattern transmitted in this character position each time a general response or a new message or message block is transmitted by the aircraft. Any retransmission of a given downlink required to secure a response from the DSP contains the same bit pattern as the first transmission of that downlink.

DSPs handle downlinked messages with or without DBIs. When DSPs receive a downlink message with a DBI, they send an acknowledgment in the following manner:

1. If the Block Check Sequence (BCS) passes, the DBI character is reflected in the technical acknowledgment field of the next uplink sent to the aircraft. The uplink response can be an uplink message already on queue for the aircraft (referred to as an embedded acknowledgment), or a general response acknowledgment.

2. If the BCS fails, no acknowledgment will be sent to the aircraft. It is the aircraft's responsibility to assume a link failure and retransmit the message.

   Note: A DSP may elect to respond to a downlink message that fails the BCS by embedding the NAK character in the technical acknowledgment field of the next uplink message.

A1.9 Message Sequencing

At present message sequencing is provided only in downlink messages.

The original version of the Downlink Message Sequence Field consists of a time stamp minute-minute/second-second format (mmss) generated by the MU at the time message is first attempted to downlinking.

Optionally the MU may or if the message is externally sourced by a onboard subsystem such as the DFDAU the field contains a DEVICE ID, such as D for DFDAU, and a three digit numeric field that is incremented for each downlink transmission.

NOTE: This implies that this is actually a BLOCK Sequence Number and not a MESSAGE Sequence Number.

A1.10 Voice to Data Changeover

The following crew annunciation functions were supported by ACARS MUs which had the capability to support both VOICE and DATA modes.

A1.10.1 Voice Busy Uplink

If a Voice Busy, label Q4, uplink is received the MU should provide a VOICE CIRCUIT BUSY annunciation.

Various forms of annunciation may be utilized depending on user requirements and aircraft configuration.

All CMU's should provide the capability to annunciate the VOICE BUSY condition on the ACARS CDU.

Additionally the 724B MU should provide a digital annunciator of VOICE BUSY in its Label 270 output word on its ARINC 429 General Purpose data buses.

The advisory may be reset within the MU in response to appropriate flight crew action; e.g., acceptance of the Advisory via the CDU or could automatically time out with an internal timer.

A1.10.2 Voice Circuit Busy Advisory - Label Q4

Voice Circuit Busy Advisory, Label Q4, is an uplink message transmitted when the party on the ground with whom the pilot desires voice communications cannot be reached because ground circuits are busy or his telephone is already in use.

The format of the message is defined in Section 4.2.4 of ARINC Specification 620.

APPENDIX B
ACARS OVERVIEW

The following outline provides an overview of ACARS system functionality. The basis for this description is an article written by Nigel Lee, Boeing. A number of revisions were inserted by the ACARS Subcommittee.

AIRCRAFT COMMUNICATIONS ADDRESSING AND REPORTING SYSTEM (ACARS)

Reprinted with permission from Boeing Airliner.

by Nigel J. Lee

Flight Data Systems Engineer, Avionics Engineering

The Aircraft Communications Addressing and Reporting System (ACARS) is a communication data link system which sends messages between an airplane and ground system including airline host computers (for AOC messages), ATC host computers (for ATS messages), and other parties. ACARS is available as an option on most commercial aircraft currently in production or as a retrofit. The operational features of ACARS equipment, and the ways in which ACARS is used in service, vary widely from airline to airline.

ACARS Overview

A message from the airplane to the ground is called a downlink and a message from the ground to the airplane is an uplink. ACARS downlink messages are sent from the airplane through either a VHF transceiver to a ground network or via SATCOM satellite Airborne Earth Station (AES) SATCOM transmitter to the ground network. The ground network delivers the message to the airline ground operations base or ATC facility. Uplinks are routed vice versa. Messages to be downlinked can be entered manually by the flight crew using a control unit keyboard or may be generated automatically by the ACARS or one of its interfacing airplane systems.

There is nothing new about sending messages between the airplane and the ground. What makes ACARS unique is that messages concerning everything from the contents of the fuel tanks and maintenance problems to food and liquor supplies can be sent by ACARS in a fraction of the time it takes using voice communications, in many cases without involving the flight crew.

ACARS relieves the crew of having to send many of the routine voice radio messages by downlinking preformatted messages at specific times in the flight. These may include the time the airplane left the gate, lift off time, touchdown time, and time of arrival at the gate. These basic ACARS functions are known as the Out Off On In or OOOI times. In addition, ACARS can be requested by the airline ground operations base to collect data from airplane systems and downlink the requested information to the ground.

Most ACARS messages take less than one second of air time to transmit. Because of the automatic reporting functions described above, the number of radio frequency changes that flight crews must make is reduced on ACARS equipped airplanes. Sending and receiving data over the ACARS network reduces the number of voice contacts required on any one flight, thereby reducing communication workload and costs. ACARS messages are limited to a length of 220 characters of text which is adequate for routine messages. Longer messages, known as multi-block messages, can be sent as a series of separate ACARS messages, which are later regrouped by the ground system.

The accurate reporting of event times, engine information, crew identification, and passenger requirements provides for a close control of any particular flight. Airplane system data, such as engine performance reports, can be sent to the ground on a pre-programmed schedule, or

APPENDIX B
ACARS OVERVIEW

personnel on the ground may request data at anytime during the flight. This allows ground personnel to observe the engines and systems and can alert them to problems to be investigated.

The uses of ACARS are almost endless and vary from airline to airline. The following is a short list of ACARS applications which tend to be common among ACARS users:

- Crew Identification
- Out Off On In Times
- Dispatch and Weather Updates
- Engine Performance
- Fuel Status
- Weather Services
- Automatic Terminal Information Service (ATIS)
- Selective Calling (SELCAL)
- Flight Status (ETA, Delays, Diversions)
- Passenger Services
- Maintenance Items

The ACARS network is made up of three sections: the airborne system, the service provider ground network, and the airline operations center (See Figure 1).

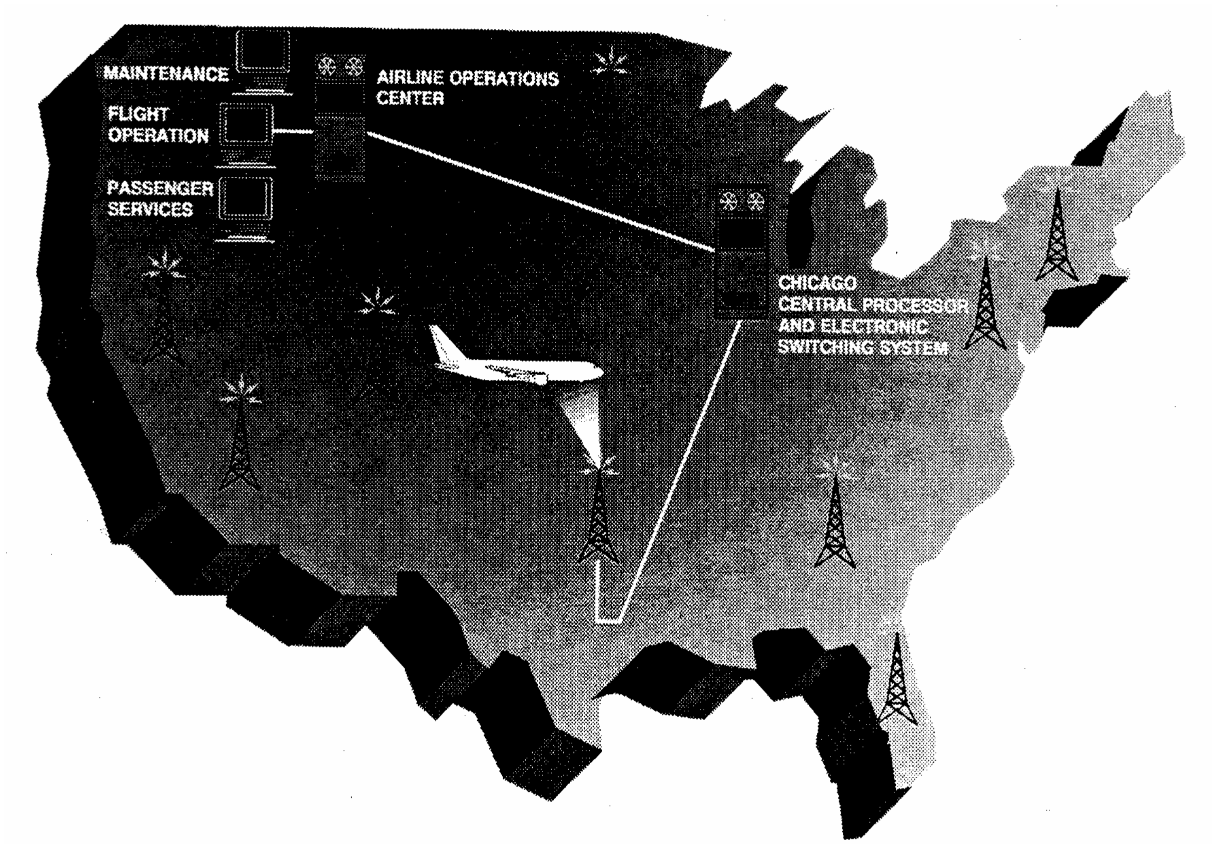


Figure 1 – Components of the ACARS Network

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ACARS OVERVIEW

ACARS Airborne System

The airborne system (See Figure 2) has an ACARS Management Unit (MU), which manages the incoming and outgoing messages, and a control unit (CU) which is used by the crew to interface with the system. A printer may be installed to print incoming messages. An optional cabin terminal may be installed to provide the cabin crew with direct access to the ACARS network, thereby avoiding the need to distract the flight crew with passenger service communications.

ACARS may be connected to other airplane systems such as the Digital Flight Data Acquisition Unit (DFDAU). The DFDAU collects data from many of the airplane systems such as air data, navigation and engine instruments; and in turn makes the data available to the ACARS. More recently ACARS installations have been connected to the Flight Management Computer permitting flight plan updates, predicted wind data, takeoff data and position reports to be sent over the ACARS network.

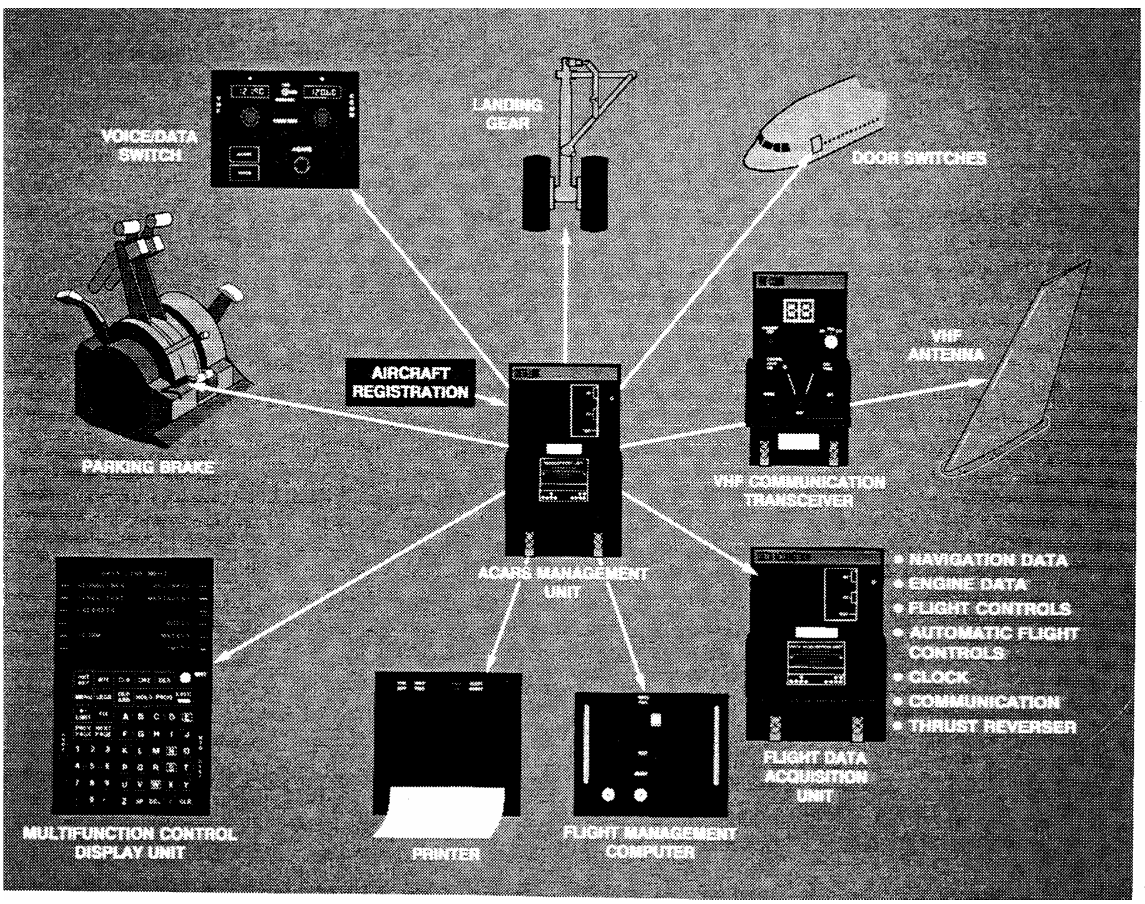

Figure 2 Typical ACARS Airplane Installation

The ACARS uses an airplane VHF communication system (usually No. 3 VHF) to transmit and receive data. The VHF communication system is usually dedicated to ACARS but in some installations a VOICE/DATA switch is installed to enable the VHF used by ACARS to be used in the voice mode like any other VHC communication system. The ACARS MU is responsible for controlling the VHF communication system associated with it. In the United States, all ACARS messages are initially transmitted on a VHF frequency of 131.55 Mhz; in other countries, different frequency may be used.

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ACARS OVERVIEW

Whenever the ACARS MU is ready to downlink a message, it will first determine if the ACARS channel is free of other traffic. Once the MU has determined that the ACARS channel is free of traffic, it will downlink the message. The ground station, on receiving the message, will perform an error check. If the message is error free, the ground station will send the message via a land-line to the addressee. In addition, the ground station will generate an ACKnowledgment (ACK) and uplink it back to the airplane. On receipt of the ACK the task will be complete. The MU will clear the message from its memory and return to a quiescent state.

An acknowledgment will only be uplinked if the ground station determines the message to be error free. If no acknowledgment is received by the MU, the MU will try to send the message again. The MU will try to send downlink a total of six times before it gives up. The message to be downlinked will then be stored and the crew will be notified by a message on the control unit indicating that no communication (NO COMM) was made with the ground station. This scenario also holds true for downlinks that are attempted when the airplane is out of range of a ground station. In this case the unacknowledged message is stored in memory until the crew initiates another downlink. If that does not occur, the message will be stored until a valid uplink message addressed to that airplane is received, or an IN event (parking brake on and at least one door open) occurs, after which the stored message will be downlinked.

Should two airplanes attempt to simultaneously downlink a message, the messages will be garbled when received by the ground network and no acknowledgment will be sent to either airplane. In this case, the airplanes will try to downlink the messages again, and because the MU has a random timer, the second attempt of the message is highly unlikely to be downlinked at the same instant by both airplanes.

The Management Unit is responsible for formatting the messages. The protocols for formatting the messages are varied.

For a complete description please refer to ARINC Specification 618 and 620. Additional information will be found in Annex 10 to the Convention on International Civil Aviation (an ICAO document).

ACARS Message Structure

The structure of messages uplinked and downlinked is the same (see Figure 3). The MU attaches a preamble to the message to be downlinked.

Typically, the first 23 characters of the message preamble are known as the Pre-Key and each character is represented by seven bits of logic 'ones'. These characters allow the receiver automatic gain control and transmitter power to stabilize. The next two characters (bit ambiguity) enable the receiver to determine that the process of identifying character bits is operating correctly. The two-character synchronization (SYN) bits allow the message processor to establish character synchronization. Following the SYN characters is the start of heading (SOH) character which indicates the beginning of the message block. The Mode character which follows the SOH is transmitted to indicate the category of operation. ACARS supports two categories of operation, CAT A and CAT B. CAT A operation is identified by a Mode character of 2. The seven-character address field identifies the destination of the message. In an uplink message, the address is the airplane registration or the flight number. The address of a downlink message is the registration of the airplane originating the message. Every downlink message will contain an Uplink Block Identifier (UBI) indicating an acknowledgment or a Negative Acknowledgment (NAK) and the character following the address will always be an UBI or a NAK. The two-character label identifies the message type and routing. For example, the label characters 5U identify a weather report. The next character is the block identifier which is used by the ACARS MU to identify duplicate messages or message blocks of multi-block messages. The end of the preamble is identified by the end of the text control character (ETX) for messages which contain no text, or the start of text control character (STX) if the message contains text.

The message text is suffixed by the end of text control character ETX. The suffix is followed by the block check sequence (BCS) which is used for error detection.

ACARS message are classified as system related messages or service related messages. System messages are those associated with the operation of the ACARS network as a digital communication system. Such messages include data transceiver automatic tuning and voice control circuit busy. Service related messages are those associated with the services that the ACARS provides such as an on report or ATIS request.

Messages uplinked are checked by the MU to ensure that only properly formatted and valid messages are accepted. The MU first checks the upcoming message to see if it is addressed to the airplane registration or flight number (both the airplane registration and the flight number are valid addresses) on which the MU is installed. If it is not, the message will be discarded and no further processing will take place. If the message is addressed to the correct registration or flight number, the complete message will be received and stored. The flight crew will be notified by the control unit that a message is waiting to be displayed (MESSAGE WAITING).

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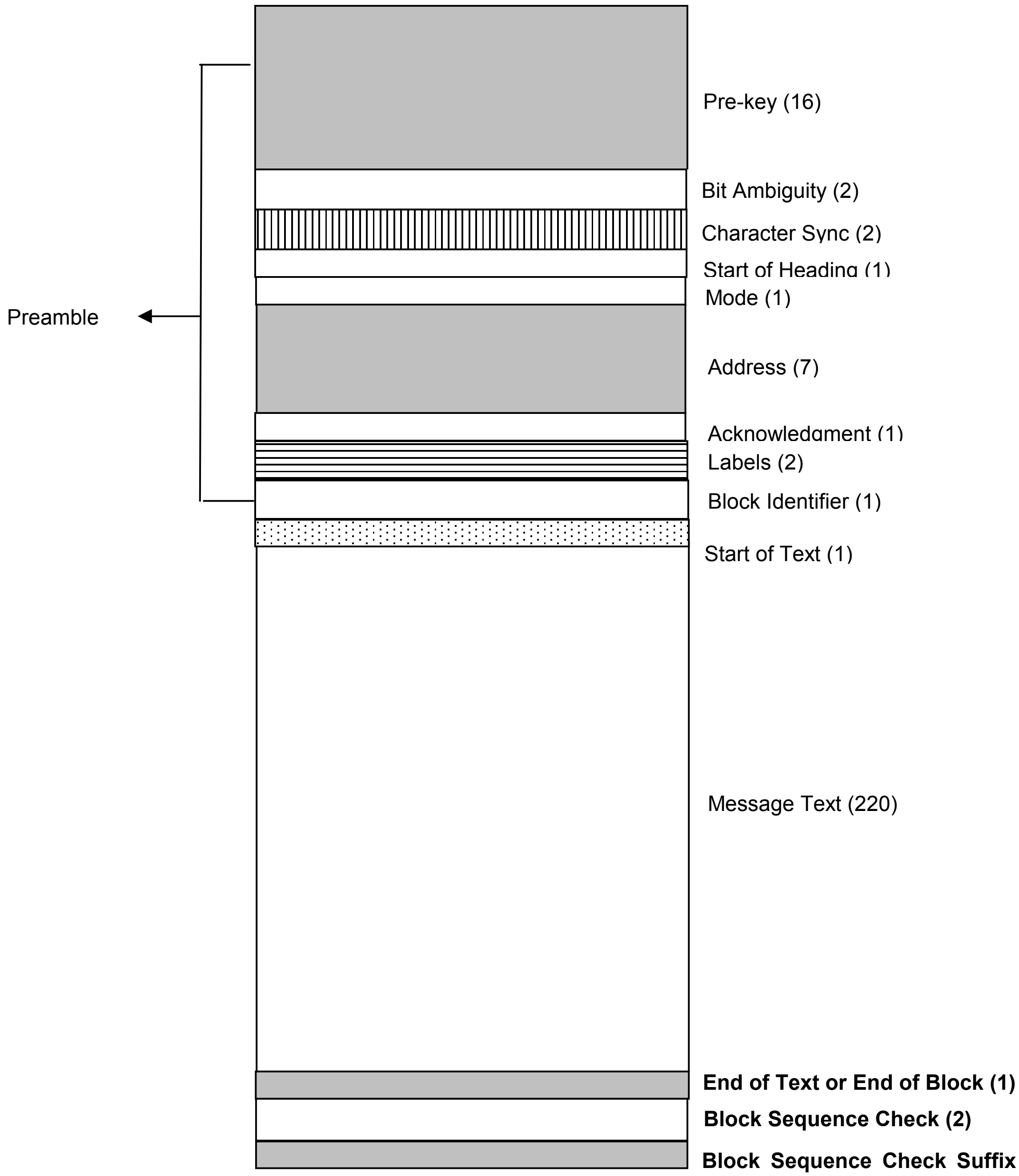

Figure 3 – ACARS Message Structure

An uplinked message can be addressed to a peripheral piece of equipment such as the Digital Flight Data Acquisition Unit (DFDAU) or Flight Management Computer (FMC). Messages addressed to the DFDAU can request that data be collected by the acquisition unit, formatted, and sent to the ground. Data from peripheral equipment can also be sent to the ground on a schedule determined by flight mode such as when the airplane reaches a stable cruise, altitude or top of descent.

The ACARS can be used to establish Selective Calling (SELCAL) contacts. The uplinked SELCAL message attracts the flight crew's attention by sounding a chime. The flight crew silences the chime and makes radio contact on the frequency contained in the uplinked message which is displayed on the control unit or printed on the cockpit printer. Call Select (CALSEL) message are used to downlink the address (telephone number) of parties on the ground with whom the crew wish to communicate.

ACARS Ground System

The ACARS ground system is made up of the two parts (see Figure 1). The first part is the radio and message handling network, which is controlled by Aeronautical Radio, Incorporated (ARINC) in the United States, the Air Canada Network in Canada, AVICOM in Japan and Societe Internationale de Telecommunications Aeronautiques (SITA) in Europe and other parts of the world. The service provider operates the remote radio sites, to Front End Processing System and to data network system which act like a post office and ensure that the messages are routed to the correct addressee.

The second part of the ground network is an airline's operations or message center. The network is connected to the airline operations center by a land-line. At the airline, the message handling is performed by a computer system which sends received messages to the appropriate department (operations, engineering, maintenance, customer services, payroll) for the appropriate action. Messages from an airline department, such as a request from engineering for engine data, follow the same route in reverse.

Typical ACARS Flight

The flight profile depicted in Figure 4 [see page 89] describes some of the ACARS messages that may be sent on a typical flight. Before the ACARS can be used, the system must be initialized. This is done by entering such data as the crew identification, flight number, fuel on board, departure airport and destination airport. If the time on the ACARS display is incorrect (the Universal Time Clock [UTC] should be accurate to one second in 24 hours), it may be updated by initiating a UTC clock update downlink to which the uplink response will automatically update the ACARS internal clock. After the system has been initialized, it is ready for use.

When all the airplane doors have been closed and the parking brake released, the ACARS will automatically downlink the OUT report. The OFF report will be sent when the airplane takes off, which is usually actuated by the main gear squat switch taking up the airborne position.

When the DFDAU determines the airplane has reached a stable cruise, it will downlink an engine report. At some interval during the flight, the crew may be required to make routine position reports. The crew will be prompted to enter such data as position, altitude, ETA, fuel on board and weather conditions. When the information has been entered into the ACARS, pressing the send button will downlink the message.

At touchdown (weight on the wheels), an ON report will be sent automatically. When the parking brake is set and at least one door is open, the IN report will be transmitted.

Summary

ACARS has been a great benefit to the using airlines. The advantages of ACARS equipment have been quickly realized; more and more airplanes are being delivered with ACARS equipment installed. ACARS will continue to be intensely developed to meet a growing need to exchange information between the airplane and the ground. ACARS can reduce flight crew workload and alert maintenance by providing a data link with personnel on the ground.

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The ACARS in use today vary greatly from one airline to another and are tailored to meet each airline's operational needs.

There is a trend toward standardization of ACARS without sacrificing airline flexibility which in the long run will be beneficial to all. Some ACARS can have their software programs changed without removing the unit from the airplane. This feature permits common hardware to easily take on different characteristics.

When satellite communication systems as adopted in the near future, ACARS will take on a truly global aspect.

References

1. ARINC Characteristic 597, Mark 2 Aircraft Communications Addressing and Reporting System
2. ARINC Characteristic 724, Mark 2 Aircraft Communications Addressing and Reporting System
3. ARINC Characteristic 724B, Aircraft Communications Addressing and Reporting System (ACARS)
4. ARINC Specification 618, Air/Ground Character-Oriented Protocol Specification
5. ARINC Specification 619, ACARS Protocols for Avionic End Systems
6. ARINC Specification 620, Data Link Ground System Standard and Interface Specification
7. ARINC Specification 622, Processes for ATS data Link Applications Over ACARS Air/Ground Network
8. ARINC Specification 623, Character-Oriented Air Traffic Service (ATS) Applications
9. Annex 10 to the "Convention on International Civil Aviation, ", International Civil Aviation Organization (ICAO)

UTC	FLIGHT NUMBER				

ENGINE DATA REPORT

UTC	FLIGHT NUMBER	OFF TIME	FUEL QTY	

OFF REPORT

UTC	FLIGHT NUMBER	OUT TIME	FUEL QTY	

OUT REPORT

UTC	FLIGHT NUMBER	TIME	

POSITION REPORT

UTC	FLIGHT NUMBER	ON TIME	

ON REPORT

UTC	FLIGHT NUMBER	IN TIME	FUEL QTY	

IN REPORT

Figure 4 – Typical Flight Segments for an ACARS-Equipped Airplane

B1.0 Addressing

The Address field of both uplink and downlink ACARS blocks contains the address of the aircraft. The aircraft must provide its identification information in the Address field of all downlink blocks. The address of the aircraft will normally be the aircraft Registration Mark. In the case of uplink messages, when the registration mark is unknown by the DSP's Data Link Service Processor, the Flight Identifier is entered in the Address field. In this case, the ACARS MU is required to recognize its own Flight Identifier and respond to the uplink with a downlink containing its Registration Mark in the Address field. For this purpose, the Flight Identifier supplied by the user must be unique. Otherwise multiple aircraft may recognize the message as being addressed to them.

B1.1 Aircraft Identification

In order to establish and maintain contact with an aircraft and service messages to/from the aircraft, the Data Link Service Processor needs to recognize which user owns the aircraft. This is because the information concerning the delivery of downlink messages by the Data Link Service

Processor is based on user identification. The DSP configures the Data Link Service Processor, allocating a unique two letter identification code (normally its agency code) to each user.

There are two methods of configuring an aircraft as belonging to a given user, static configuration and dynamic configuration. In static configuration, the aircraft's registration mark is identified by an Data Link Service Processor operator as belonging to a given user code. If however dynamic configuration is used, the Data Link Service Processor will dynamically configure any aircraft that report the user's code in the Agency Code field of their messages. In one DSP implementation, aircraft in the register are cleared from the dynamic configuration file at 0000 hours UTC if there has been no communication with them during the preceding 24 hours. To use the dynamic configuration facility, users must ensure that their agency code is not used by other operators.

B1.2 System Access Area Function

In ground networks utilizing Category B operation, the System Access Area (SAA) function allows an aircraft to designate which ground station it wants to use. This function is an extension to the original ACARS definition. The SAA function is achieved by allocating an SAA code to each RGS. The SAA code is configured in the Ground Terminal Computer (GTC) of the RGS, and it will only relay downlink messages containing its SAA code or a '2' in the Mode Character position. Each GTC is configured with a squitter interval of approximately 120 seconds. The interval is not precisely the same for any two RGS because the squitters could overlap and collide. The squitters are generated and transmitted at the squitters interval by the GTC (and not by the Data Link Service Processor) in the absence of any other traffic in order to make aircraft within range aware of the presence of the RGS.

Both the Data Link Service Processor and the Remote Ground Station (RSG) play a part in the SAA function. The aircraft configuration tables in the Data Link Service Processor indicate that a given aircraft is equipped with the SAA function. For uplinks to SAA equipped aircraft, the Data Link Service Processor places a code in the Mode Character field to indicate to the GTC that it should place its SAA code in the message before transmission on the Radio Frequency. Thus, all uplinks to such aircraft will automatically contain the RGS's SAA code (even if the aircraft has not previously designated the RGS). The Data Link Service Processor does not validate the SAA character in downlink messages. It will accept multiblock messages with blocks that arrive through multiple RGS with different SAA characters.

B2.0 Block Identification

In the original ACARS definition, which is still used in some aircraft, the Block Identifier field is only present in uplink ACARS blocks. The function of the Uplink Block Identifier (UBI) was to enable the ACARS MU to detect a duplicate uplink block i.e., one that had already been received. A secondary benefit was that it enabled ground stations to recognize blocks sent by other ground stations as uplinks so that they could be discarded and ignored. As a result of modification to the ACARS RF protocol definition, a Downlink Block Identifier (DBI) was added to improve duplicate detection by ground systems. The DBI field is also used in the acknowledgement process as described in Section D.3 below. The range of possible Uplink Block Identifiers sent by the Data Link Service Processor is limited to "A" (41 Hexadecimal) to "Z" (5A Hexadecimal). The range of Downlink Block Identifiers sent by the ACARS MU is limited to "0" (30 Hexadecimal) to "9" (39 Hexadecimal). The Block Identifier must be incremented with each new block successfully sent. The Data Link Service Processor uses a combination of the DBI and the Message Sequence Number (MSN) to detect retransmitted downlink blocks. For example, in one DSP implementation, if the DBI and MSN of a received block are the same as those of either of the two preceding blocks from that aircraft, the block is considered a duplicate.

B3.0 ACARS Acknowledgement

The ACARS protocol requires that each block sent across the RF by the sender be acknowledged by the recipient. In the aircraft, the acknowledgement protocol is administered by the ACARS Management Unit (MU).

In the original definition of the ACARS protocol, which is still used in some aircraft, only one field of the ACARS block is used in the acknowledgement process, the Technical Acknowledgement field. In a block which does not acknowledge another block, the Technical Acknowledgement field contains the character <NAK> which has the 7-Bit code ‘15’ Hexadecimal. In a block which does acknowledge another block, the Technical Acknowledgement field contains the character <ACK> which has the 7-Bit code ‘06’ Hexadecimal. The protocol also allows for a negative acknowledgement (NAK) in the case where a message is received but the Block Check Sequence (BCS) checksum is found to be incorrect. The receipt of a negative acknowledgement (NAK) prompts the immediate retransmission of the negatively acknowledged block.

The process described above has the disadvantage that an acknowledgement does not explicitly acknowledge a specific block. As described in Section D.2, the ACARS definition was upgraded to improve the acknowledgement procedure by allowing an explicit acknowledgement. The method chosen to achieve this was to add a downlink block identifier to the format of downlink blocks and to specify that an acknowledgement should contain the block identifier of the block being acknowledged in its Technical Acknowledgement field. The negative acknowledgement process was not altered.

The ACARS protocol is half duplex protocol. A half duplex protocol does not allow communications in both directions at the same time. In both the VHF and Satellite systems, it is possible for an uplink and a downlink block to be sent at more or less the same time and to cross over. The ACARS MU and the Data Link Service Processor will both be waiting for an acknowledgement for the block they have sent and will instead receive a block which does not contain an acknowledgement. Receiving a response with a NAK to a message is defined to mean that the block should be retransmitted, but if each sender were simply to repeat the block which appears to have been negatively acknowledged, the retransmissions would fall into the cross over pattern as well and the communication could be continue indefinitely (locked up). The convention chosen to resolve this situation is that if an ACARS MU is expecting an acknowledgement for a previously transmitted block but instead receives a block which does not contain an acknowledgement, it should accept the received block and immediately retransmit the previously transmitted block including an acknowledgement for the received block. On the ground side, if the Data Link Service Processor is expecting an acknowledgement for a previously transmitted block but instead receives a block which does not contain an acknowledgement, it discards the block and continues to wait for the acknowledgement from the ACARS MU of the original uplink. On receiving the acknowledgement, the Data Link Service Processor will acknowledge the downlink block.

A block acknowledgement may be contained in any ACARS message type but, if no message is waiting to be sent and a block requires acknowledgement, the following label can be used:

ACARS BLOCK LABEL	RELATED FUNCTION
_DEL	General response

An ACARS MU will acknowledge all ACARS message types except General Response. The Data Link Service Processor will acknowledge all ACARS message types except General Response, certain service messages (such as Labels Q5 and CA-CF), and the Temporary Suspension (Label 5P) message.

B4.0 Multiblock Messages

The protocol defined for ground/ground communications between the Data Link Service Processor and user ground systems in Chapter 3 is capable of transporting 3840 characters in a single packet. The ACARS protocol is capable of transporting only 220 characters of text in each block. In order to avoid restricting message length to the length of the ACARS block text field, the ACARS protocol allows for multiblock messages.

The Block Terminator field of all messages is coded with the ASCII character <ETX>. The first and intermediate blocks of multiblock messages are coded with <ETB> in their Block Terminator field. Thus, the Block Terminator field of all single block messages and the final block of multiblock messages are coded with <ETX>.

B4.1 Multiblock Uplink

The Data Link Service Processor automatically divides messages received from user ground systems into as many ACARS blocks as necessary and sends them block by block to the airborne avionics. The maximum length of an uplink message is not limited by the Data Link Service Processor but by the maximum length of a message permitted by the communication link from the user to the Data Link Service Processor. Assuming proper format and addressing, any uplink message received by the Data Link Service Processor will be transmitted across the RF link. A maximum length message will result in an ACARS message consisting of 16 (occasionally 17) ACARS blocks.

B4.2 Multiblock Downlink

Multiblock downlink ACARS messages are reassembled by the Data Link Service Processor before being passed to the message processing functions. A reassembly session is closed by one of the following events:

- The last ACARS block of the message is received
- No ACARS block received for at least 11 minutes
- A fifteenth ACARS block ended by ETB suffix is received

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The third criterion dictates that, for multiblock downlink messages, a maximum of 15 ACARS blocks of the same message are reassembled in the Data Link Service Processor. If a downlink message contains more than 15 blocks, the Data Link Service Processor will send two messages to the user users host system, the first containing the first fifteen blocks and then a second message containing the remaining blocks.

The transmission of multiblock messages was not foreseen in the initial ACARS definition and multiblock early attempts at reassembly were prone to error. A recent development in the protocol definition of the Message Sequence Number (MSN) will, on implementation, make multiblock reassembly more precise. Using the new MSN definition, the Data Link Service Processor is able to recognize when a new message is being sent and when a block is missing in a sequence.

APPENDIX C
INSTALLATION TEST GUIDANCE

ABSTRACT

This appendix contains a collection of procedures and pass/fail criteria pertaining to the testing of ACARS MU and SATCOM equipment to be used in aircraft installations supporting FANS-1 ATS VHF and SATCOM communications. These procedures and criteria were developed by airframe manufacturers to satisfy regulatory requirements. Usage of terms such as "shall" reflect the necessity for meeting specific criteria to obtain certification from regulatory authorities rather than any reflection of the desires of the Airlines Electronic Engineering Committee. The acceptance of regulatory authorities of installations that meet the following criteria is not assured, however. This document may not be totally current at the time of any specific installation. Designers and installers should coordinate closely with the appropriate regulatory authority to ascertain that all certification criteria are known.

Our thanks to the Boeing Airplane Company for contributing the initial documentation from which this appendix was derived.

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INSTALLATION TEST GUIDANCE

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C1.0 INTRODUCTION

This document contains a collection of requirements, procedures, and pass/fail criteria for data link communications installations.

COMMENTARY

The original document, upon which this appendix is based, was created as a result of discussions between Boeing and the Federal Aviation Administration to reflect the requirements for certification of B747-400 aircraft to support ATS communications in a FANS 1 environment.

The ACARS Management Unit (MU) is an aircraft device that serves as a communications processor for an aircraft. The ACARS MU communicates with ground-based communication systems to send and receive datalink communications between the aircraft and airline, Air Traffic Control (ATC), or other datalink services. The ACARS MU utilizes SATCOM and VHF air-ground datalink paths to convey the data messages. The ACARS MU has interfaces established on the aircraft to other avionics equipment, such as the Flight Management Computer (FMC), the Central Maintenance Computer (CMC), and the Aircraft Condition Monitoring System (ACMS). The ACARS MU transmits and receives datalink messages to and from these devices and relays messages transmitted over the air-ground datalink path.

COMMENTARY

For the B747-400, the FMC contains the ATS functions which generate and receive ATC and ATS datalink messages. For aircraft not fitted with an FMC, alternate configurations for housing the ATS functions include the MU itself, a GNNS Navigation Unit (GNU), and a GNNS Navigation and Landing Unit (GNLU). The following text assumes the existence of an FMC onboard. In alternate configurations, substitute the appropriate title (e.g. GNU) for FMC. The following text also assumes the existence of an Engine Instrument Control System (EICAS). If the EICAS is not used, these functions should be available through another device (or other devices).

C1.1 PURPOSE

The purpose of the test described herein is to verify that the aircraft ACARS MU and SATCOM equipment will perform their intended function for datalink communications to convey ATS messages to and from the ATS applications on the aircraft and between the aircraft and the ground communications systems. This test is intended to demonstrate compliance with the system requirements established by regulatory authorities. In some cases, the tests will verify that the ACARS is not susceptible to conditions and operations experienced in previous demonstration testing and determined to be unacceptable. The document can also serve to correlate the ATS System Requirements and Objectives (SR&O) for the ACARS MU to the related test sections of the Aircraft Equipment Interface Test (AEIT). This correlation is presented in Appendix 1.

COMMENTARY

Each installation designer should prepare a detailed ATS System Requirements and Objectives (SR&O) document, or its equivalent.

C1.2 Scope

This document establishes a formal means by which ACARS MU and SATCOM software can be demonstrated to provide the datalink performance necessary to support operation with FANS 1 ATS software consistent with the FANS 1 ATS SR&O document. The tests detailed within are intended to demonstrate that the particular versions of ACARS MU and SATCOM software are not susceptible to potential performance delays that might deter the datalink system from meeting the FANS 1 datalink performance guarantees of message delivery within one minute 95% of the time. This document does not provide the basis for certification of equipment installation on production aircraft, or upon in-service aircraft. Normal installation and certification requirements still apply. This test may be utilized when an airline modifies the ACARS MU or SATCOM software, to prove continued acceptability for use with FANS 1 communications.

C1.3 Test Setup

The testing shall be conducted at the designated laboratory using a test bench configuration which adequately represents the expected aircraft configuration. The ACARS and SATCOM software tested will be the production version or "red label" equivalent of the systems to be installed on the aircraft for use with the FANS 1 ATS functions of the FMC. The ACARS MU and SATCOM will be tested along with a real FANS 1 FMC. Additionally, whenever possible, other real (*rather than simulated*) interfacing avionics equipment will be used, such as the CMC, ACMS, MCDUs, and aircraft printer. If necessary, some of the interfacing equipment may be simulated.

C1.4 Test Article Configuration

C1.4.1 ACARS Configuration

From an ACARS SYSTEM STATUS page, record the following parameters:

Aircraft Type = ___________________________

Airline Ident = ___________________________

MU Part No = ___________________________

S/W Part No(s) = _________________________(multiple numbers, if applicable)

Serial Number = ___________________________

If implemented, ensure that the MEDIA ADVISORY messages are enabled

(Note: an alternative is for the DSP to transmit all ATS uplinks to the aircraft on SATCOM datalink).

Display the ACARS VHF Frequency Table, and record the VHF frequencies and identifiers that are in the table.

PRIM = ____________________ at frequency __________MHz.

SEC1 = ____________________ at frequency __________MHz.

SEC2 = ____________________ at frequency __________MHz.

SEC3 = ____________________ at frequency __________MHz.

If the information is available, record the SCAN time and CONTACT time values for each of the listed VHF frequencies.

PRIM SCAN = ____________________, CONTACT = ________________

SEC1 SCAN = ____________________, CONTACT = ________________

SEC2 SCAN = ____________________, CONTACT = ________________

SEC3 SCAN = ____________________, CONTACT = ________________

C1.4.2 SATCOM Configuration

Record the SATCOM SDU S/W Part Number ________________________________

Record the SATCOM SDU H/W Part Number ________________________________

Record the SATCOM SDU ORT Part Number ________________________________

Record the SATCOM SDU ICAO Code ________________________________

Record the SATCOM SDU Serial Number ________________________________

C2.0 Flight Deck Annunciations

C2.1 Annunciation of ACARS COMM status - (8.2.1.2.1 b) and media advisory tests

Note: Verification of the ACARS COMM status is determined by monitoring the state of:

bit 17 (0= Sat Data Link available),
bit 18 (0= VHF Data Link available),
bit 19 (0= Mode S Data Link available),
bit 20 (1= ACARS Active),
bit 24 (1= HF Data Link available), and
bit 25 (1= Gatelink available)

of the ACARS label 270 label status word. These are the same bits that are used by EICAS to determine the DATALINK LOST and DATALINK AVAIL messages. When all five link bits are set to indicate Not Available, and bit 20 indicates ACARS Active, the DATALINK LOST message should be displayed on EICAS.] If media advisory messages are enabled, then record the results of the italic underlined test steps. If media advisory messages are not enabled, the italic underlined test conditions can be ignored.

Status Label Presence

Verify that ACARS is continuously broadcasting a label 270 on each of its general purpose output buses at an approximate rate of 1 transmission per second For a single ACARS installation, confirm SDI (bit 9=0, bit 10=0). For a dual ACARS installation, confirm that the appropriate SDI is set (bit 9=0, bit 10=1 for R-ACARS).

No Datalink

Confirm that bit 17=1, bit 18=1, and bit 19=1, bit 20 =1, bit 24=0, and bit 25=0. (DATALINK LOST is present on EICAS).

VHF Only

Allow ACARS to acquire an active datalink channel on VHF. Confirm that ACARS sends a Q0 or other downlink on the VHF channel, and receives and ACK to the downlink. Confirm that bit 17=1, bit 18=0, bit 19=1, bit 20 =1, bit 24=0, and bit 25=0. (DATALINK LOST is not present on EICAS and DATALINK AVAIL is present on EICAS after 90 seconds). Confirm that a Media Advisory downlink (ACARS label ‘SA’) is sent only after the link check has been completed.

VHF and SATCOM

Log onto SATCOM. Confirm that ACARS sends a Q0 or other downlink on the SATCOM channel and receives an ACK to the downlink. Confirm that bit 17=0, bit 18=0, bit 19=1, bit 20 =1, bit 24=0, and bit 25=0*. (DATALINK LOST is not present on EICAS). (* Note: bit 25 is allowed to be set to “1” whenever bit 17 = “0”.) Confirm that a Media Advisory downlink (ACARS label ‘SA’) is sent only after the link check has been completed.

SATCOM Only

This test will demonstrate that a priority ATS Downlink is transmitted before a Media Advisory. While SATCOM is logged on, disable VHF datalink. Initiate an FMC ATS downlink. Confirm that ACARS considers VHF not available. Confirm that ACARS then transmits the downlink on the SATCOM channel, prior to sending a media advisory downlink. Verify that the media advisory downlink is sent only after any ATS downlinks have been sent. Confirm that bit 17=0, bit 18=1, bit 19=1, bit 20 =1, bit 24=0, and bit 25=0*. (DATALINK LOST is not present on EICAS). (* Note: bit 25 is allowed to be set to “1” whenever bit 17 = “0”.)

No Datalink

Remove power from the Satcom SDU. Confirm that bit 17=1, bit 18=1, and bit 19=1, bit 20 =1, bit 24=0, and bit 25=0. (DATALINK LOST is present on EICAS).

SATCOM Restoration

Restore power to the SDU, and logon to SATCOM. Allow ACARS to establish a completed datalink. Confirm that bit 17=0, bit 18=1, bit 19=1, bit 20 =1, bit 24=0, and bit 25=0*. (DATALINK LOST is not present on EICAS, and DATALINK AVAIL is present on EICAS after 90 seconds). (* Note: bit 25 is allowed to be set to “1” whenever bit 17 = “0”.) Confirm that a single Media Advisory downlink (ACARS label ‘SA’) is sent.

VHF Restoration

Establish a VHF datalink on ACARS. Confirm that bit 17=0, bit 18=0, bit 19=1, bit 20 =1, bit 24=0, and bit 25=0* (DATALINK LOST is not present on EICAS). (* Note: bit 25 is allowed to be set to “1” whenever bit 17 = “0”.) Confirm that a Media Advisory downlink (ACARS label ‘SA’) is sent only after the link check has been completed.

VHF Only

Logoff SATCOM. Confirm that bit 17=1, bit 18=0, bit 19=1, bit 20 =1, bit 24=0, and bit 25=0. (DATALINK LOST is not present on EICAS). Confirm that a Media Advisory downlink (ACARS label ‘SA’) is sent.

No Datalink

Disable VHF Communication. Confirm bit 17=1, bit 18=1, bit 19=1, bit 20=1, bit 24=0, bit 25=0 (DATALINK LOST is present on EICAS).

C2.2 DATALINK SYS Advisory and ACARS MU Status Messages - (8.2.1.2.1 b)

Pull the ACARS circuit breaker. Verify that ACARS no longer transmits a label 270 status word on its output buses (EICAS displays DATALINK SYS advisory and ACARS MU status messages). Restore ACARS power and confirm that the label 270 label is transmitted at an approximate once per second rate on output bus 2. (DATALINK SYS and ACARS MU messages are extinguished).

C2.3 VHF DATA OFF Memo Message - (8.2.1.2.1 b)

Select VHF voice mode. Confirm that ACARS sets bit 13 of its label 270 Status to 1. (This should cause EICAS to display the VHF DATA OFF Memo Message).

Select VHF data mode. Confirm that ACARS resets bit 13 of its label 270 Status to 0. (This should cause EICAS to extinguish the VHF DATA OFF message.)

C2.4 ACARS MESSAGE Memo Message - (8.2.1.2.1 b)

Uplink an ACARS display message to ACARS. Confirm that after receipt of the uplink, ACARS sets bit 11 of the label 270 Status to 1. This test is used to document unique features and capabiliti es of the data link system. The results of this test are evaluated in combination with other tests in determining the suitability of the data link system for FANS-1.

C2.5 PRINTER MESSAGE Memo Message - (8.2.1.2.1 b)

Uplink an ACARS printer message to ACARS. Confirm that after receipt of the uplink, ACARS sets bit 21 of the label 270 Status to 1. This test is used to document unique features and capabilities of the data link system. The results of this test are evaluated in combination with other tests in determining the suitability of the data link system for FANS-1. Note: Display of the PRINTER MESSAGE is dependent on EIU program pin.

C2.6 PRINTER STATUS MESSAGE (8.2.1.2.1 b)

Remove the printer paper from the printer and close the printer door. Record the status of bit 22 of the label 270 Status word. Reload the printer paper and close the printer door. Confirm that bit 22 of the label 270 Status word is set to “0”. Open the printer door. Record the status of bit 22 of the label 270 Status word. Close the printer door. Confirm that bit 22 of the label 270 Status word is set to “0”. Initiate a CMC printout, and attempt to send an ACARS printout also. Observe if a Printer Busy indication is seen on the ACARS screen, and if displayed, note the status of bit 22 of the label 270 Status word. This test is used to document unique features and capabilities of the data link system. The results of this test are evaluated in combination with other tests in determining the suitability of the data link system for FANS-1.

C2.7 SATCOM DATA Advisory and Status Messages (8.2.1.3 C)

[Note: The tests in Sections 2.7 through 2.11 assume that the SATCOM system shall be installed with both high gain and low gain antennas.]

[Note: Verification of the SATCOM Crew Alerting messages is determined by monitoring the label 270 label Status word transmitted by the SDU from the output bus located on pins MP 1J,1K.]

Open the ACARS to SDU data bus to prevent SDU receipt of the ACARS label 270 Status. Confirm that the SDU sets bit 29 of its 270 Status word to EICAS. (This should lead to the SATCOM DATA EICAS Advisory and Status annunciations.) Restore the ACARS to SDU data bus.

Open the SDU to ACARS data bus to prevent ACARS from receiving the SDU label 270 Status. Confirm that ACARS sets bit 23 of its 350 label to indicate a SATCOM to ACARS input fail. (This should lead to the SATCOM DATA EICAS Advisory and Status annunciations.) Restore the SDU to ACARS data bus, and confirm that ACARS resets bit 23 of the 350 Status word to 0 (SATCOM DATA messages extinguished).

C2.8 SATVOICE LOST and SATVOICE AVAIL Advisory Messages (8.2.1.3 C)

[Note: Verification of the SATCOM Crew Alerting messages is determined by monitoring the label 270 label Status word transmitted by the SDU.]

Logoff of SATCOM, and confirm that the SDU sets bit 13 (SATCOM VOICE LOST/AVAIL) of its label 270 Status word, and bit 20 = 0 (no SATCOM Fault). (Setting of bit 13 to 1 and bit 20 to 0 should cause EICAS to display the SATVOICE LOST advisory message). Establish SATCOM logon once more, and verify bit 13 is reset (=0). (Bit 13 = 0 should cause EICAS to extinguish SATVOICE LOST and display SATVOICE AVAIL advisory message after 20 seconds.)

Adjust the reported antenna gain from the simulated BSU to cause the SDU to revert to a low gain mode. Confirm that the SDU sets bit 13 of its label 270 Status word, and resets bit 20 to 0. Restore the BSU reported gain and verify bit 13 is reset (=0) when the SDU restores back to the high gain mode.

C2.9 SATCOM VOICE Advisory Message and SATCOM HIGH GAIN Status Message (8.2.1.3 C)

[Note: Verification of the SATCOM Crew Alerting messages is determined by monitoring the label 270 label Status word transmitted by the SDU.]

Open each Beam Steering Unit (BSU) to SDU ARINC 429 data bus. Confirm that SATCOM sets bit 21 of the label 270 label Status word to 1. (Setting of bit 21 to 1 should cause EICAS to display the SATCOM VOICE advisory message, and the SATCOM HIGH GAIN status message.) Reconnect the BSU to SDU ARINC 429 data buses, and confirm that bit 21 = 0. (Bit 21 = 0 should cause EICAS to extinguish the SATCOM VOICE Advisory and the SATCOM HIGH GAIN status message.)

Disconnect power from the High Gain Antenna (HGA) High Power Amplifier (HPA). Confirm that SATCOM sets bit 21 of the label 270 label Status word to 1. Restore power to the HGA HPA, and confirm that bit 21 = 0.

C2.10 SATCOM Advisory Message and SATCOM SYSTEM Status Message (8.2.1.3 C)

[Note: Verification of the SATCOM Crew Alerting messages is determined by monitoring the label 270 label Status word transmitted by the SDU.]

Disconnect power from both the Low Gain Antenna (LGA) HPA, and the HGA HPA. Confirm that SATCOM sets bit 20 of the label 270 label Status word to 1. Restore power to the LGA HPA and the HGA HPA, and confirm that SATCOM resets bit 20 to 0.

C2.11 SATCOM LOW GAIN Status Message (8.2.1.3 C)

[Note: Verification of the SATCOM Crew Alerting messages is determined by monitoring the label 270 label Status word transmitted by the SDU.]

Disconnect power from the LGA HPA. Confirm that SATCOM sets bit 28 of its label 270 Status label to 1. (Bit 28 = 1 should cause EICAS to display the SATCOM LOW GAIN status message.) Restore power to the LGA HPA. Confirm that SATCOM resets bit 28 to 0. (Should cause EICAS to extinguish the SATCOM LOW GAIN status message.)

C3.0 VHF Management

C3.1 VHF Frequency Establishment Process and VHF No Comm (8.2.1.2.1 g)

This test requires an ACARS printer audit or a VHF simulator record of the VHF retries.

Category B Test

On the ACARS MU, select a Category B frequency. Use the VHF simulator to send uplink general ACK messages from 2 different Category B sites, distinguished by a unique mode character, and to respond to any link check downlink with a technical Ack uplink. While ACARS has been in VHF communication, disable the VHF datalink response. Initiate an ACARS downlink message. Once the ACARS has exhausted its tries on the initial Cat B site (after 3 or 4 unacknowledged downlinks), verify that ACARS will attempt the downlink according to the normal number of retries upon the second Cat B site . Record the time elapsed between downlink attempts, the number of retries on each ground station, and the total time elapsed until a NO COMM is declared. Then confirm that ACARS will begin a frequency search on a different frequency. Verify that ACARS will consider a frequency search state to be a VHF No Comm condition, and will set bit 18 of its 270 label Status word to 1 to indicate VHF No Comm. If the downlink process is different than described here, please describe the details below.

Category A Test

On the ACARS MU, select a Category A frequency. Use the VHF simulator to send an uplink general ACK message from a category A ground station, and respond to any link check downlinks with a technical Ack uplink. While ACARS has been in VHF communication, disable the VHF datalink response. Initiate an ACARS downlink message. Once ACARS has exhausted its tries on the initial Cat A site (after 3 or 4 unacknowledged downlinks), verify that ACARS will declare a NO COMM condition and begin a frequency search mode. Record the time elapsed between downlink attempts, the number of downlink attempts made, and the total time elapsed until a NO COMM is declared.

C3.2 ACARS Shall Send VHF Downlink Upon Returning to VHF COMM (8.2.1.2.1 e, f)

This test requires an ACARS printer audit. Enable the ACARS printer audit, if available.

Disable VHF communication. Logoff of SATCOM. Confirm that ACARS status label 270 has bits 17=1, 18=1, 19=1, 20=1, 24=0, 25=0 (which should drive an EICAS DATALINK LOST message). Allow the ACARS to sit idle. Initiate an uplink message on the ACARS data frequency. Confirm that ACARS sends a VHF downlink when ACARS hears any valid uplinked VHF data, even if directed to another airplane. Using the ACARS printer audit, confirm that ACARS does not change bit 18 to a zero state until an ACK has been received for the downlink. (should cause EICAS to annunciate a DATA LINK AVAIL 90 seconds after an ACK is received for the downlink message).

C4.0 SATCOM Management

C4.1 ACARS LABEL Q0 (or other) Downlink Upon SATCOM Logon (8.2.1.2.1 m)

This test requires a printer audit or a service provider audit to observe the SATCOM downlink activity. Start the ACARS printer audit. Confirm that the ACARS VHF is in COMM and SATCOM is logged off. Log on SATCOM. Confirm ACARS sends a label Q0 or other application level downlink message on SATCOM.

C4.2 Confirm ACARS Retry Over SATCOM if No Response Within 180 Seconds (8.2.1.2.1 i,j)

This test requires an ACARS printer audit or ARINC 429 logic analyzer and an ARINC 429 simulator.

Disable VHF comm. Disconnect ACARS from SATCOM. Using an ARINC 429 simulator, send a SATCOM 270 label, bit 11 = 0, to ACARS signifying SATCOM link is available. (Note, a '172 label may also need to be sent, with bits 9 10 14 15 and 16 set to 1.) Confirm that the ACARS MU sends a downlink to verify the SATCOM link. From the ARINC 429 simulator, provide an acknowledgement uplink to the link check downlink, and to other downlinks that may occur (such as for media advisory). Send an ACARS downlink via SATCOM. Using the printer audit or recording from the ARINC 429 logic analyzer, confirm that ACARS retries the SATCOM downlink in approximately 180 seconds. Confirm that approximately 180 seconds after the second (or third for some implementations) SATCOM downlink attempt, ACARS declares SATCOM NOCOMM. Confirm that bit 17 of ACARS Status label 270 is set to 1, indicating SATCOM NO COMM.

C4.3 ACARS dDetermination of SATCOM COMM if Valid Uplink Received (8.2.1.2.1 l)

This test requires an ACARS printer audit or ARINC 429 logic analyzer and an ARINC 429 simulator.

(Note: perform the test steps below as a continuation from the end of Test 4.2. Repeat Test 4.2, if necessary. The following condition occurs during the 10 minute wait window)

While SATCOM 270 bit 11 = 0, use the ARINC 429 simulator to send a SATCOM uplink to the ACARS. Confirm that ACARS receives the message, acknowledges it, and then sends a downlink to verify the SATCOM link. Use the ARINC simulator to provide a General Acknowledgement to the SATCOM downlink. When the downlink is acknowledged, verify the ACARS SATCOM status changes to AVAIL, and bit 17 of ACARS Status Label 270 is set to 0.

C4.4 ACARS Will Reattempt SATCOM Downlink 10 Minutes After Declaring NOCOMM While SATCOM Bit 11 Indicates COMM (8.2.1.2.1 l)

This test requires an ACARS printer audit or ARINC 429 logic analyzer and an ARINC 429 simulator.

Disable VHF data link. Send an ACARS downlink over SATCOM. Do not provide an acknowledgement to the SATCOM downlink from the ARINC 429 simulator. Confirm that ACARS retries the downlink after 3 minutes, and after a second (or third) 3 minute period without an acknowledgement indicates SATCOM NO COMM. Confirm that ACARS attempts to retransmit downlinks again (including the outstanding ACARS downlink) over SATCOM 10 minutes after declaring SATCOM NO COMM.

C4.5 ACARS Acks New Uplink During the 180 Second Retry Tme Period

Note: This test is used to document unique features and capabilities of the data link system. The results of this test are evaluated in combination with other tests in determining the suitability of the data link system for FANS-1. This test requires an ACARS printer audit or ARINC 429 logic analyzer and an ARINC 429 simulator.

Initiate a new downlink message (or continue with the condition at the end of test 4.4). Do not provide an uplink ACK for the downlink, but send an unsolicited uplink message. Confirm that ACARS immediately Acks the uplink message. Record ACARS actions with respect to the outstanding downlink, whether ACARS retries the downlink after sending the ACK, or whether ACARS continues to wait for the full timeout period before resending.

C4.6 ACARS Considers SATCOM Available When Logon Occurs During 10 Minute Wait Period. (8.2.1.2.1 h, k, l)

This test requires an ACARS printer audit or ARINC 429 logic analyzer and an ARINC 429 simulator.

Repeat test 4.2. Then, during the following 10 minute wait period, set the SATCOM label 270 bit 11 to 1 to indicate SATCOM logoff. Confirm that ACARS considers SATCOM as NO COMM, and bit 17 of the ACARS label 270 word indicates SATCOM NO COMM. Set the SATCOM label 270 bit 11 to 0 to indicate SATCOM logon. Confirm that ACARS sends a downlink on SATCOM to confirm the link. Provide an ACK to the downlink. Confirm that ACARS sets bit 17 of the label 270 Status to 0 to indicate SATCOM Available, and sends the outstanding downlink if it has not already been transmitted.

C4.7 Acars Mu Priority Processing of FMC Downlink Request (8.2.1.2.1 U.1)

Note: This test requires an ARINC 429 logic analyzer to record the Williamsburg protocol between the FMC and the ACARS MU, and an ACARS printer audit.

Disconnect the ARINC 429 Simulator and logon to the real SATCOM. Initiate a downlink message from the FMC, with VHF not available. Confirm the downlink is sent on the SATCOM channel. Before the network responds with an uplink acknowledgement, attempt an ACARS downlink message on SATCOM, and a second FMC downlink message. Confirm that the FMC is sending Williamsburg Request to Send (RTS) words to the MU, and the MU is providing Williamsburg BUSY responses to the FMC. After the ACARS acknowledgement is received for the first SATCOM downlink, record whether the next message transmitted is the FMC priority message or the ACARS message.

C5.0 VHF/SATCOM OPERATION

C5.1 ACARS MU Shall Consider VHF Frequency Search to be VHF Not Available State, and Deliver Priority Downlinks Over Another Medium, if Available. (8.2.1.2.1 d)

This test requires an ACARS printer audit or a VHF simulator record of the VHF retries.

Logon to SATCOM. With ACARS in VHF communication, disable the VHF datalink. Initiate an FMC downlink message. Once the ACARS has exhausted its tries on the initial VHF station (after 3 or 4 unacknowledged downlinks), confirm that the downlink is sent on SATCOM.

Note: The ACARS will release the FMC downlink to be sent over SATCOM when it has determined that VHF is Not Available, or the VHF is already in use.

C5.2 ACARS Receipt and Acknowledgement of Simultaneous VHF and SATCOM Uplinks (8.2.1.2.1 n)

This test requires an ACARS printer audit or service provider audits to observe ACARS downlink acknowledgments.

Simultaneously send two multiblock uplinks to the FMC using SATCOM and VHF. Using the ACARS printer audit, confirm that ACARS is receiving the SATCOM and VHF uplinks. Record the ACARS response to this condition (does the ACARS reject the second multiblock uplink, or are both uplinks successfully delivered to the FMC?). Using the printer audit or the Datalink Service Provider (DSP) audits, confirm that ACARS provides acknowledgement downlinks to the SATCOM uplink via SATCOM, and to the VHF uplink via VHF. If ACARS rejects the message, confirm that a downlink label Q5 is sent. Note the DSP response to the reject message (retry or discontinue).

Simultaneously send two uplinks to ACARS using SATCOM and VHF, one to the FMC, and one to the printer. Using the ACARS printer audit, confirm that ACARS is receiving the SATCOM and VHF uplinks. Confirm that both the FMC and the Printer successfully receive their respective messages. Using the printer audit or the DSP audits, confirm that ACARS provides acknowledgement downlinks to the SATCOM uplink via SATCOM, and to the VHF uplink via VHF.

C5.3 ACARS Receipt of Multiblock Messages During VHF/SATCOM Changeovers (8.2.1.2.1 o,r,y)

This test requires either a printer audit or a Williamsburg Protocol Trace between the FMC and ACARS MU.

Ensure VHF is in COMM and the SDU is logged on. Uplink a valid multiblock ATS message to the FMC via VHF. Before all blocks are received, pull the C-VHF circuit breaker, and leave open. Wait several minutes for the service provider to uplink the entire multiblock uplink using SATCOM. Verify that the message is received correctly by the FMC.

C5.4 ACARS Downlink of Message Following Loss of Media (8.2.1.2.1 q)

This test requires a printer audit or a service provider audit to observe the downlinks.

Logoff of SATCOM. Send an FMC multiblock downlink and disable VHF datalink so that the network acknowledgement to the first block is not received. Wait for the ACARS to retry on VHF until the initial Cat B site has failed to acknowledge any of the downlink attempts. Enable the VHF datalink and confirm that ACARS transmits the message when VHF becomes available.

Send an FMC multiblock downlink and disable VHF datalink so that the network acknowledgement to the first block is not received. Wait for the ACARS to retry on VHF until the initial Cat B site has failed to acknowledge any of the downlink attempts. Logon SATCOM and confirm that ACARS transmits the message when SATCOM becomes available.

C5.5 The ACARS Shall Complete Message Transmission Over a Given subnetwork if Possible (8.2.1.2.1 p)

This test requires a printer audit or a service provider audit to observe the downlinks. Logon to SATCOM. Disable VHF data Link. Send a long FMC multiblock downlink. Wait for the VHF path to be declared Not Available. Confirm that the MU sends the first block on SATCOM. A few seconds after the first block is sent on SATCOM, restore VHF datalink prior to the completion of the FMC downlink. Confirm that all blocks of the FMC multiblock downlink were sent via SATCOM.

C5.6 ACARS Passes ATS Multiblock Messages Without Affecting CRC (8.2.1.2.1 x, 8.2.1.3 b, 8.2.2 a)

This test requires the use of an ATS decode program, or an audit of an ATS ground terminal.

Send a multiblock FMC ATS message on SATCOM to a ground terminal equipped with end to end CRC error detection. Confirm that the FMC ATS downlink passed the CRC check on the ground.

C5.7 ACARS Rejects FMC Uplinks When FMC Not Reachable

This test requires a printer audit or a service provider audit to observe the downlinks.

Remove power to the FMC. Send an uplink FMC message. Verify that the FMC transmits a downlink label QX in response to the uplink. Record the response of the DSP to the label QX downlink (retry or halt?).

C6.0 ACARS to End System Interface

C6.1 ACARS Message Routing by Destination Code (8.2.1.2.1 c)

While SATCOM is logged on, open the VHF-C circuit breaker. Send an FMC downlink, and observe the FMC's downlink status indication. Wait up to 2 minutes. Verify that the FMC indicates the downlink has been sent. (via SATCOM)

While VHF is in COMM, log off SATCOM. Send an FMC downlink, and observe the FMC's downlink status indication. Verify that the FMC indicates the downlink has been sent (via VHF), within 2 minutes.

While SATCOM is logged on and VHF is in COMM, send an FMC downlink. Record the initial media choice of the ACARS (VHF or SATCOM). Verify that the FMC indicates the downlink has been sent within 2 minutes.

C6.2 ACARS Prioritization by LRU (8.2.1.2.1 t,u)

Enable the ACARS printer audit, if available. Simulate the VHF link, and do not allow acknowledgments to be sent to the ACARS. Logoff SATCOM. In succession, initiate long ACARS downlinks from the CMC, the ACMS Data Management Unit (DMU) if capable, the Cabin if available, the ACARS MU, and the FMC. Allow ACARS to enter into the NO COMM state. Then enable VHF datalink. Using the ACARS printer audit, confirm that the FMC multiblock message is sent first. Record the order of the other downlink messages.

Note: If an ACARS printer audit is not available, this requirement should be verified by using service provider audits, or demodulated ACARS to VHF signals.

C6.3 ACARS Shall aAccept an FMCS Downlink While a Message from Another Peripheral is Being Transmitted (8.2.1.2.1 s)

Enable the printer audit, if available. Send a long CMC downlink via ACARS. While the CMC downlink is still in progress, send an FMC downlink. By observing the FMC datalink status annunciation, confirm that the FMC downlink gets sent.

C6.4 While the MU is in VHF NOCOMM and Has a Downlink Message with a "V" Destination Code in Queue, the MU Will Still Accept and Downlink Destination Code "S" and "G" Messages from Other Peripherals (8.2.1.2.1 c, 8.2.1.2.1 v)

Ensure that SATCOM is logged on. Send an subsystem downlink (real or simulated) with a "V" destination code to the ACARS MU. Prior to receiving a network acknowledgment for the downlink, pull the C-VHF circuit breaker. Confirm that the "V" downlink is not sent over the SATCOM data link. Send an FMC downlink. Confirm that the ACARS sends the FMC downlink via SATCOM.

C6.5 Higher Priority Single Block Downlink (8.2.1.2.2 a)

Note: This test is used to document unique features and capabilities of the data link system. The results of this test are evaluated in combination with other tests in determining the suitability of the data link system for FANS-1. This test requires an ACARS printer audit or service provider audit. Enable VHF and SATCOM. Initiate a multiblock downlink from the CMC on VHF. Confirm that the downlink is being sent to the ground. Then send a single block FMC message. Note whether the single block downlink is sent between different blocks of the

CMC multiblock message, or is sent immediately on the SATCOM channel.

C6.6 Higher Priority Multiblock Downlink

Note: This test is used to document unique features and capabilities of the data link system. The results of this test are evaluated in combination with other tests in determining the suitability of the data link system for FANS-1. This test requires an ACARS printer audit or service provider audit. Enable VHF and SATCOM. Initiate a multiblock downlink from the CMC on VHF. Confirm that the downlink is being sent to the ground. Then send a multi-block FMC message. Record the result. Does the FMC message get sent on the SATCOM channel, or is it queued up behind the CMC downlink message?

Logoff SATCOM. Initiate a CMC multiblock downlink over VHF. Also initiate an FMC multiblock downlink. Prior to completion of the CMC multiblock downlink, disable VHF and go into NO COMM. Restore VHF and record the downlink transmission order.

Log on SATCOM. Initiate an ACMS downlink and disable VHF communications before it gets completed. Trigger CMC and FMC multiblock downlinks on SATCOM. Restore VHF communications, and record the message downlink order, and transmission medium. (Does FMC message get reassigned to VHF, before the ACMS message?)

C6.7 High Priority Downlink When VHF is in Voice Mode (8.2.1.2.1 g.1)

This test requires an ACARS printer audit or service provider audit. Enable VHF and SATCOM. Select ACARS VHF VOICE mode. Initiate an FMC downlink message. Confirm that the downlink is sent on the SATCOM channel.

C7.0 ACARS Technical ACK Downlinks

C7.1 ACARS Provides Technical Ack Downlinks (8.2.1.2.1 w)

This test requires a printer audit or service provider support to observe the VHF and SATCOM technical ACK downlinks.

For all valid test uplinks, confirm that ACARS provides a technical acknowledgement downlink.

C8.0 ACARS Message Throughput Test

This test requires a printer audit to observe the VHF and SATCOM downlinks. This test is used to document unique features and capabilities of the data link system. The results of this test are evaluated in combination with other tests in determining the suitability of the data link system for FANS-1.

Establish a VHF datalink using the VHF simulator. Find an FMC report that can be sent quickly and repetitively. For a period of 3 minutes, initiate a downlink as often as possible. Record the total number of acknowledged downlinks during the 3 minute period. Record performance.

Establish a SATCOM link only. Find an FMC report that can be sent quickly and repetitively. For a period of 3 minutes, initiate a downlink as often as possible. Record the total number of acknowledged downlinks during the 3 minute period. Record performance.

Ensure that both VHF and SATCOM links are established. Find an FMC report that can be sent quickly and repetitively. For two minutes, send the reports as rapidly as possible (on VHF). At two minutes, disable VHF datalink, and allow the ACARS to transition to SATCOM. Continue to transmit reports as quickly as possible, for 3 minutes on SATCOM. Restore VHF and establish a datalink. Continue sending downlinks on VHF for 2 minutes, as rapidly as possible. Record the total downlink message completions. Record performance.

C9.0 ACARS Embedded Acknowledgments (8.2.1.2.2 b)

This test requires a printer audit or service provider support to observe the VHF and SATCOM downlinks.

Select an AIRCOM SATCOM GES and logon.

On SATCOM, initiate an ACARS downlink and an uplink to the aircraft on SATCOM at the same time. Confirm that the ACARS receives the uplink without an embedded Ack to acknowledge the ACARS downlink, and that ACARS sends a general acknowledgement downlink, as soon as possible. (Note that the SATCOM may not immediately accept the downlink ACK until the prior downlink has cleared). If the service provider resends the uplink message with an embedded Ack, confirm that ACARS acknowledges the resent uplink and provides an acknowledgement. Confirm that ACARS does not retransmit the downlink that had been Acked via the embedded ACK. If the service provider does not respond to the original downlink message, confirm that the ACARS will retry the downlink on SATCOM three minutes following the initial downlink.

Select a COMSAT SATCOM GES and logon.

On SATCOM, initiate an ACARS downlink and an uplink to the aircraft on SATCOM at the same time. Confirm that the ACARS receives the uplink without an embedded Ack to acknowledge the ACARS downlink, and that ACARS sends a general acknowledgement downlink, as soon as possible. (Note that the SATCOM may not immediately accept the downlink ACK until the prior downlink has cleared). If the service provider does not respond to the original downlink message, confirm that the ACARS will retry the downlink on SATCOM three minutes following the initial downlink.

Select a SITA VHF Station.

On VHF, initiate an ACARS downlink and an uplink to the aircraft on VHF at the same time. Confirm that ACARS receives the uplink without an embedded Ack, and that ACARS resends the downlink with an embedded ACK as soon as possible.

Confirm that the service provider sends an uplink general ACK. Confirm that ACARS does not retransmit the downlink that had been Acked via the general ACK.

Select an ARINC VHF Station

On VHF, initiate an ACARS downlink and an uplink to the aircraft on VHF at the same time. Confirm that ACARS receives the uplink without an embedded Ack, and that ACARS resends the downlink with an embedded ACK as soon as possible. Confirm that the service provider sends an uplink general ACK. Confirm that ACARS does not retransmit the downlink that had been Acked via the embedded ACK.

C10.0 ACARS Problem Reports

List all problem reports generated and sent to the supplier as a result of conducting these test conditions. Include a brief title, a reference number, a short description, a responsibility assignment and a priority assignment.

Table C1 – AEIT Cross-Reference to ATS SR&O Requirements

SR&O	DESCRIPTION	SYSTEM	AEIT
8.2.1.2	ACARS MU		
8.2.1.2.1	ACARS MU Requirements		
a	The ACARS MU to be installed in the 747-400 FANS system shall conform to ARINC 724B with the additional requirements specified below.	MU	
b	The MU shall determine and maintain status alerting, via ACARS output label 270, during all modes of operation whether each sub-network is considered available or not.	MU	2.1,2.2, 2.3,2.4, 2.5,2.6
c	The MU shall respond to the FMC supplied Destination code (G) as defined in ARINC 724B.	MU	6.1, 6.4
d	For VHF, the MU shall consider frequency acquisition (frequency search) to be a VHF not available state (ARINC 618, section 5.3). The MU shall downlink an FMC message via SATCOM if the primary category B site fails to respond to all downlinks, and shall do so prior to searching the alternate sites to establish a new primary category B site.	MU	5.1
e	For VHF, Receipt of any valid uplink block shall stimulate the MU to downlink a message to both verify the integrity of the data link as well as providing a stimulus for the DSP to recognize the path to that airplane.	MU	3.2
f	For VHF, The MU shall not consider itself IN COMM until it receives an acknowledgment to it's downlink (ARINC 618, section 5.6.2.2).	MU	3.2
g	For VHF, The MU shall declare VHF NOCOMM if a downlink is not acknowledged, and all retries are unsuccessful.	MU	3.1
g.1	For VHF, The MU shall consider ACARS voice mode to be a VHF not available state. The MU should downlink an FMC message via SATCOM if available.	MU	6.7
h	For SATCOM, the MU shall first ensure that the SATCOM has declared a data link available (SATCOM label 270, bit 11 "not set").	MU	4.6
i	For SATCOM, If the MU does not receive an acknowledgment within 180 seconds after first sending a message, the MU shall retransmit the message (ARINC 618, section 7.7.2, AT7 NO ACK timer).	MU	4.2
j	For SATCOM, Failure to receive an uplink acknowledgment within 180 seconds of transmission of the second downlink attempt shall cause the MU to declare the SATCOM link to be NOCOMM (ARINC 618, section 7.7.2, AT6 NOCOMM timer).	MU	4.2
k	For SATCOM, A SATCOM NOCOMM shall also be declared if the SATCOM Bit 11 transitions to "set" for any period of time.	MU	4.6

APPENDIX C
INSTALLATION TEST GUIDANCE

SR&O	DESCRIPTION	SYSTEM	AEIT
l	For SATCOM, The MU shall presume the link is IN COMM once again if one of the following events occur (ARINC 618, section 7.7.5): a valid uplink is received; SATCOM label 270 bit 11 transitions from set to not set (i.e., data link not available to available).; 10 minutes after declaring NOCOMM while the SATCOM label 270 bit 11 has remained "not set" (i.e., data link available)	MU	4.3, 4,4 4.6
m	The MU shall send Q0 or other application level message upon detecting that the SATCOM has logged on.	MU	4.1
n	The MU shall be capable of receiving and acknowledging uplink messages concurrently on SATCOM and VHF.	MU	5.2
o	The correct order of multi-block uplink messages shall be retained. (including during VHF/SATCOM change-over or concurrent use)	MU	5.3
p	The MU shall complete message transmission over a given subnetwork if possible.	MU	5.5
q	If the subnetwork connection which the MU is currently transmitting is lost, the MU shall re-queue the downlink message when a link is acquired.	MU	5.4
r	If the subnetwork connection which the MU is currently receiving a message upon is lost, any multi-block uplink in progress shall be treated as an incomplete multi-block uplink.	MU	5.3
s	The MU shall provide the capability to receive a downlink from the FMCS while a message from another peripheral is being transmitted.	MU	6.3
t	The MU shall transmit messages from the FMC, and those created from direct MCDU interface with the MU, prior to those from other peripherals.	MU	6.2
u	When an appropriate channel is available, the MU shall transmit the next highest priority message stored in its queue at the time.	MU	6.2
u.1	When the FMC has a downlink message which it is attempting to deliver to the MU, the MU should not send any non-FMC message prior to receiving and sending the FMC message.	MU	4.7
v	The MU shall not operate such that a downlink message, with a destination code of "V", from one peripheral is able to prevent downlink messages, with a destination code of "S" or "G", from other peripherals from being sent.	MU	6.4
w	The MU shall provide a positive technical acknowledgment to each valid uplink (ARINC 618, section 3.2.1).	MU	7.1
x	The MU shall divide a downlink ATS message into ACARS blocks as necessary, add air-ground headers and its own checksum to the ATS message but shall not modify any part of the ATS message, received from the FMC, beginning with the first byte immediately following the five byte Control/Accountability header, through and including, the last byte of the end system application CRC.	MU	5.6
y	For an ATS uplink to the FMC, the MU shall translate the ACARS blocks into a file beginning with the first character immediately following the sublabel field. A five byte Control/Accountability header shall be added by the MU to the front of the file and the entire file is then transferred to the FMC.	MU	5.3
8.2.1.2.2	**ACARS Performance Issues**		
a	The MU should be capable of interrupting a downlink multi-block message with a higher priority, downlink single block message (based on source as defined above). If the MU has this capability, the MU should use true message sequence numbers (instead of the time stamps) to ensure detection of incomplete multiblock messages. The MU may alternatively (to nesting) downlink FMC messages via SATCOM if the VHF media is busy with lower priority traffic.	MU	6.5

APPENDIX C
INSTALLATION TEST GUIDANCE

SR&O	DESCRIPTION	SYSTEM	AEIT
b	If the ACARS receives an uplink over SATCOM that does not acknowledge a downlink over SATCOM (criss-cross situation), the MU should immediately downlink a general response acknowledgment of the uplink and not reset the NO ACK timer for the original downlink.	MU	9.0
8.2.1.3	**Satcom**		
a	The SATCOM system shall comply with ARINC 741 part 1 and part 2.	SATCOM	
b	The Satcom System is considered a pass-through system and it shall not modify any ATS message.	SATCOM	5.6
c	The SATCOM System shall support EICAS messages as described in section 7.1.3 and section 7.1.6.	SATCOM	2.7, 2.8, 2.9, 2.10, 2.11
d	If the SATCOM System utilizes a high gain antenna, the SATCOM system shall provide for continued data transmission capability if the high gain antenna reports less than 7dBi of gain. The SATCOM may either utilize a separate low gain antenna or utilize the high gain antenna as a low gain antenna in this circumstance.		
8.2.1.4	VHF Radio		
a	There are no additional requirements beyond compliance to ARINC 716.	VHF	
8.2.2	Satellite Environment		
a	The satellite component is considered a pass-through system and shall not modify any ATS message.	Satellite	5.6
b	Other satellite systems may be used to support the FANS 1 system, but the interfaces with the airplane Satcom system and the ground system must be shown to be inter operable.	Satellite	

APENDIX D
SATELLITE CATEGORY B

Satellite Category B capability has been developed to optimize the performance of the ACARS protocols and to provide new functionality. The main features from this mode of operation are

Unlimited message size and elimination of multi-block processing

Satellite Ground Station acknowledgement of ACARS downlinks

ACARS selection of Data Link Service Provider

Although this mode of operation has no limit to message length, other restrictions may in fact limit the message size. Some ground networks limit a message (headers + text) to 3840 characters. If a message is to be processed using other media and Satellite Category B, these other media are likely to have a 220 character text limitation in each block, with 16 blocks maximum. The system that creates a message will need to respect the limitations of any media that may be utilized.

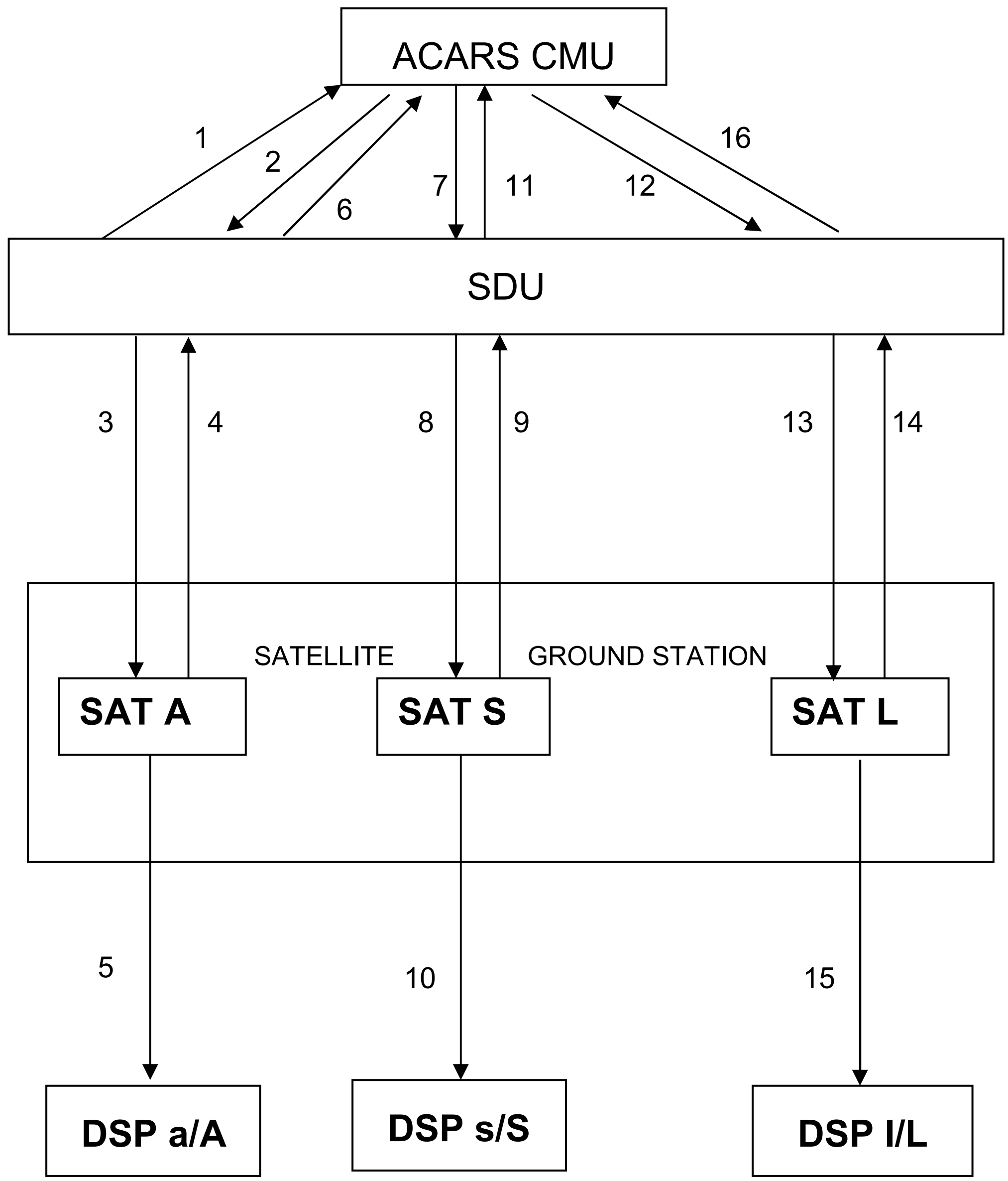
Elimination of multi-block processing should improve message delivery reliability.

Providing acknowledgements to ACARS downlinks at the Satellite Ground Station allows the satellite link to close out ACARS transactions without the delay in sending the downlink to the DSP and waiting for the DSP to process the message and return the acknowledgement. This allows more ACARS transactions to be transmitted in a given amount of time. This function can be provided for both Category A and Category B modes. In the event that the DSP provides an acknowledgement in a general response uplink, the SGS will discard it and not transmit it. If the DSP provides an embedded ack in an uplink, the SGS will transmit the message. However, the ACARS MU will have already closed the transaction earlier (when the SGS acknowledged the message) and therefore the will discard the embedded ack.

Establishing a connection to each DSP allows each DSP to uplink messages to the ACARS Management Unit without the need to internetwork to another DSP. This is useful when the originator of the uplink is unsure which DSP might be available, or when originators of messages to the MU have access to only one, but different DSPs.

There may be some DSPs that are preferred for certain types of downlinks. This may be due to certain services that are provided uniquely. For example, requesting departure clearance, or ATIS.

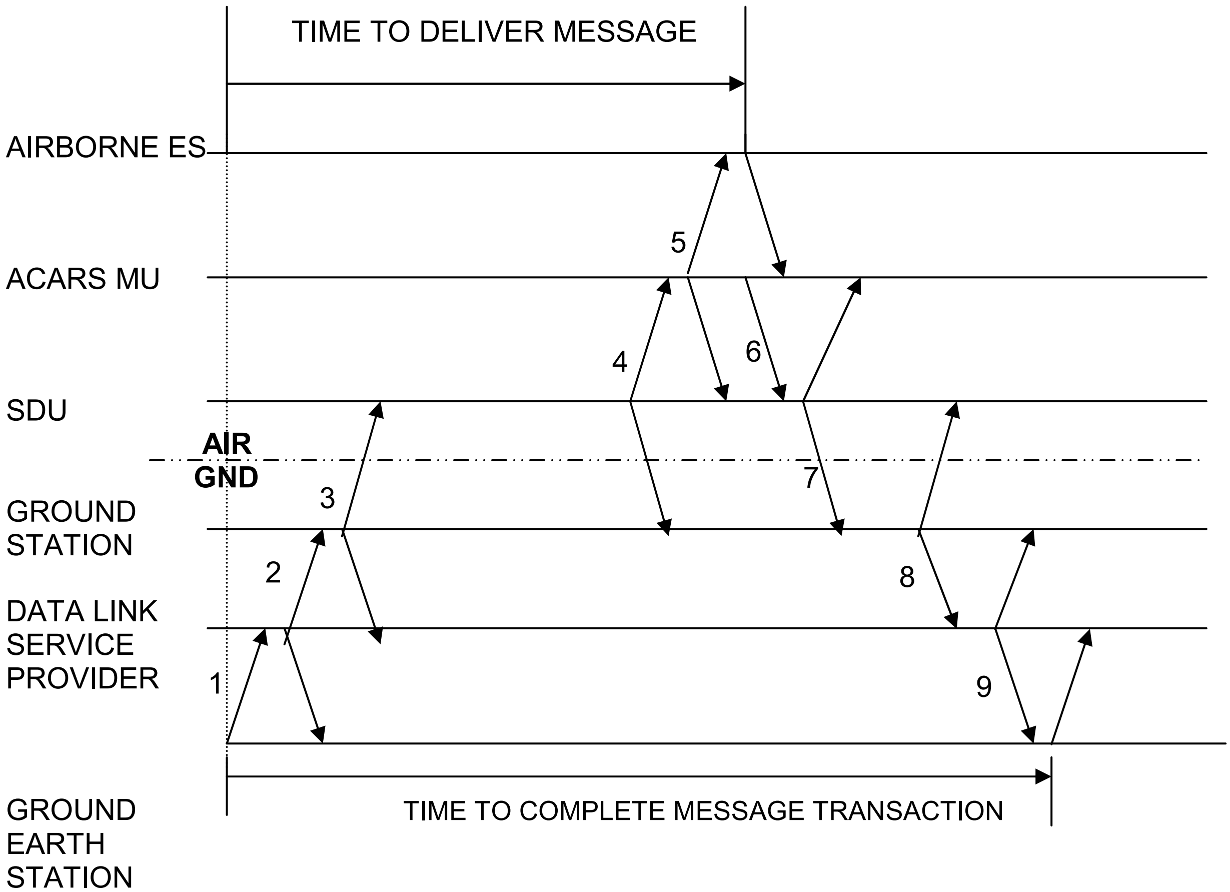
APPENDIX D
SATELLITE CATEGORY B



ACARS LINK ESTABLISHMENT OVER CATEGORY B SATCOM

1. Satellite link available. SDU logs onto SGS and SGS uplinks squitters. SDU indicates LOG ON (label 270/11=0). SDU transfers squitters to CMU.
2. ACARS Management Unit sends link test or other message using Mode Character A to Satellite Data Unit
3. Satellite Data Unit sends message to Satellite Ground Station
4. Satellite Ground Station send ACK using Mode Character a to Satellite Data Unit
5. Satellite Ground Station sends message to DSP a/A and establishes a switched virtual circuit to this aircraft
6. Satellite Data Unit sends ACK using Mode Character a to ACARS Management Unit
7. ACARS Management Unit sends link test or other message using Mode Character S to Satellite Data Unit
8. Satellite Data Unit sends message to Satellite Ground Station
9. Satellite Ground Station send ACK using Mode Character s to Satellite Data Unit
10. Satellite Ground Station sends message to DSP s/S and establishes a switched virtual circuit to this aircraft
11. Satellite Data Unit sends ACK using Mode Character s to ACARS Management Unit
12. ACARS Management Unit sends link test or other message using Mode Character L to Satellite Data Unit
13. Satellite Data Unit sends message to Satellite Ground Station
14. Satellite Ground Station send ACK using Mode Character l to Satellite Data Unit
15. Satellite Ground Station sends message to DSP l/L and establishes a switched virtual circuit to this aircraft
16. Satellite Data Unit sends ACK using Mode Character l to ACARS Management Unit

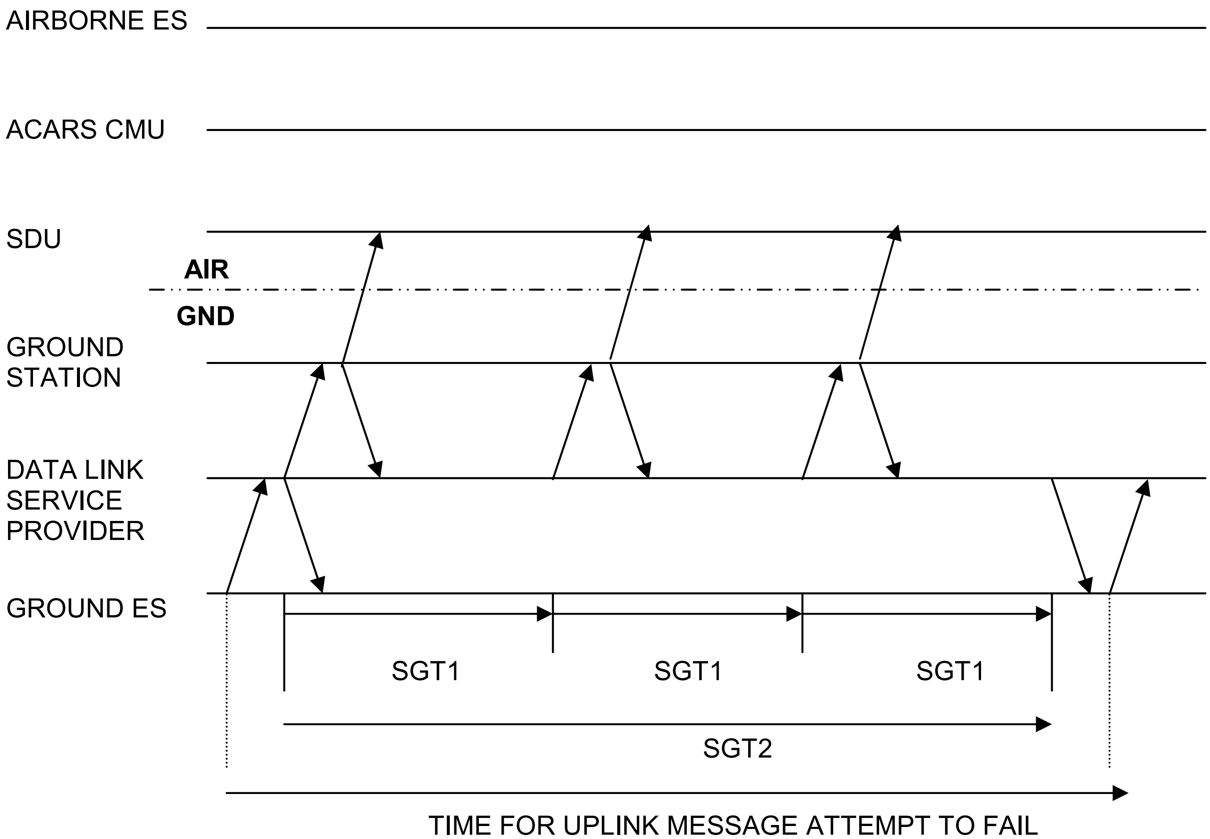
APPENDIX D
SATELLITE CATEGORY B



SATCOM CATEGORY B UPLINK

1. Ground End System sends message to Data Link Service Provider
2. Data Link Service Provider sends message to Satellite Ground Station
3. Satellite Ground Station send message to airborne Satellite Data Unit
4. Satellite Data Unit sends message to ACARS Management Unit
5. ACARS Management Unit sends message to Airborne End System
6. ACARS Management Unit sends ACK to Satellite Data Unit
7. Satellite Data Unit sends ACK to Satellite Ground Station
8. Satellite Ground Station sends ACK to Data Link Service Provider
9. Data Link Service Provider optionally sends message assurance to Ground End System

APENDIX D
SATELLITE CATEGORY B

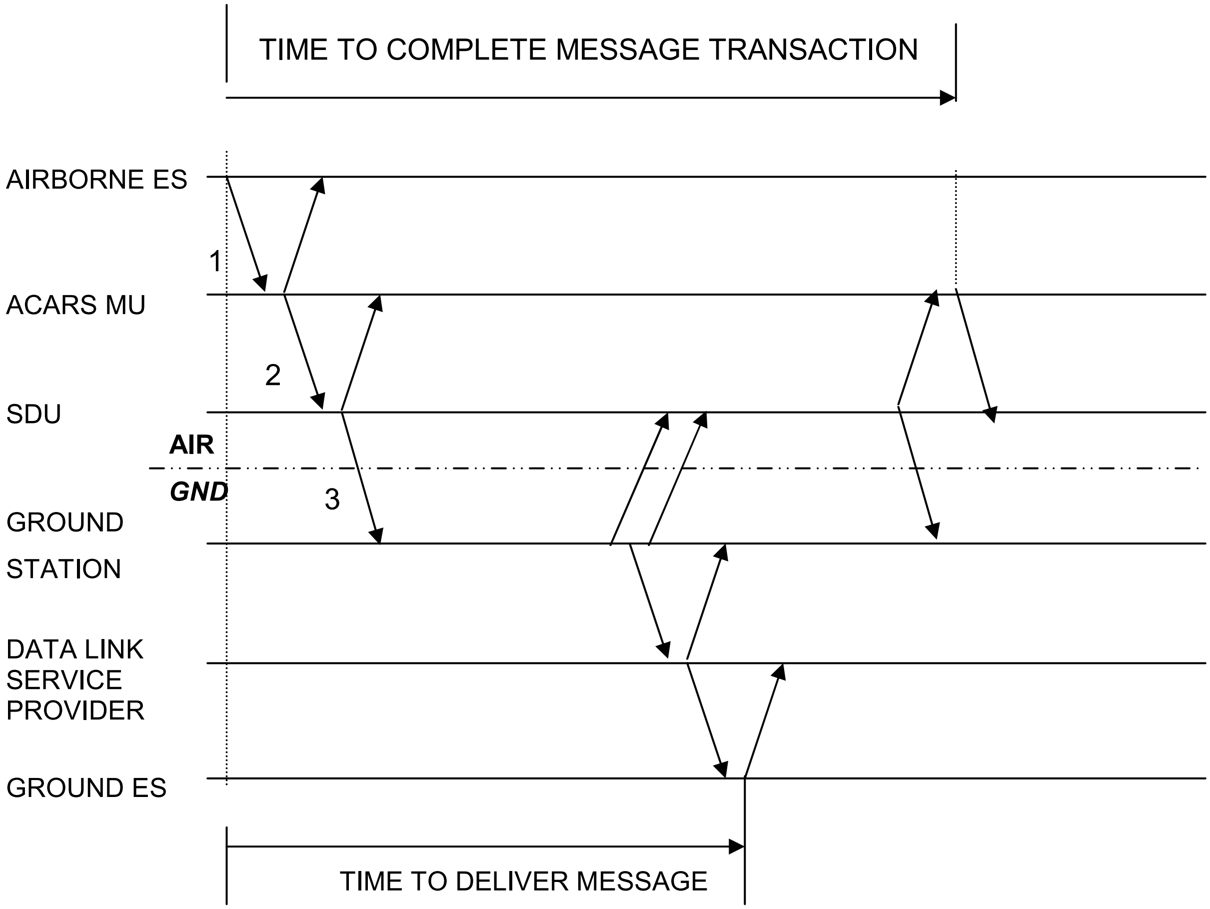


SATCOM CATEGORY B UPLINK FAILURE

1. Ground End System sends message to Data Link Service Provider
2. Data Link Service Provider sends message to Satellite Ground Station
3. Satellite Ground Stations attempts to send message to Satellite Data Unit
4. SGT1 timer expires, Satellite Ground Station discards message and Data Link Service Provider resends message to Satellite Ground Station
5. Satellite Ground Station attempts to send message to Satellite Data Unit
6. SGT1 timer expires, Satellite Ground Station discards message and Data Link Service Provider resends message to Satellite Ground Station
7. Satellite Ground Station attempts to send message to Satellite Data Unit

SGT1 timer expires, SGT2 timer expires, Satellite Ground Station discards message and Data Link Service Provider retry counter exceeds SGC1. Data Link Service Provider sends unable to send message to Ground End System or takes other appropriate action.

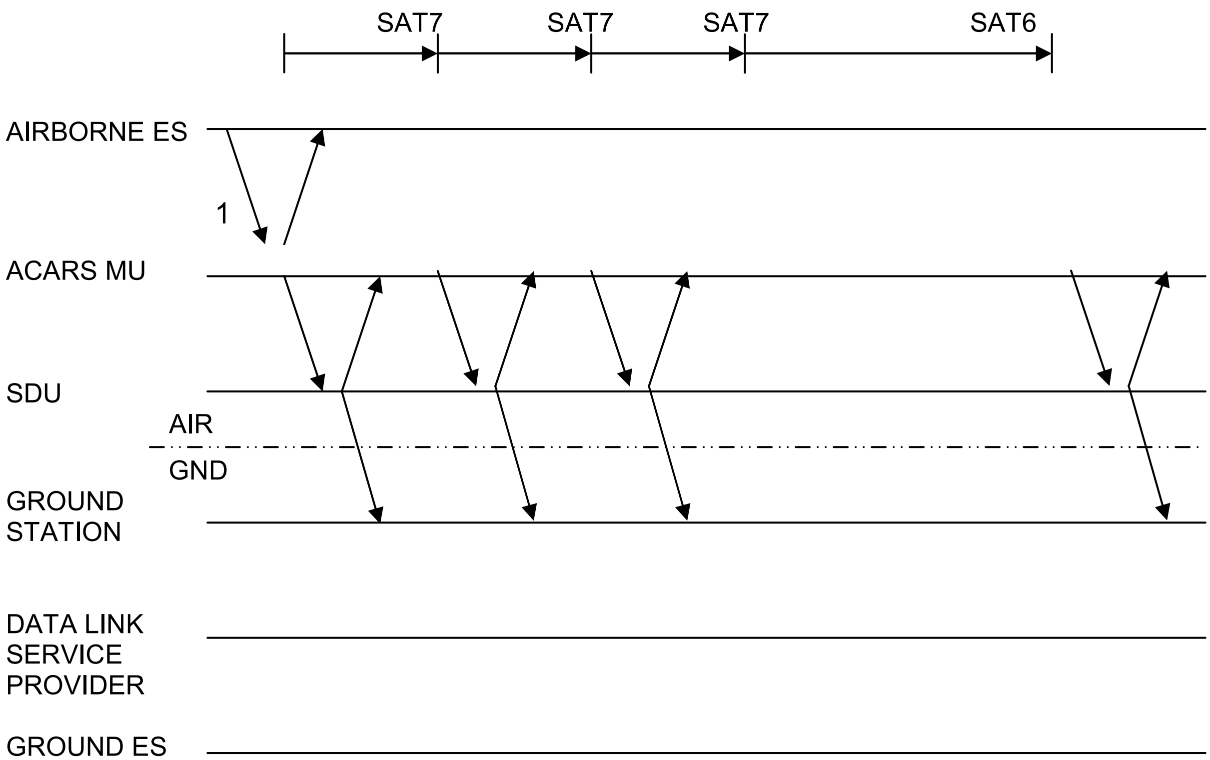
APPENDIX D
SATELLITE CATEGORY B



SATCOM CATEGORY B DOWNLINK

1. Airborne End System sends message to ACARS Management Unit
2. ACARS Management Unit sends message to Satellite Data Unit
3. Satellite Data Unit sends message to Satellite Ground Station
4. Satellite Ground Station sends message to Data Link Service Provider
5. Satellite Ground Station sends ACK to Satellite Data Unit
6. Data Link Service Provider sends message to Ground End System
7. Satellite Data Unit sends ACK to ACARS Management Unit

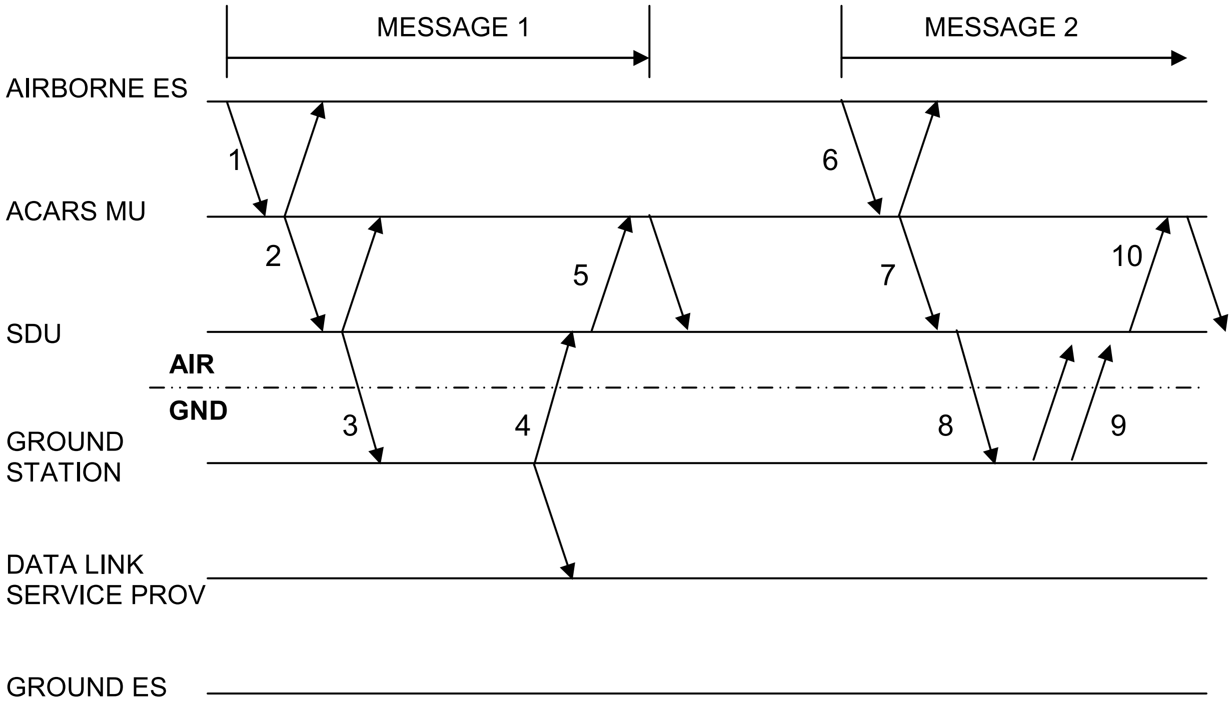
APENDIX D
SATELLITE CATEGORY B



SATCOM CATEGORY B DOWNLINK FAILURE

1. Airborne End System sends message to ACARS Management Unit
2. ACARS Management Unit sends message to Satellite Data Unit
3. Satellite Data Unit attempts to send message to Satellite Ground Station
4. SAT7 timer expires, Satellite Data Unit discards message and ACARS Management Unit resends message to Satellite Data Unit
5. Satellite Data Unit attempts to send message to Satellite Ground Station
6. SAT7 timer expires, Satellite Data Unit discards message and ACARS Management Unit resends message to Satellite Data Unit
7. Satellite Data Unit attempts to send message to Satellite Ground Station
8. SAT7 timer expires, Satellite Data Unite discards message, SAC1 counter is met and ACARS Management Unit declares Satellite link NO COMM.
9. SAT6 timer expires, ACARS management unit declares satellite link IN COMM and resends message to Satellite Data Unit

APPENDIX D
SATELLITE CATEGORY B



SATCOM CATEGORY B DOWNLINK DIRECTED TO A DSP THAT IS NO LONGER REACHABLE FROM THE SATELLITE GROUND STATION

1. Airborne End System sends message 1 to ACARS Management Unit
2. ACARS Management Unit sends message 1 to Satellite Data Unit
3. Satellite Data Unit sends message 1 to Satellite Ground Station
4. Satellite Ground Station send ACK to message 1 to Satellite Data Unit and attempts to send message to Data Link Service Provider as designated by the Mode Character in the Preamble. The Satellite Ground Station will continue to send this message until successful or until manually purged.
5. Satellite Data Unit sends ACK to message 1 to ACARS Management Unit
6. Airborne End System sends message 2 to ACARS Management Unit
7. ACARS Management Unit sends message 2 to Satellite Data Unit
8. Satellite Data Unit sends message 2 to Satellite Ground Station
9. Satellite Ground Station sends a NAK to the SDU for message 2.
10. Satellite Data Unit sends NAK to message 2 to the MU

If the SGS/DSP link fails and the ACARS MU attempts to downlink a message to that Data Link Service Provider, the Satellite Ground Station will NAK the message to the ACARS Management Unit. The ACARS Management Unit can then choose to retry the message through the same DSP (each attempt will be NAK'd until the MU retry counter is exceeded and the MU declares that DSP NOCOMM). The MU may redirect the message to another Data Link Service Provider using Satellite Category B methods (Mode character in the Preamble). It is possible that all Data Link Service providers are tried without success. In this case, the ACARS MU may attempt to establish a satellite link by sending the message using Satellite Category A (Mode character 2 in the Preamble) to direct the message to a default Data Link Service Provider. If the default DSP is not reachable, the Satellite Ground Station will NAK the message. The Satellite Ground Station will also send a special message to the

SDU directing it to LOGOFF and LOGON to a new Satellite Ground Station. After this is accomplished, the ACARS Management Unit will reattempt to initialize in Satellite Category B mode, using the original message if necessary.

Normal Initialization

ACARS	INOP
SDU	INOP
SGSs	Operational
DSPs	Operational

The SDU powers up and registers itself with a visited gateway. Seeing no CMU, it does noting more.

CMU powers up and broadcasts operational status words. The SDU sees that a CMU os operational and initates a data link logon call to an SGS.

The SGS accepts the logon call and uplinks version 0 squitters for each operational DSP, using the appropriate satellite category B mode character and 2 letter code for each service provider (Section 4.2.5 of ARINC Specification 620).

The SDU shows data link available (270/11=0), and passes on the uplink squitters to the CMU.

The CMU examines the squitters and responds with downlinks directed to each DSP that it desires a connection with.

The SGS acknowledges each downlink and passes them onto the appropriate DSPs.

Each DSP, upon receiving a downlink, updates it's routing tables for future uplinks.

Other Transitions:

The CMU is reset after the SDU has logged on and the connections to each DSP are established.

The SDU will monitor the CMU status. If the CMU becomes unavailable (429 SSM not valid or no activity), the SDU logs off of the SGS and declares data link not available. Then, when the CMU becomes available again, the normal initialization occurs (logon, uplink squitters, downlink to each DSP).

The SDU is reset while the CMU stays operational.

The CMU will purge it's routing table when the SDU data link becomes unavailable. Once the SDU becomes operational, normal initialization will proceed.

A single DSP becomes unavailable.

Since the SGSs are internetworked, the loss of a single DSP (and while other DSPs are available) may occur when no SGS can reach that DSP. An SGS should not acknowledge downlinks directed to a DSP not reachable, and the CMU will eventually declare that DSP NOCOMM when it attempts to downlink a message to it. Since all SGSs may not be able to reach the DSP, there may be no benefit to notifying the SDU and have it attempt a connection to an alternate SGS.

All DSPs become unavailable to a single SGS.

This is a catastrophic failure condition due to either SGS failure or terrestrial networking failure. If this is due to a terrestrial networking failure, the SGS should immediately command the SDU logoff and logon to an alternate SGS. If this is due to SGS failure, there will be no way to notify the SDU to logoff until the CMU or some other data link source attempts a downlink (at which point the SDU, not getting an answer to it's call, will automatically call an alternate SGS). For downlinks, the catastrophic failure of the logged on SGS will delay the message while the SDU determines it is not able to deliver the downlink and declares logoff and goes through normal initialization, selecting a new SGS to log on to. Uplinks to the aircraft will not be delivered until the SDU logs onto a new SGS and normal initialization occurs, resetting the communications path to each DSP.

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
MU <> SDU	No	No	No	No	Yes	Yes	Yes	Yes
SDU <> SGS	No	No	Yes	Yes	No	No	Yes	Yes
SGS <> DSP	No	Yes	No	Yes	No	Yes	No	Yes

MU <> SDU = 429 Williamsburg link layer is operational

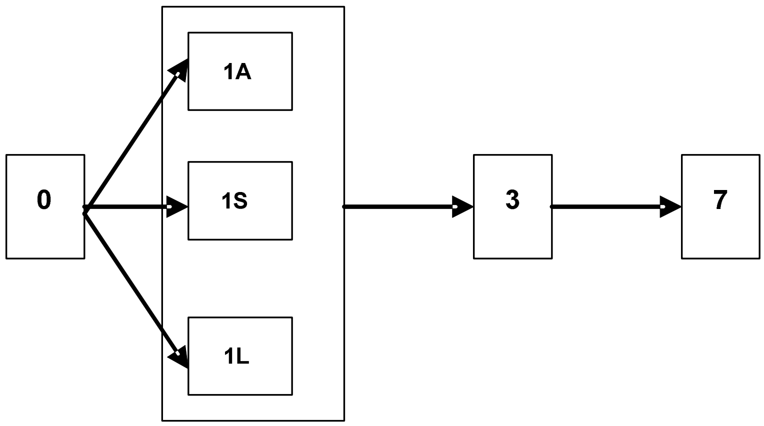
SDU <> SGS = Satellite air to ground communications are operational

SGS <> DSP = Ground to ground communications are operational

0. All systems are inoperable. The initial state.
1. The SGS and each DSP establish and monitor their capability to exchange data continuously. Prior to the SGS accepting any ACARS messages from any SDU, the SGS should establish connectivity with at least one DSP.
2. The SGS should notify the SDU that it has lost all DSP connections, and advise the SDU to logon to another SGS.
3. Once the SDU is operable, it will establish a connection with the SGS.
4. The ACARS MU becomes operable and the SDU is inoperable. This can occur when the ACARS MU is the first to power up.
5. The SDU and the SGS are not able to exchange messages, yet otherwise are fully operable. This can occur when the RF link is disrupted due physical

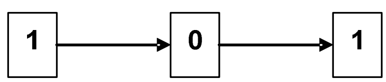
blockage or RF interference. The SDU indicates logoff on label 270/bit 11. The SGS will accept uplinks from the DSP in any case and attempt to deliver them.

6. While the MU and DSP are exchanging messages, the selected DSP becomes unreachable from the SGS. This can create a downlink message that is acknowledged by the SGS but not deliverable.
7. The MU establishes a link to the SDU only after the SDU has successfully established a link to the SGS, and while the SGS has a link available to at least one DSP. This allows the MU and DSP to exchange messages.

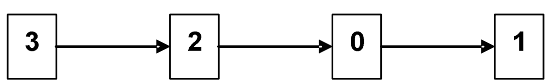


The first thing that should happen is the SGS and DSP establish a link. Then the SDU establishes a link with the SGS. The SDU then tells the MU that it is logged on. The MU establish a link with the DSPs and messages are exchanged.

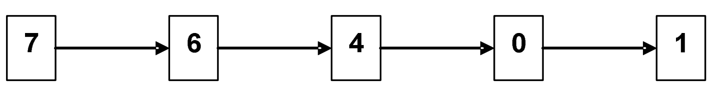
Normal Transition



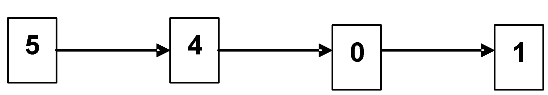
This transition is of no consequence.



State 3 is encountered only briefly if the ACARS is fully operational. State 3 is also encountered if the MU/SDU link fails. The unrelated or coincidental nature of this transition is improbable.



This is the normal transition when the SGS loses the link to the DSP.



This transition is encountered when the SGS/DSP link fails just after the SGS/SDU link fails and before the SDU tears down the SDU/MU link. A failure of the SGS is likely to cause both of these events. The normal failure of the SDU/SGS link is RF related. The SDU will notify the MU quickly, so there is minimal exposure to this second unrelated failure in this short time window.

SGS Loses Link to DSP

2 → 0 → 1

State 2 is encountered only if this SDU/SGS link fails just after the SGS link to the DSP fails. Failure of the SGS would likely cause both of these events.

3 → 1 → 3

Possible to occur when having difficulty establishing a reliable satellite link.

6 → 4 → 0 → 1

State 6 transition is encountered only if this SDU/SGS link fails just after the SGS link to the DSP fails. Failure of the SGS would likely cause both of these events.

7 → 5 → 1 → 3

Normal transition when the SDU/SGS link is lost. The SDU indicates logged off to the MU. Eventually, the SDU re-establishes a link to the SGS.

SDU and SGS Lose Communications

7 → 3 → 7

Normal transition. The failure of the SDU/MU link, while maintaining the SDU/SGS link would most likely occur when an ACARS MU failed.

6 → 2 → 1 → 3

State 6 transition is encountered only if the SDU/MU link fails just after the SGS/DSP link fails. This requires two unrelated failures and is considered extremely improbable.

5 → 1 → 3

State 5 transition is encountered if the SDU/MU link fails after the SDU/SGS link fails. Failure of the SDU would likely cause both of these events.

APENDIX D
SATELLITE CATEGORY B

$\boxed{4} \longrightarrow \boxed{0} \longrightarrow \boxed{1}$

This transition occurs after the failure of the SDU/SGS and SGS/DSP links. This transition quickly seeks state 0.

MU and SDU Lose Communications

DETERMINATION OF UPLINK MODE CHARACTER BY SATELLITE GROUND STATION

A Category B capable Satellite Ground Station provides an uplink ACK for each downlink. The Satellite Ground Station will always use the corresponding Mode character to the one provided by the ACARS Management Unit in the downlink. The DSP will never provide an acknowledgement when utilizing a Category B capable Satellite Ground Station.

The default DSP is the DSP that the customer has designated as the default DSP. The Satellite Ground Station should have access to a preference table for each aircraft designating the DSP that is preferred as the default DSP. The default DSP is also reachable by directing a downlink using the appropriate Mode character in the Preamble. It may be possible to designate more than one DSP for use as the default. In this case, the Satellite Ground Station has a preferential list, and seeks the DSP highest in preference.

Satellite Category A operation is defined in any message through the use of 2 (3/2) as the Mode character in the Preamble. Any message using Category A should respect the 220 character limit in the text field. The Satellite Ground Station should route a Category A downlink via the default DSP. The DSP should provide an uplink acknowledgement for each downlink block.

A Category B capable Satellite Ground Station will respond with a NAK (or not respond at all) to any downlink to a DSP that is not reachable. The Satellite Ground Station will advise (if able) the SDU to logon to an alternate SGS if no DSP (Category B operation), or the default DSP (Category A operation), is not reachable.

An ACARS MU that is capable of Satellite Category B operation will utilize each desired DSP. If any DSP becomes unavailable (downlinks are not acknowledged), the ACARS CMU chooses to either:

1. Utilize another available DSP.
2. Revert to Category A operation.

The Satellite Data Unit should indicate data link available (270/11=0) while satellite transmissions are received and while the Satellite Data Unit has established a connection to a Satellite Ground Station. The Satellite Ground Station must support at least one DSP for it to establish a connection to a Satellite Data Unit.

In the event that a DSP becomes unreachable, uplinks from that DSP may no longer be delivered.

An ACARS MU with Category B Satellite protocol should have predetermined what action to take when it becomes aware that a DSP is no longer available. If it is programmed to utilize an alternative DSP that is available, no further action is necessary.

If the ACARS MU is programmed such that the available DSPs no longer satisfy it's requirements, it may revert to Category A operation. If the default DSP is not available, the Satellite Data Unit should indicate data link is not available (270/11=1) and logon to an alternative Satellite Ground Station. The ACARS MU should exercise the new Satellite Ground Station using normal Satellite Category B initialization procedures.

The DSP must uplink messages using the proper Mode character. This would be either the unique Category B Mode Character, or "2" (3/2). The DSP determines which Mode character to use by inspection of the last downlink received from the ACARS MU.

NORMAL INITIALIZATION

ACARS	INOP
SDU	INOP
SGSs	Operational
DSPs	Operational

The SDU powers up and registers itself with a visited gateway. Seeing no CMU, it does nothing more.

CMU powers up and broadcasts opeational status words. The SDU sees that a CMU is operational and initiates a data link logon call to an SGS.

The SGS accepts the logon call and uplinks version 0 squitters for each operational DSP, using the appropriate satellite Category B mode character and 2 letter code for each service provider.

The SDU shows data link available, and passes on the uplink squitters to the CMU.

The CMU examines the squitters and responds with downlinks directed to each DSP that it desires a connection with.

The SGS acknowledges each downlink and passes them onto the appropriate DSPs.

Each DSP, upon receiving a downlink, updates it's routing tables for future uplinks.

Other Transitions:

The CMU is reset after the SDU has logged on and the connections to each DSP are established.

The SDU will monitor the CMU status. If the CMU becomes unabilable (429 SSM not valid or no activity), the SDU logs off of the SGS and declares data link not available. Then, when the CMU becomes available again, the normal initialization occurs (logon, squitter, downlink).

The SDU is reset while the CMU stays operational.

The CMU will purge it's routing table when the SDU data link becomes unavailable. Once the SDU becomes operational, normal initialization will proceed.

A single DSP becomes unavailable.

Since the SGSs are internetworked, the loss of a single DSP can only occur when all SGSs cannot reach the DSP. The SGSs will not acknowledge downlinks directed to a DSP not reachable, and the CMU will declare that dSP NO COMM when it attempts to downlink a message to it. Since all SGSs cannot reach the DSP, there is no reason to notify the SDU and have it attempt a connection to an alternate SGS.

APPENDIX E
VDL MODE 2 TIMING BUDGET

E1.1 VDL Mode 2 Timing Budget for VGT1

Figure 19-1 of Attachment 19 illustrates the components of the link time budget for an uplink with avionics that implement VDL Mode 2 as defined in Section 11. The propagation times stated herein come from the referenced documents. Any changes in those documents supersede these values. The components are:

1. Propagation of the uplink from the computer that manages VGT1 through the service provider's ground network, through the ground station until the ground station is ready to emit that uplink as an RF signal
2. Typical MAC/CSMA delay for that network, including impact of persistence and the value of P (average delay increases with lower values of P)
3. RF propagation
4. Propagation of the uplink through the VDR: RF signal detected by VDR, processed according to ARINC Characteristic 750 and begin ARINC 429 file transmission to the CMU maximum 1 second according to ARINC Characteristic 750
5. File transfer of uplink from VDR to CMU (transmission of file): nominal maximum 0.40 second according to ARINC Characteristic 750 (assumes no delays)
6. Propagation of the uplink through the CMU receive ARINC 429 file transfer (processing after CRC determination), uplink processing and response determination and prepare ARINC 429 file transfer. The maximum latency is 5 seconds. See Section 11.4.1
7. File transfer of response from CMU to VDR (transmission of ARINC 429 words and CRC calculation): nominal maximum 0.40 second according to ARINC Characteristic 750 (assumes no delays)
8. Propagation of the response through the VDR: delay from file transfer CRC check until the VDR is ready to emit an RF signal: maximum 0.1 second according to ARINC Characteristic 750 when P=1
9. Typical MAC/CSMA delay for that network including impact of persistence and the value of P
10. Propagation of the downlink from the ground station, through the service provider's ground network, to the computer that manages VGT1

The avionics (CMU) propagation delay is 5 seconds when everything works as expected (access to ARINC 429 bus not delayed and no ARINC 429 CRC errors). ARINC 429 Williamsburg Version 3 does not perform retries; therefore, in the unlikely event of an ARINC 429 CRC error the recovery is performed by the air-ground protocol.

The VGT1 timer should be set to a value larger than the sum of the propagation delays listed above. The service provider should characterize the performance of its network and set the value of VGT1 accordingly. It is recommended that the value of VGT1 be larger than the minimum so that needless retransmissions are minimized. If the implementation of the ground network provides shorter propagation delays, then the value of VGT1 may be reduced by a proportional amount.

E1.2 VDL Mode 2 Timing Budget for VAT7

The propagation times stated herein come from the referenced documents and changes in the referenced documents supersede these values. The components are:

1. Propagation of the downlink through the CMU
2. File transfer from CMU to VDR (transmission of ARINC 429 words): maximum 0.40 seconds according to ARINC Characteristic 750
3. Propagation of the downlink through the VDR: delay from the file transfer CRC check until the VDR is ready to emit an RF signal: maximum 0.1 seconds according to ARINC Characteristic 750 when P=1
4. Typical MAC/CSMA delay for that network including impact of persistence and the value of P. VDR sends ARINC 429 file indicating when transmission has occurred so that CMU can start VAT12
5. Propagation of the downlink from the ground station, through the service provider's ground network, to the computer that generates the response, propagation of the response through the ground network and the ground station until the ground station is ready to emit RF
6. Typical MAC/CSMA delay for that network including impact of persistence and the value of P
7. Propagation of the uplink through the VDR: RF signal detected by VDR, processed according to ARINC Characteristic 750 and ready to transmit ARINC 429 to the CMU: maximum 1 second according to ARINC Characteristic 750
8. File transfer of uplink from VDR to CMU (transmission of ARINC 429 words): maximum 0.40 seconds according to ARINC Characteristic 750
9. Propagation of the uplink through the CMU delay from the file transfer CRC check until the ARINC Specification 631 AVLC

The VAT7 timer should be set to a value larger than the sum of the propagation delays listed above. The service provider should characterize the performance of its network (components d, e and f) so that the avionics vendors can set the value of VAT7 to a value compatible with the network performance. It is recommended that the value of VAT7 be larger than the minimum so that needless retransmissions are reduced.

ARINC 429 Williamsburg Version 3 does not perform retries; therefore, in the unlikely event of an ARINC 429 CRC error the recovery is performed by the air-ground protocol.

COMMENTARY

If the value of VAT7 is not commensurate with the network performance and the avionics performance then needless retransmissions may occur.

APPENDIX F
TERMS AND ACRONYMS

ACARS	Aircraft Communications Addressing and Reporting System
ACK	Positive Acknowledgment Character
ACMS	Aircraft Condition Monitoring System
ADSU	Automatic Dependent Surveillance Unit
AEEC	Airlines Electronic Engineering Committee
AEIT	Aircraft Equipment Interface Test
AES	Aircraft Earth Station
AIDS	Aircraft Integrated Data System
AOA	ACARS Over AVLC
ARINC	Aeronautical Radio Incorporated
ATA	Airline Transport Association
ATN	Aeronautical Telecommunications Network
ATSU	Air Traffic Service Unit
AVLC	Aviation VHF Link Control
AWGN	Additive White Gaussian Noise
BCS	Block Check Sequence
CALSEL	Call Select
CLNP	Connectionless Network Protocol
CMU	Communications Management Unit
CRC	Cyclic Redundancy Check
DBI	Downlink Block Identifier
DFDAU	Digital Flight Data Acquisition Unit
DGSS/IS	Data Link Ground System Standard and Interface Specification
DSP	Data link Service Provider
EICAS	Engine Instrument Control System
FCS	Frame Check Sequence
FMC	Flight Management Computer
FMGC	Flight Management Graphic Computers
FMGEC	Flight Management Graphic Enhancement Computer
FMS	Flight Management System
HF	High Frequency
HFDR	High Frequency Data Radio
HFDU	High Frequency Data Unit
GNLU	GNSS Navigation and Landing Unit
GNU	GNSS Navigation Unit
GSIF	Ground Station Information Frame

APPENDIX F
TERMS AND ACRONYMS

GTC	Ground Terminal Computer
IATA	International Airline Transport Association
ICAO	International Civil Aviation Organization
ICM	Interline Communications Manual
INFO	Information (AVLC Information Frame)
IPI	Initial Protocol Identifier
ISO	International Standards Organization
LRU	Line Replacement Unit
LSB	Least Significant Bit
MSB	Most Significant Bit
MSK	Minimum Shift Keying
MSN	Message Sequence Number
MU	Management Unit
NAK	Negative Acknowledgment Character
NO COMM	No VHF Communications
OAT	Optional Auxiliary Terminal
RGS	Remote Ground Station
RR	Receive Ready (AVLC Receive Ready Frame)
SAA	Service Access Area
SAL	System Address Label
SATCOM	Satellite Communications System
SELCAL	Selective Calling
SDU	Satellite Data Unit
SDN	System Definition Manual
SITA	Societe Internationale de Telecommunications Aeronautiques
SOH	Start of Header
SR&O	System Requirements and Objectives
SYN	Synchronization
UBI	Uplink Block Identifier
UTC	Universal Time Clock
VDR	VHF Data Radio

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SUPPLEMENT 1
TO
ARINC SPECIFICATION 618

AIR/GROUND CHARACTER-ORIENTED PROTOCOL SPECIFICATION

Published: December 30, 1994

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: October 19, 1994

A. PURPOSE OF THIS DOCUMENT

This supplement introduces changes to the air/ground communications protocol known as the Aircraft Communications Addressing and Reporting System (ACARS). The changes represent both corrections to the original document and additions of new provisions recommended by the ACARS Working Group.

B. ORGANIZATION OF THIS SUPPLEMENT

In the past, changes introduced by a supplement to an ARINC Standard were identified by vertical change bars with an annotation indicating the change number. Electronic publication of ARINC Standards has made this mechanism impractical.

In this document **blue bold** text is used to indicate those areas of text changed by the current supplement only.

C. CHANGES TO ARINC SPECIFICATION 618 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete listing of the changes to the document introduced by this supplement. Each change is identified by the section number and the title as it will appear in the complete document. Where necessary, a brief description of the change is included.

1.5.2 Airborne System Equipment

Text added to describe access to HF ACARS air-ground network.

1.8 Documents Referenced

ARINC Specification 623 was added to the list of referenced documents.

2.2.8 Text

In order to ensure that the identification of the aircraft is not misconstrued, all downlink messages will now be transmitted using the flight number that exists when the message is transmitted. Some previously written applications did not include the flight number in use when data was collected, relying instead on the flight number of the downlink message header to provide this information. This procedure is no longer valid.

Text was added advising users that applications that require the flight number of the flight leg under which data was collected should modify the content to include the flight number in the text of the message.

2.2.10 Block Check Sequence

Added text to indicate that the BCS is exercised over the parity bits.

2.3.2.2 Category B Mode Character

Added reference to Attachment 6 for mode character listing.

3.2.1 Acknowledgment of a Downlink Block

Added text to clarify that the MU should both increment the Pretransmission Counter and reset the NO ACK Timer when a block is retransmitted.

3.2.2 Acknowledgment of an Uplink Block

Commentary added to clarify that this solution (immediate retransmission of an unacknowledged uplink block) is incomplete but that it provides advantages over other alternatives.

3.4.1 Downlink Message Sequencing

Added clarification of DSP treatment of partial messages.

3.5.1 Uplink Retransmission Detection

Commentary was added to refer to Chapter 7 for an explanation of the different treatment given to the UBI of SATCOM uplinks.

3.6 Multi-Block Processing

Added a statement that the MU can operate in “store-and-forward” and “passthrough” modes.

3.6.2.2 Nesting of Multiblock Downlinks

Added text to provide for interruption of a multiblock message for a single block message.

3.6.2.5 Reblocking a Multiblock Downlink

Title added.

3.6.4 Multiblock Uplinks

Added text to caution peripheral designers that their LRU should implement timers for passthrough MUs.

3.6.4.1 Message Assembly Timer

Text was added to confirm that the disposition of partial messages would be to send it to the printer at the expiration of the Message Assembly timer (VAT4).

3.6.4.4 Ground Message Reject Timer

Commentary was added noting that one service provider has not yet implemented the ground-based timers VGT2 and VGT3.

3.6.4.6 Nesting of Multiblock Uplinks

New section added.

3.6.4.7 Interleaving of Multiblock Uplinks

New section added.

3.7.3 Unusable Messages

Introduce new second paragraph identifying possible reasons that messages could be declared undeliverable.

4.4.2.1 Parity Bit

New section added.

4.4.2.2 Bit Transmission Order

New section added.

5.10 Statistical Data Collection

New section added.

5.11 Statistical Data Reports

New section added.

5.11.1 Summary Reports

New section added.

5.11.2 Detailed Reports

New section added.

5.11.3 No Data Reports

New section added.

6.8.1 DATA Mode to VOICE Mode

Clarify that the MU may transmit a message over an alternate medium when VHF is not available.

7.5 ACARS Message Protocol

Change response of the MU to generate a downlink using the Underscore/Delete <_DEL> label message rather than the QX label.

7.5.1 Acknowledgment of a Downlink Block

Text was added noting that, in a General Response message received by a MU via satellite, the value of the UBI reference character is unaffected.

8.0 HF Interface

New chapter added.

9.0 Media Utilization

New chapter added.

ATTACHMENT 4 - MULTIBLOCK TIMING DIAGRAMS

These diagrams were modified to reflect the more definitive nomenclature of timers that provide a distinction between SATCOM and VHF. The value of SGT1 was changed from 120 seconds to 90 seconds in Figure 4-7, SATCOM Uplink Procedure.

ATTACHMENT 6 - MODE CHARACTER

An editorial correction was made to the ISO character equivalent for bit coding Ground station 16 (change r to p) and 17 (change p to q).

ATTACHMENT 8 - DATA RECORD CONTENTS AND FORMAT

Format of ARINC 429 broadcast label 270 MU/SDU status word was deleted. Refer to ARINC Characteristic 741, Part 2.

Old data replaced by new information: Network Statistics.

ATTACHMENT 9 - SIMPLIFIED HF AVIONICS BLOCK DIAGRAMS

New attachment added.

APPENDIX B - ACARS SYSTEM DESCRIPTION

Description of ACARS added (pending editorial corrections)

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SUPPLEMENT 2
TO
ARINC SPECIFICATION 618

AIR/GROUND CHARACTER-ORIENTED PROTOCOL SPECIFICATION

Published: December 20, 1996

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: October 22, 1996

A. PURPOSE OF THIS DOCUMENT

This supplement introduces changes related to handling intercept messages. The most significant changes are the introduction of support for nesting of multiblock messages and expansion of priority to 16 levels. Minor editorial changes and recognition of the facility to provide media availability are also added.

B. ORGANIZATION OF THIS SUPPLEMENT

In the past, changes introduced by a supplement to an ARINC Standard were identified by vertical change bars with an annotation indicating the change number. Electronic publication of ARINC Standards has made this mechanism impractical.

In this document **blue bold** text is used to indicate those areas of text changed by the current supplement only.

C. CHANGES TO ARINC SPECIFICATION 618 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete listing of the changes to the document introduced by this supplement. Each change is identified by the section number and the title as it will appear in the complete document. Where necessary, a brief description of the change is included.

2.1 General Format Description

A new entry into the message field descriptions, Block Check Sequence (BCS) Suffix, was added. The definition of BCS Suffix appeared in earlier versions of the ACARS message format definition i.e., Characteristics 597, 724/B but was unintentionally omitted when Specification 618 was published. Thus, this action constitutes a reinstatement of already existing definition.

The Field Length field was modified from 220 characters to □200 characters.

2.2.8 Text

“Free Talk” was changed to “Free Text.”

2.2.11 BCS Suffix

New section added to reinstate the original definition.

2.3.11 BCS Suffix

New section added to reinstate the original definition of the BCS suffix..

3.1 Basic Message Protocol

Commentary was added to accommodate the use of Chapter 3 provisions generically for VHF, SATCOM, and HF data links.

3.2 Acknowledgment Protocols

Editorial change: In first sentence, ‘Blocks’ was changed to ‘Each downlink block’.

3.2.1 Acknowledgment of a Downlink Block

Additional clarification was added concerning the management of the DBI register, including events that would necessitate changes to the DBI pattern.

3.2.2 Acknowledgment of an Uplink Block

Additional encouragement was added for service providers to ensure that UBI values of sequential uplink blocks are encoded incrementally - or at least not identically.

3.3.1.3 Onboard Routing

Editorial changes. The order of text was rearranged.

3.3.3 Supplementary Addresses

The reference to “Agency Flight Number” was changed to “Agency ID.” Explanatory text noted that label H1 messages should contain a sublabel.

3.4.1 Downlink Message Sequencing

An editorial change revised the final line of commentary on the first paragraph from “handling of interspersed traffic” to simply “handling of traffic.”

New text was added to provide for 2 levels of downlink nesting - multiblock on level 1 and single block on level 2.

The procedure for DSPs to issue a report of an incomplete block was corrected to specify that the report be sent only after expiration of the Retry timer (VGT4).

3.4.1.1 Message Originator

A third Flight Management Computer, Origin FMC3 was added to accommodate high-end General Aviation (GA) installations. ID code □L□ and associated Note 12 were added for ATS functions performed in the MU.

3.4.1.2 Message Number

The reader is advised that some duplicate messages may be delivered due to processing of MSN ‘00’, which will always result in delivery of the message to the user host.

3.4.1.4 DSP Processing of Out-of-Sequence MSNs

Text was added to clarify the delivery of intercept messages by the DSP. New text referencing Section 3.6.3 was added to complement multiblock message nesting. Further enhancement to this capability is planned.

3.4.2 Uplink Message Sequence

Text was added to indicate that further enhancement to multiblock nesting is expected through changes to message sequencing provisions.

3.5 Retransmissions

Editorial changes: ‘transmission’ changed to ‘retransmission’.

3.6.2.1 Incomplete Multiblock Downlink

Additional text to complement new text added to Section 3.4.1 was added to clarify the processing and reporting of incomplete messages.

3.6.2.2 Nesting of Multiblock Downlinks

Text was added to describe a new provision for nesting of multiblock downlink messages.

Commentary was added to note that service providers are expected to support a number of nesting levels equal to (or greater than) the avionics.

3.6.2.2.1 Effect of a Nested Downlink on VAT10 and VGT4

New section added. Text was added to address the new provision to support nesting of multiblock downlink messages.

3.6.2.4 Reblocking a Multiblock Downlink

Renumbered; previously this text was Section 3.6.2.5. The placeholder Section 3.6.2.4, Aborting a Multiblock Downlink, was deleted.

3.6.3 Restart Multiblock Downlink

Commentary deleted. New text added to accommodate nesting of multiblock messages.

3.6.4 Multiblock Uplinks

The introductory sentence “The case of uplink multiblocks is similar to that of downlinks.” was deleted. This similarity no longer exists for multiblock messages.

3.6.4.1 Message Assembly Timer

New text added to extend the responsibility of this timer from one to multiple downlink messages.

3.6.4.3 Ground No ACK Timer

New text added to support the nesting of multiblock messages.

3.6.4.4 Ground Message Reject Timer

New text added to support the nesting of multiblock messages.

3.6.4.6 Nesting of Multiblock Uplinks

Text was changed from precluding the nesting of multiblock messages to enabling the nesting of multiblock messages.

3.7.1 Unable to Deliver Messages

Reference to ARINC Specification 620 added.

3.7.2 Printer Reject Messages

Reference to ARINC Specification 620 added.

3.7.3 Unusable Messages

Reference to ARINC Specification 620 added.

3.7.5 Undelivered Unplink Messages

Reference to ARINC Specification 620 added.

3.8 Message Prioritization

Text referring to nesting of single block messages was deleted in deference to new text elsewhere in this document for support of nesting of multiblock messages..

The definition of 4 levels of priority was deleted; sixteen levels of priority are now defined.

A reference to Chapter 9 was added.

3.8.1 Priority of System Control Messages

Added a reference to Section 6.4.4 for unique features of the Q6 message. Also editorial changes were made.

3.8.3 Regulatory Guidance on Priority

The range of priorities that may be supported by the ACARS MU was raised from 4 to 16 by reference to Specification 619.

5.4 Timers and Counters

Commentary added.

5.4.1 Ground Based Timers

Note 1 added to VGT2 Message Reject Timer.

5.4.2 Airborne Timers

Note 1 added to VAT2 Scan Timer.

Note 1 added to VAT3 Tracker Timer.

The Restart definition of Message Assembly timer VAT4 was expanded. Notes 1 and 2 were revised extensively to clarify function. Original text is included here for historical purposes:

Note 1: VAT4 is not stopped and restarted when a duplicate (retransmitted) block is received. VAT4 is restarted when an interrupt uplink message is received.

Note 2: There is no way that the MU can tell whether the block is part of the same message. The MU assumes that it is a continuation of the message that it has been receiving if various timers associated with multiblock uplinks have not timed out.

The definition of NOCOMM Timer VAT6 was expanded.

The definition of the value of the No ACK timer VAT7 was expanded for Category B environments from 10-25 seconds to 2-25 seconds. Added commentary.

The definition of Multiblock Message Timer VAT10 was expanded.

5.4.3 Ground Timers

In Count: the text ‘No ACK timer (VGT1) expires’ was replaced by ‘by 1 each time the block is transmitted’.

5.4.4 Airborne Counters

In Count: the text ‘No ACK timer (VGT1) expires’ was replaced by ‘by 1 each time the block is transmitted’.

5.7.1 Data Transceiver Autotune Command - Label :;

A new penultimate paragraph was inserted. This new paragraph expedites transfer to another media to foster minimum delivery time for ATS messages.

5.9.3 Logical Channel Establishment

Added final paragraph. Replaced “retransmission protocol” with “retransmission logic.”

7.5.1 Acknowledgment of a Downlink Block

Text from Section 7.5.1 of ARINC Specification 618-1 was moved to Section 7.5.1.3. New text was entered into Section 7.5.1 to describe the objective of optimizing the use of the RF spectrum and introduce examples.

Text describing 3 scenarios was deleted. The functions described by the scenarios are now more explicitly defined in the new subsections to Section 7.5.1.

7.5.1.1 Downlink Acknowledgment Scenario 1, Simple Case

New section added.

7.5.1.2 Downlink Acknowledgment Scenario 2, Pending Uplink

New section added.

7.5.1.3 Downlink Acknowledgment Scenario 3, Criss-cross

New section added. This material is based on material from Section 7.5.1 of the previous supplement.

7.5.2 Acknowledgment of an Uplink Block

Text from Section 7.5.2 of ARINC Specification 618-2 was moved to Section 7.5.2.3. New text was entered into Section 7.5.1 to describe the objective of maximizing the use of the RF spectrum and introduce examples.

Text describing 3 scenarios was deleted. The functions described by the scenarios are now more explicitly defined in the new subsections to Section 7.5.2.

7.5.2.1 Uplink Acknowledgment Scenario 1, Simple Case

New section added.

7.5.2.2 Uplink Acknowledgment Scenario 2, Pending Downlink

New section added.

7.5.2.3 Uplink Acknowledgment Scenario 3, Criss-cross

New section added. Most of this material is based on material from Section 7.5.1 of the previous supplement.

7.6 SATCOM Management Link

The sentence “The timers and counters should be initialized to zero.” was added.

7.6.1 Ground Based Timers

The value of Message Reject timer SGT2 was revised from 270 to 280 to speed up delivery of messages.

7.6.2 Airborne Timers

The value of Message Assembly timer SAT4 was revised from 270 to 280 to speed up delivery of messages.

7.6.2.1 SATCOM Tracker Timer

New section added.

7.6.3 Ground Counters

Name of Counter SGC1 was changed from ‘Retransmission’ to ‘Transmission’ to avoid ambiguity regarding the count.

7.6.4 Airborne Counters

Name of Counter SAC1 was changed from ‘Retransmission’ to ‘Transmission’ to avoid ambiguity regarding the count.

8.7.2.1 HF Tracker Timer

New section added. Name of Counter HAT3 was changed from ‘Retransmission’ to ‘Transmission’ to avoid ambiguity regarding the count.

8.7.3 Ground Timers

New section added. Name of Counter HFGC1 was changed from ‘Retransmission’ to ‘Transmission’ to avoid ambiguity regarding the count.

8.7.4 Airborne Counters

New section added. Name of Counter HFAC1 was changed from ‘Retransmission’ to ‘Transmission’ to avoid ambiguity regarding the count.

9.1 Overview

The last 2 paragraphs were revised. New text was added for the provision of multiple simultaneous use of air/ground links (VHF, SAT and HF) in any combination.

9.1.1 ACARS BOP Data File

Reference to ARINC Specification 429 was added.

9.1.2 Media Advisory

New text was added. This section was originally only a placeholder.

9.1.3 Media Switching

New section added.

9.2 ACARS SATCOM Datalink

The section title, previously VHF/SATCOM, was revised for clarification.

9.2.1 SATCOM Channel Operation

Text was revised to support simultaneous use of multiple air/ground links.

9.3 ACARS HF Datalink

The section title was revised for clarification.

9.3.1 HF Channel Operation

Text was revised to support simultaneous use of multiple air/ground links.

9.3.2 Media Advisory

Placeholder section deleted.

9.4 VHF/SATCOM/HF

Placeholder section deleted.

9.4.1 VHF/SATCOM/HF Channel Operation

Placeholder section deleted.

9.4.2 Media Advisory

Placeholder section deleted.

Attachment 9

New attachment added.

Attachment 10

New attachment added.

Attachment 11

New attachment added.

Attachment 12

New attachment added.

Attachment X

Completed issues were deleted and one new issue, now Item 2, was added.

Appendix C

New appendix added. This appendix contains a collection of procedures and pass/fail criteria pertaining to the testing of ACARS MU and SATCOM equipment to be used in aircraft installations supporting FANS-1 ATS VHF and SATCOM communications.

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SUPPLEMENT 3
TO
ARINC SPECIFICATION 618

AIR/GROUND CHARACTER-ORIENTED PROTOCOL SPECIFICATION

Published: November 18, 1998

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: October 8, 1998

A. PURPOSE OF THIS DOCUMENT

This supplement introduces changes to expedite the delivery of messages. It does so by modifying some timer values and by establishing a time budget (see Section 5.4.5) for the MU in its handling of messages. This supplement also introduces a definition of the protocol used between the ACARS MU and the VHF Data Radio (VDR) described in ARINC Characteristic 750. A new chapter, Chapter 11, has been added to define provisions specific to operations in a Mode A configuration with a digital interface between the MU and the VDR.

Minor editorial changes are also added.

B. ORGANIZATION OF THIS SUPPLEMENT

In the past, changes introduced by a supplement to an ARINC Standard were identified by vertical change bars with an annotation indicating the change number. Electronic publication of ARINC Standards has made this mechanism impractical.

In this document **blue bold** text is used to indicate those areas of text changed by the current supplement only.

C. CHANGES TO ARINC SPECIFICATION 618 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete listing of the changes to the document introduced by this supplement. Each change is identified by the section number and the title as it will appear in the complete document. Where necessary, a brief description of the change is included.

1.0 Air/Ground Communication

Throughout the document “MU” has been replaced by [C]MU to reflect the utilization of a CMU for ACARS communications.

1.5.2 Airborne System Equipment

Introduce the [C]MU as a system capable of supporting ACARS functions.

2.1 General Format Description

Editorial changes were made.

2.2.2.2 VHF Category B Mode Character

Editorial changes were made.

2.2.2.4 Satellite Category B Mode Character

New section to introduce LEO/MEO SATCOM interfaces and air/ground link functionality. These systems use the Mode Character ‘B’.

2.3.3.2.1 Airline Identifier

Definition revised to enable either of the two characters to be assigned as a number. This expansion is necessary due to the growth in the number of airlines.

3.3.1.4 DSP Identity

New section to introduce LEO/MEO SATCOM air/ground links.

3.3.2.2 VHF SITE Address

New section title.

3.3.2.4 DSP Identify

New section added to introduce LEO/MEO SATCOM air/ground links.

3.4.1.1 Message Originator

New Origin ID codes were added for HFDR 1, 2 and SDU 3, 4. Associated notes were added.

3.4.2 Uplink Message Sequencing

New text (last paragraph) added to describe LEO/MEO SATCOM function.

3.7 Unable to Handle Uplink

Editorial change to identify Label Q5 as the “Unable to Deliver” message.

3.7.1 Unable to Deliver Messages

Editorial change to identify Label Q5 as the “Unable to Deliver” message.

3.7.3 Unusable Messages

Editorial change to identify label QX as the “Unusable” message.

3.7.5 Undelivered Uplink Messages

Editorial change to identify label HX as the “Undeliverable” message.

4.4.7 ACARS Demodulator Performance for Processing Uplink ACARS Blocks

New section added.

4.4.7.1 Uplink Performance in an ACARS RF Environment Free from Contention Background Signals

New section added.

4.4.7.2 Uplink Performance in an ACARS RF Environment Containing Interfering, Co-Channel Background ACARS Signals

New section added.

5.4.1.1 VGT1, No ACK Timer

The value of VGT1 was changed from a fixed value of 10 seconds to a nominal value of 10 seconds with the actual value depending on the timing budget. For further description see Section 5.4.5.1

5.4.1.5 VGT5, Unable to Deliver (Q5) Timer

Title of section changed. Previously the title was listed as “Q5 Timer.”

5.4.1.6 VGT6, Squitter Timer #1

Clarifying language was added to activity features of ground squitter message generation.

5.4.2.2 VAT2, Scan Timer

Fast Scan mode added. The Timer value is now subject to mode. Added Note 1.

5.4.2.6 VAT6, NO COMM Timer

Reference added.

5.4.2.7 VAT7, No ACK Timer

Reference added. Start of timer definition added for VDR Mode A, Mode 2 Configuration.

5.4.4 Airborne Counters

The definition of Stop for VAC1 was modified from “VAC1 is stopped when an uplink containing an acknowledgment indicating on error is received.“ to “VAC1 is stopped when an uplink containing an acknowledgment indicating an error free downlink was received by the DSP.“

5.4.5 Timing Budget

New Section 5.4.5 and Subsections 5.4.5.1 through 5.4.5.2 were added to ensure a response adequate to satisfy ground based protocol timers and avoid unnecessary retransmissions. This addition was precipitated by the introduction of the VDR Mode A Configuration.

5.4.5.1 VDR Mode A Timing Budget for VGT1

New section added.

5.4.5.2 VDR Mode A Timing Budget for VAT7

New section added.

5.6.2.1.1 Frequency Selection Algorithm

Editorial change of “service provider” to DSP’s.

5.6.2.1.1.1 Base Frequency Scan Sequence

New section added.

5.6.2.1.1.2 Geographic Filtering of Base Frequencies

New section added.

5.6.2.1.1.3 Scanning with Multi-Base-Frequency DSPs

New section added.

5.6.2.1.1.4 Fast Scan of Base Frequencies

New section added.

5.6.2.1.1.5 Normal Scan of Base Frequencies

New section added.

5.6.2.1.3 Scan Timer

Fast Scan mode introduced.

5.7.2 SP Broadcast Autotune Uplink

New section added.

5.10 Statistical Data Collection and Reporting

This section was reorganized. Material was moved into Section 5.10 to improve clarity.

5.10.1 Message Statistical Data Collection

New section added. The contents were formerly contained in Section 5.11.

5.10.1.1 Statistical Data Reports

New section added.

5.10.1.1.1 Summary Reports

New section added.

5.10.1.1.2 Detailed Reports

New section added.

5.10.1.1.3 No Data Reports

New section added.

5.10.2 VHF Channel Performance Data

New section and subsections 5.10.2.1.1 through 5.10.2.1.23 were added.

7.0 SATCOM Interface

Provisions were added to integrate the use of LEO/MEO SATCOM systems into the ACARS environment. Generally, references to the SATCOM AERO H Satellite Data Unit (SDU) were expanded to include the Satellite Terminal Unit (STU).

7.2 Data Bus Interface

Interface possibilities were expanded to include multiple types of SATCOMs.

7.2.3.1 SDU Subsystem Identifier (Label 172) and

7.2.3.2 STD/SDU Subsystem Identifier (Label 172)

Sections merged.

7.3.3 Status to ACARS MU (Label 270)

New section title.

7.3.3.1 SDU Status to ACARS MU (Label 270) and

7.3.3.2 STU Status to ACARS MU (Label 270)

Sections merged.

7.4 Link Interface

A table containing LRU, SAL and Destination codes was added. Options 6 and 7 were changed to “reserved” because they are now obsolete. Note 1 added to clarify ARINC 429 data bus speed selection.

7.5 ACARS Message Protocol

New subsections 7.5.1 through 7.5.1.4 added.

7.5.1 Acknowledgment of a Downlink Block

7.7 Media Utilization

The second paragraph, identifying known SATCOM service provider options, was added.

8.4 Link Interface

Added the System Address Label (SAL) of the [C]MU.

8.7.2 Airborne Timers

Assigned the value of HFAT3 to 30 minutes (1800 seconds). Previously, it was identified as Not Applicable (N/A).

8.7.2.1 HF Tracker Timer

Original text was removed. TBD was used as a placeholder to retain the section in case the Tracker Timer should be reinstated.

9.0 Media Utilization

New sections 9.1 through 9.2.2 added.

10.0 MU Operating with a Mode A VDR

New chapter added to document the provisions that vary from the basic protocol when the MU is interfaced with a VDR. This arrangement is referred to as the Mode A configuration.

Attachment 3

Changed title of attachment to be consistent with ARINC Specification 619.

Attachment 6

New attachment added.

Attachment 13

New attachment added.

Attachment 14

New attachment added.

Attachment X

Deleted.

Appendix D

New appendix added.

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SUPPLEMENT 4
TO
ARINC SPECIFICATION 618

AIR/GROUND CHARACTER-ORIENTED PROTOCOL SPECIFICATION

Published: August 16, 1999

Prepared by the Airlines Electronic Engineering Committee

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A. PURPOSE OF THIS DOCUMENT

This supplement incorporates descriptions of the air/ground protocol that were formerly contained in ARINC Specification 620. This text was removed from Specification 620 to enable that document to encompass the VDL Mode 2 air/ground link.

B. ORGANIZATION OF THIS SUPPLEMENT

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In this document **blue bold** text is used to indicate those areas of text changed by the current supplement only.

C. CHANGES TO ARINC SPECIFICATION 618 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete listing of the changes to the document introduced by this supplement. Each change is identified by the section number and the title as it will appear in the complete document. Where necessary, a brief description of the change is included.

2.1 General Format Description

New introductory sentence. Added Notes 2 and 3.

2.2 Downlink Block Format

Two paragraphs from Section 3.6 of Specification 620 were transferred to this section.

2.2.3.3 Satellite Category A Mode Character

New text added.

2.2.2.4 Satellite Category B. Mode Character

New section added.

2.2.2.5 HF Mode Character

New section added.

2.2.6 Downlink Block Identifier

Commentary added.

2.2.8 Text

Added second sentence to the first paragraph and the second sentence to the second paragraph. These define the maximum length of a Satellite Category B message and the content of Application Text respectively. More Commentary was added to explain the General and Business aviation use of the aircraft address. Even More Commentary was added to explain Airline ID and Flight Number anomalies.

2.3 Uplink Block Format

Two paragraphs from Section 3.7 of Specification 620 were transferred to this section.

2.3.8 Text

The Text field length definition for Satellite Category B was added.

3.1.2 Uplinks

A new first paragraph was inserted, using text removed from Section 2.2.1 of ARINC Specification 620.

3.3.1.1 Aircraft Address

The final three paragraphs were added using text from Section 3.2.2 of ARINC Specification 620.

3.3.3 Supplementary Addresses

The final paragraph was added using text from Section 3.6.1 of ARINC Specification 620.

3.4.1 Downlink Message Sequencing

An explanation of the absence of multiblock in a Satellite Category B link is explained in the last paragraph.

3.4.1.1 Message Originator

Message origin ID codes F,G,H,K,P,V, 5-8, R, T and U were added. Note 13 was added.

3.4.2 Uplink Message Sequencing

An explanation of the absence of multiblock in a Satellite Category B link is explained in the last paragraph.

3.6.2 Multiblock Downlinks

The final three paragraphs were added using text from Section 3.6.1 of ARINC Specification 620.

3.6.2.1 Incomplete Multiblock Downlink

The penultimate paragraph was added using text from Section 2.2.2 of ARINC Specification 620.

3.6.4 Multiblock Uplinks

The final five paragraphs were added using text from Sections 3.7.2, 4.4.1 and 4.4.2 of ARINC Specification 620.

3.7.1 Unable to Deliver Messages

The final paragraph was added using text from Section 3.5.1 of Specification 620, amended to state that the original UBI is not retained for these retransmissions.

3.7.2 Printer Reject Messages

The final paragraph was added using text from Section 3.5.1 of Specification 620, amended to state that the original UBI is not retained for these retransmissions.

4.1 Radio Frequency Environment

The final paragraph was added using text from Section 2.1 of Specification 620.

4.1.1 Equipment Architecture

The final paragraph was added using text from Section 2.1 of Specification 620.

4.4.2 Data Encoding

The first paragraph was added using text from Section 2.1 of Specification 620.

5.4.5.1 VDR Mode A Timing Budget for VGT1

Reference to Figure 14-2 was added.

5.6 Frequency Management

The last two paragraphs were added to explain ground station squitter messages by DSPs. Commentary was added.

5.7 Operation on Alternate Frequencies

New text added.

5.7.2 DSP Broadcast Autotune Uplink

Text added to clarify the definition of the terminal phase of flight. The new maximum value of 120 seconds delay was defined for downlink attempts.

5.8 Category A Network Operation

New first paragraph added using text from ARINC Specification 620.

5.9 Category B Network Operation

A final entry (last line) was added to ensure that the MU maintains a logical channel during VHF Category B operation.

5.10.2.1 VHF Channel Data Report Generation

The commentary was amended to note that the snapshot and periodic reports have the same format.

5.10.2.1.1 Cumulative VHF Channel Busy (Tcu)

Text added to clarify that the cumulative VHF channel busy value is set to zero at the beginning of each report interval.

5.11 Transit Times

New section added.

7.3.1 Subsystem Identifier (Label 172)

Use of Label 172 was added to identify the satellite bearer systems that a single SDU supports. Multiple bearer systems is a new feature. Reference to ARINC 761 added.

Satellite Category B Operation

New last paragraph and second from last paragraph were added.

9.3.1 HF Channel Operation

Provision for tracker message was deleted.

ATTACHMENT 15 – GENERAL FORMAT OF AIR/GROUND DOWNLINK AND UPLINK MESSAGES

New attachment added.

APPENDIX A – PROTOCOL HISTORY

A1.8 Original Format Description

New text was transferred to this section from ARINC Specification 620.

APPENDIX B – ACARS OVERVIEW

Text B.1 through B.4.2 w

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SUPPLEMENT 5
TO
ARINC SPECIFICATION 618

AIR/GROUND CHARACTER-ORIENTED PROTOCOL SPECIFICATION

Published: August 31, 2000

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: June 26, 2000

A. PURPOSE OF THIS DOCUMENT

This supplement primarily introduces the ACARS over AVLC (AOA) air/ground protocol definition. Some additional editorial updates are included.

B. ORGANIZATION OF THIS SUPPLEMENT

In the past, changes introduced by a supplement to an ARINC Standard were identified by vertical change bars with an annotation indicating the change number. Electronic publication of ARINC Standards has made this mechanism impractical.

In this document **blue bold** text is used to indicate those areas of text changed by the current supplement only.

C. CHANGES TO ARINC SPECIFICATION 618 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete listing of the changes to the document introduced by this supplement. Each change is identified by the section number and the title as it will appear in the complete document. Where necessary, a brief description of the change is included.

1.1 Introduction

New paragraph added.

1.8 Documents Referenced

More reference documents added.

5.4.5 VDL Mode A Timing Budget

Changed section title.

5.4.5.1 VDL Mode A Timing Budget for VGT1

Changed section title. Added RF propagation to list.

5.4.6 VDL Mode 2 Timing Budget

New section added.

7.3.1 Subsystem Identifier (Label 172)

Text added to second paragraph to indicate CMU use of the Label 172 to control its operation with an SDU having multi-bearer capabilities.

7.3.3 Status to ACARS [C]MU (Label 270)

Reference to ARINC Characteristic 761 added. Third paragraph deleted.

7.4 Link Interface

Version 1 added to first paragraph. SDU #3 and SDU #4 deleted from first table.

9.4 ACARS Using VDL Mode 2 Data Link

New section added.

9.4.1 ACARS Messages Over VDL Mode 2

New section added.

10.0 CMU With VDR Operating in VDL Mode A

New Section 10 title.

10.4.3.2 VDL Mode 1 Initialization

Noted that this configuration was defined by ICAO SARPs but is being removed due to not being implemented.

10.4.3.3 VDL Mode 2 Initialization

Section reference added.

11.0 ACARS Over AVLC

New section added.

ATTACHMENT 16 - AOA PROTOCOL ARCHITECTURE

New attachment added.

ATTACHMENT 17 - AVLC FRAME STRUCTURE

New attachment added.

ATTACHMENT 18 - AOA MESSAGE SEQUENCE CHARTS AND FLOW DIAGRAMS

New attachment added.

ATTACHMENT 19 - AOA TIMING DIAGRAMS

New attachment added.

APPENDIX E – VDLM2 TIMING BUDGET

New appendix added.

APPENDIX F - TERMS AND ACRONYMS

New appendix added.

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SUPPLEMENT 6
TO
ARINC SPECIFICATION 618

AIR/GROUND CHARACTER-ORIENTED PROTOCOL SPECIFICATION

Published: June 16, 2006

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: April 4, 2006

A. PURPOSE OF THIS DOCUMENT

This document refines the definition of the switchover from ACARS to AOA, and the process for fallback to ACARS when VDL Mode 2 connectivity becomes unavailable. Squitter sensing is introduced to facilitate switchover from ACARS to AOA. HF DLK connectivity is enhanced by increasing the number of airborne retries to four.

B. ORGANIZATION OF THIS SUPPLEMENT

In the past, changes introduced by a supplement to an ARINC Standard were identified by vertical change bars with an annotation indicating the change number. Electronic publication of ARINC Standards has made this mechanism impractical.

In this document **blue bold** text is used to indicate those areas of text changed by the current supplement only.

C. CHANGES TO ARINC SPECIFICATION 618 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete listing of the changes to the document introduced by this supplement. Each change is identified by the section number and the title as it will appear in the complete document. Where necessary, a brief description of the change is included.

1.3 Document Organization

A short description of Chapters 10 and 11 were added to Section 1.3.

1.8 Documents Referenced

Added ARINC 631 and ARINC 750 to the list of reference documents

2.1 General Format Description

The second sentence of the first paragraph is deleted for accuracy.

2.2 Downlink Block Format

Added a reference to Table 15-1.

2.2.2.4 Satellite Category B Mode Character

Replaced the previous provision.

2.3.3 Address Recognition

Replaced the previous provision for address recognition for squitter messages with a reference to the squitter address defined in Section 2.3.3.3.

2.3.3.3 Squitter Address

This section was re-numbered from 2.3.3.2.3 to 2.3.3.3.

3.3.1.1 Aircraft Address

The provision of the capability CMU was modified from "…decoding all uplink traffic and squitters, …" to "… extracting SQP data and the Mode Character from all uplink traffic, …."

In the last sentence of the fourth paragraph, replace the previous provision for address recognition for squitter messages with a reference to the squitter address defined in Section 2.3.3.3.

5.4.1.8 VGT8, Temporary Suspension Timer

Added a sentence at the end of the section.

5.4.2.7 VAT7, No ACK Timer

The second sentence under Start was deleted.

5.6.2.1.1.3 Scanning with Multi-Base Frequency DSPs

This section was deleted.

5.6.2.4 Power Interruption/Frequency Recall

New section was added.

5.6.2.4.1 While Operating in Base Frequency Maintenance State in POA

New section was added.

5.6.2.4.2 While operating in VDL Mode 2 AOA

New section was added.

5.7.1 Data Transceiver Autotune Control – Label

A new fourth paragraph was inserted after paragraph three. Subsequent paragraphs were retained.

5.7.2 DSP Broadcast Autotune Uplink

This section was deleted.

7.5.1 Acknowledgment of a Downlink Block

An introductory sentence was added to Section 7.5.1.

7.5.2 Acknowledgment of an Uplink Block

The last sentence of Section 7.5.2 was deleted.

8.6.1 Acknowledgment of a Downlink Block

A new sentence was added to Section 8.6.1 just before the commentary.

8.7.4 Airborne Counters

In Table 8.7.4-1 the Value column was changed from “2” to “4.”

9.1.2 Media Advisory

A new paragraph was added at the end of Section 9.1.2

9.3.1 HF Channel Operation

In the fourth paragraph “SAC1” was changed to “HFAC1.”

10.2 Data Bus Interface

A fourth paragraph was added.

10.2.1 Version 1 Implementation

New section was added.

10.2.2 BOP Version 3 Implementation

New section was added.

10.4 Link Interface

Removed the first paragraph of Section 10.4. All material from old Section 10.4, following the third paragraph up to the second last paragraph, was moved to new Section 10.4.1.1. The last paragraph of old Section 10.4 was deleted.

10.4.1 Link Interface using BOP

New material was developed for Section 10.4.1.

10.4.1.1 Link Interface using Version 1 BOP

Section 10.4.1.1 was added.

10.4.1.2 Link Interface Using Version 3 BOP

Section 10.4.1.2 was added.

10.4.1.3 CMU-VDR Messages

Section 10.4.1.3 was added.

10.4.2 VDR Configuration

In the third paragraph, “and destination code 00_h” was removed from the first sentence.

After paragraph three, two paragraphs were added.

In paragraph 5 of Section 10.4.2, “00_h” is changed to “00_b” and “01_h” is changed to “01_b.”

The paragraph before the commentary starts with “During VDR configuration” instead of “At this time.”

10.4.3 VDR Initialization

In Section 10.4.3, the first sentence of paragraph two was changed to read as follows: “When Mode A (ACARS protocol) is selected then the initialization is performed using extended GFI $F2_h$ and destination codes or Command type depending on whether BOP Version 1 or 3 is being used as defined in Attachment 11 of ARINC Characteristic **750**.” (Formerly the reference was to ARINC Characteristic 750-2).

10.4.3.1 Mode A VDR Initialization

A new third paragraph was inserted. Previously, the paragraph read: "The DSP may choose to continue sending 220 character blocks even when N1 is larger. The DSP does not have to supersize the uplink blocks."

10.6.4.2.7 VAT7, No ACK Timer

In the "Start" section the sentence that ends in "by the VDR" is changed to "by the VDR, or VAT7 is started when the CMU receives the UNIDATA.confirm message from the VDR indicating that the message was transmitted."

A commentary was added just before the start of the "Stop" section.

11.0 ACARS Over AVLC

The title for Section 11.0 was changed from "DATA RECORD CONTENTS AND FORMAT" to "ACARS OVER AVLC."

11.3.1 Message Format

Paragraph 8 of Section 11.3.1 was rewritten.

11.3.2 Acknowledgement of a Downlink Block

The last sentence in the first paragraph of Section 11.3.2 was removed.

A new second paragraph was added.

11.3.3 Acknowledgement of an Uplink Block

A new paragraph was added at the end of Section 11.3.3.

11.4.2.1 Management of Inter-Media Switch Timer (VAT12) and Debounce Timer (VAT13)

In item b, the sentence is changed to:

b. VAT12 should be initialized when the avionics tunes to the indicated AOA frequency.

Item e. was added.

11.5.1 ACARS to AOA (Normal)

New text was added to explain a transition from ACARS to AOA based on information provided by Squitters. Some text was moved to new Sub-sections 11.5.1.1 and 11.5.1.2.

11.5.1.1 ACARS to AOA Switchover Based on Squitters

New Sub-section created. This section now includes text from Section 11.5.1. The provisions of Steps 1, 2, and 3a were re-written and augmented to clarify how data provided in a Squitter could be used to facilitate switchover from ACARS to AOA.

Added Step 1a and an associated commentary.

11.5.1.2 ACARS to AOA Switchover Based on Label VDL Retune Command

This section was added to specify new capabilities.

11.5.2 AOA to ACARS (Normal)

This section was added to specify new provisions.

11.5.2.1 AOA to ACARS Switchover Based on Label: Autotune Command

This section was added.

11.5.2.2 AOA to ACARS Switchover Without Autotune Command

This section was added.

11.6.4 Voice/Data Switching

Paragraph 3 was modified for clarification. A note was also added for proper definition of terms.

The end of the sentence in the third paragraph was changed from “mode frequency” to “mode and frequency.”

ATTACHMENT 8 - DATA RECORD CONTENTS AND FORMAT

A statement was added to specify when a record is started.

Table 8-1 was expanded to include a new column “Definition.” Values of parameters in the columns are revised for accuracy.

In Table 8-2, Note 1 was deleted and in Note 2 the phrase “it should” is deleted.

ATTACHMENT 13 - MU-VDR PROTOCOL NEGOTIATION MESSAGE SQUENCE CHART EXAMPLES

In Figure 13-4 the start of VAT7 (left middle of page) is shown by either of two inputs.

ATTACHMENT 18 - AOA MESSAGE SEQUENCE CHARTS AND FLOW DIAGRAMS

In Figure 18-4, the sequence of events was changed to reflect that the aircraft falls back to original ACARS frequency, VAT12 is terminated, and finally VAT13 is started.

In Figure 18-5, the sequence of events was changed to show that after VAT12 expires, the aircraft falls back to ACARS base frequency and VAT 13 is started.

APPENDIX E - VDL MODE 2 TIMING BUDGET

E1.1 VDL Mode 2 Timing Budget for VGT1

In paragraph 6, “Tlatency” was changed to “latency.”

ARINC Standard – Errata Report

1. *Document Title*

ARINC Specification 618-6: *Air/Ground Character-Oriented Protocol Specification,* June 16, 2006

2. Reference

Page Number: ______ Section Number: ______________ Date of Submission: ______________

3. Error

(Reproduce the material in error, as it appears in the standard.)

4. Recommended Correction

(Reproduce the correction as it would appear in the corrected version of the material.)

5. Reason for Correction *(Optional)*

(State why the correction is necessary.)

6. Submitter (Optional)

(Name, organization, contact information, e.g., phone, email address.)

Please return comments to fax +1 410-266-2047 or standards@arinc.com

Note: Items 2-5 may be repeated for additional errata. All recommendations will be evaluated by the staff. Any substantive changes will require submission to the relevant subcommittee for incorporation into a subsequent Supplement.

[To be completed by IA Staff]

Errata Report Identifier: ______________ **Engineer Assigned:** __________________________

Review Status: ____

ARINC IA Project Initiation/Modification (APIM)

1.0 Name of Proposed Project **APIM #: _____**

(Insert name of proposed project.)

2.0 Subcommittee Assignment and Project Support

2.1 Identify AEEC Group

(Identify an existing or new AEEC group.)

2.2 Support for the activity

Airlines: *(Identify each company by name.)*

Airframe Manufacturers:

Suppliers:

Others:

2.3 Commitment for resources *(Identify each company by name.)*

Airlines:

Airframe Manufacturers:

Suppliers:

Others:

2.4 Chairman: (Recommended name of Chairman.)

2.5 Recommended Coordination with other groups

(List other AEEC subcommittees or other groups.)

3.0 Project Scope *(why and when standard is needed)*

3.1 Description

(Insert description of the scope of the project. Use the following symbol to check yes or no below. ☒)

3.2 Planned usage of the envisioned specification

New aircraft developments planned to use this specification yes ❑ no ❑

Airbus: *(aircraft & date)*

Boeing: *(aircraft & date)*

Other: *(manufacturer, aircraft & date)*

Modification/retrofit requirement yes ❑ no ❑

Specify: *(aircraft & date)*

Needed for airframe manufacturer or airline project yes ❑ no ❑

Specify: *(aircraft & date)*

Mandate/regulatory requirement yes ❑ no ❑

Program and date: *(program & date)*

Is the activity defining/changing an infrastructure standard? yes ❑ no ❑

Specify *(e.g., ARINC 429)*

When is the ARINC standard required?
______*(month/year)*__________

What is driving this date? _______*(state reason)*_____________________

Are 18 months (min) available for standardization work? yes ❑ no ❑

If NO please specify solution: __________________

Are Patent(s) involved? yes ❑

If YES please describe, identify patent holder: __________________

3.3 Issues to be worked

(Describe the major issues to be addressed.)

4.0 Benefits

4.1 Basic benefits

Operational enhancements yes ❑ no ❑

For equipment standards:

a. Is this a hardware characteristic? yes ❑ no ❑

b. Is this a softwareware characteristic? yes ❑ no ❑

c. Interchangeable interface definition? yes ❑ no ❑

d. Interchangeable function definition? yes ❑ no ❑

If not fully interchangeable, please explain: __________________

Is this a software interface and protocol standard? yes ❑ no ❑

Specify: __________________

Product offered by more than one supplier yes ❑ no ❑

Identify: *(company name)*

4.2 Specific project benefits

(Describe overall project benefits.)

4.2.1 Benefits for Airlines

(Describe any benefits unique to the airline point of view.)

4.2.2 Benefits for Airframe Manufacturers

(Describe any benefits unique to the airframe manufacturer's point of view.)

4.2.3 Benefits for Avionics Equipment Suppliers

(Describe any benefit unique to the equipment supplier's point of view.)

5.0 Documents to be Produced and Date of Expected Result

5.1 Meetings and Expected Document Completion

The following table identifies the number of meetings and proposed meeting days needed to produce the documents described above.

Activity	Mtgs	Mtg-Days (Total)	Expected Start Date	Expected Completion Date
Document a	*# of mtgs*	*# of mtg days*	*mm/yyyy*	*mm/yyyy*
	*# of mtgs **	*# of mtg days **		
Document b	*# of mtgs*	*# of mtg days*	*mm/yyyy*	*mm/yyyy*
	*# of mtgs **	*# of mtg days **		

** Indicate unsupported meetings and meeting days, i.e., technical working group or other ad hoc meetings that do not requiring IA staff support.*

6.0 Comments

(Insert any other information deemed useful to the committee for managing this work.)

For IA Staff use

Date Received: _____________ IA Staff Assigned: ___________

Estimated Cost: _____________

Potential impact: ______

*(**A**. Safety **B**. Regulatory **C**. New aircraft/system **D**. Other)*

Forward to committee(s) (AEEC, AMC, FSEMC): _____________ Date Forwarded:_____________

Committee resolution: _______

*(**0** Withdrawn **1** Authorized **2** Deferred **3** More detail needed **4** Rejected)*

Assigned Priority:______ Date of Resolution:_________________

*(**A** High - execute first **B** Normal - may be deferred.)*

Assigned to SC/WG:_________________