ARINC

AIR-GROUND CHARACTER-ORIENTED PROTOCOL SPECIFICATION

ARINC SPECIFICATION 618

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Prepared by the Airlines Electronic Engineering Committee

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FOREWORD

Activities of AERONAUTICAL RADIO, INC. (ARINC)

and the

Purpose of ARINC Reports and Specifications

Aeronautical Radio, Inc. is a corporation in which the United States scheduled airlines are the principal stockholders. Other stockholders include a variety of other air transport companies, aircraft manufacturers and foreign flag airlines.

Activities of ARINC include the operation of an extensive system of domestic and overseas aeronautical land radio stations, the fulfillment of systems requirements to accomplish ground and airborne compatibility, the allocation and assignment of frequencies to meet those needs, the coordination incident to standard airborne communications and electronics systems and the exchange of technical information. ARINC sponsors the Airlines Electronic Engineering Committee (AEEC), composed of airline technical personnel. The AEEC formulates standards for electronic equipment and systems for airlines. The establishment of Equipment Characteristics is a principal function of this Committee.

It is desirable to reference certain general ARINC Specifications or Reports which are applicable to more than one type of equipment. These general Specifications or Reports may be considered as supplementary to the Equipment Characteristics in which they are referenced. They are intended to set forth the desires of the airlines pertaining to components or equipment is concerned.

An ARINC Report (Specification or Characteristic) has a twofold purpose which is:

(1) To indicate to the prospective manufacturers of airline electronic equipment the considered opinion of the airline technical people coordinated on an industry basis concerning requisites of new equipment, and

(2) To channel new equipment designed in a direction which can result in the maximum possible standardization of those physical and electrical characteristics which influence interchangeability of equipment without seriously hampering engineering initiative.

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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.

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 724/B refers to BOTH ARINC Characteristic 724 and ARINC Characteristic 724B.

1.3 Document Organization

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

Chapter 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.

Chapter 3 defines the ACARS MU Message Handling Protocols including priorities and multi-block handling.

Chapter 4 describes the VHF ACARS.

Chapter 5 describes Link Management for a VHF air-ground network.

Chapter 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.

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

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 two 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 both media.

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

ACARS is the portion of the system incorporated by the service provider's ground network and the equipment on board the aircraft needed to facilitate the transfer of the messages.

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.

1.0 AIR-GROUND COMMUNICATION (cont'd)

1.5.1 Ground System Equipment (cont'd)

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.

1.5.2 Airborne System Equipment

The airborne equipment consists of an ACARS Management Unit (MU) which is connected to a control/display unit (either dedicated or multi-purpose) and any ancillary equipment which supports the MU 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 SATCOM ACARS air-ground network, the ACARS MU is connected to the Satellite Data Unit (SDU). The satellite system is described by ARINC Characteristic 741.

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 MU may be designed to support Data Level 0, 1, or 2 SATCOM as described within the INMARSAT SDM. The ACARS MU/SATCOM SDU protocol interface and a definition of SATCOM Data Levels are described within Section 7.0 of this specification.

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 Chapter 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 Chapter 2 of this Specification. The definition of the text portion to be inserted for each specific message is contained in Chapter 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 Project Paper 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 Receiver
ARINC Characteristic 566,
 Airborne VHF Communications Transceiver & Mark 1 VHF SATCOM System

1.0 AIR-GROUND COMMUNICATION (cont'd)

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 620,
Data Link Ground System Standard and Interface Specification (DGSS/IS)
ARINC Characteristic 716,
Airborne VHF Communications Transceiver
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 (SATCOM)
PART 1 Aircraft Installation Provisions
PART 2 System Design
PART 3 Circuit Mode Voice and Data Services
PART 4 Specification and Description Language

AEEC Project Paper 619,
Airborne Equipment Protocols for File Transfer of Character Data

Proceedings of the IRE, January 1961, "Cyclic Codes for Error Detection".

Code of Federal Regulations (USA)

2.0 AIR-GROUND BLOCK STRUCTURE

2.1 General Format Description

The ACARS air-ground message structure closely follows the recommendations of RTCA Document No. DO-136 dated March 17, 1968.

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	NOTES
Start of Heading	(1 character)	
Mode	(1 character)	
Address	(7 characters)	
Technical Acknowledgement	(1 character)	
Label	(2 characters)	
Uplink/Downlink Block Identifier	(1 character)	
Start of Text	(1 character)	1
Text	(220 char.max.)	
Suffix	(1 character)	
Block Check Sequence	(16 bits)	

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

All messages should be structured to minimize the number of blocks passed across the air-ground media.

2.2 Downlink Block Format

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 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 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 MU based on the uplink Mode character as described in Section 2.3.2.2.

2.2.2.3 SAT Mode Character

The Mode character should be set to the value 2 (3/2).

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 (see Attachment 3) 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 MU should not transmit any downlink messages unless it has a valid aircraft registration mark. Once the MU acquires the aircraft registration mark then it should remember it at least until power to the MU is removed.

COMMENTARY

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

2.2.4 Positive Technical Acknowledgement

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

2.0 AIR-GROUND BLOCK STRUCTURE (cont'd)

The Positive Technical acknowledgement 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 MU should be capable of generating all downlinks identified as system-essential. The MU 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.

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. See Chapter 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 shaded portion of Table 3-1 in Attachment 3 indicates those characters which are not recommended in the "Free Talk" 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 Talk" portion is not recommended. See ARINC Specification 620 for a description of "Free Talk".

Every downlink transmission must 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 must be present in all downlinks.

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

COMMENTARY

> Optionally, the MU may prompt the crew to enter airline identification when it is not provided by the aircraft. The MU 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 3.3.2.3 and 3.2.2.4 of ARINC Specification 620 for details.

2.2.9 Suffix

Each single block should be terminated with the control character 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).

2.2.10 Block Check Sequence

A Block Check Sequence (BCS) of 16 bits is transmitted following the ETB or ETX character. These bits constitute the remainder of the division of the function derived from considering the binary digits of the message to be the coefficients of a polynomial, of arbitrary value x, by the CCITT polynomial.

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

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 acknowledgement 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.

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 MU has a message queued for

2.0 AIR-GROUND BLOCK STRUCTURE (cont'd)

2.2.10 Block Check Sequence (cont'd)

COMMENTARY (cont'd)

downlink that fails the BCS check, the MU 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). MU 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.

2.3 Uplink Block Format

2.3.1 Start of Header

The MU 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 MU 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 apostrophe "'" (6/0) through the left bracket "{" (7/13).

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

2.3.3 Address Recognition

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

The MU 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 MU should also accept squitter messages as having a valid address.

Once the MU 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 MU 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 A to Z.

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 MU 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 MU will add the 0 character.

2.3.3.2.3 Squitter Address

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

2.3.4 Positive Technical Acknowledgement

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

2.0 AIR-GROUND BLOCK STRUCTURE (cont'd)

The positive acknowledgement 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 MU 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/Suffix

The MU 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.

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 MU 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 MU to determine whether or not the uplinked message is error-free.

3.0 ACARS MESSAGE PROTOCOL

3.1 Basic Message Protocol

This Chapter 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.

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 MU (that is, transmissions which are not generated in response to a ground message) should contain the Negative Acknowledgement character (NAK) in the Technical Acknowledgement field (see Section 2.2.4 of this document) of each transmission.

3.1.2 Uplinks

The procedure for the initiation of messages by the ground processor is similar to the foregoing. The Technical Acknowledgement field of each uplink block that is not sent in response to a downlink block should contain the Negative Acknowledgement 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 Acknowledgement to the ground. This Positive Acknowledgement 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 Acknowledgement, the ground processor, after performing an error check on the block and finding it error-free, returns to the aircraft with another Positive Acknowledgement, 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 Acknowledgement should result in another acknowledgement cycle being initiated. When the original Positive Acknowledgement is downlinked in a General Response message, however, the airborne subsystem returns to the quiescent state as soon as transmission of the response is complete.

3.2 Acknowledgement Protocols

Blocks (other than the General Response message) sent by the avionics subsystem should be acknowledged by the ground network to confirm their receipt of the block. Similarly, the MU 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 acknowledgement. The exceptions are noted in the following subsections.

3.2.1 Acknowledgement of a Downlink Block

The MU 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 value is inserted into each downlink block when it is sent.

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

The value of the DBI character should be incremented when the MU receives an acknowledgement to its downlink message. The MU should determine if the acknowledgement 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 MU 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 MU will conclude that the ground network will not be able to uplink an acknowledgement.

Recognition of an uplink containing a "NAK" (1/5) character in the Technical Acknowledgement 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 MU of an uplink block which does not positively acknowledge a preceding downlink block, for which an acknowledgement 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 acknowledgement to the uplink block just received.

When the MU prepares an unsolicited downlink (not a response to an uplink), it should insert a "NAK" character in the Technical Acknowledgement field.

3.2.2 Acknowledgement of an Uplink Block

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

3.0 ACARS MESSAGE PROTOCOL (cont'd)

Acknowledgement criteria:

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

b. Valid address and bad Block Check Sequence (BCS) should yield a negative response.

c. Any message with the All Call address (7 NULs) should not elicit an acknowledgement. See Section 2.3.3.2.3.

d. Any message with an address which is not valid for the MU should be ignored in terms of acknowledgment handling.

Negative acknowledgement is always accomplished by transmitting a "NAK" (1/5) character in the Technical Acknowledgement field.

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

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

A downlink block which does not positively acknowledge a preceding uplink block, for which an acknowledgement is outstanding, may result in the uplink block being retransmitted immediately (in accordance with Section 4.5.2). This uplink retransmission should retain the UBI of the original uplink block. In addition, it should contain an acknowledgement to the downlink block just received.

COMMENTARY

For more efficient use of the RF spectrum, the DSP may acknowledge the downlink block, which does not positively acknowledge a preceding uplink block, with a General Response block. The uplink block retransmission should then be performed when the NO ACK timer (GT1) expires. See Section 5.4.1 for a description of the NO ACK timer (GT1). The retransmitted uplink block should retain the original UBI and contain a "NAK" (1/5) in the Technical Acknowledgement field.

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 MU 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 MU should also be capable of decoding all uplink traffic and squitters, regardless of address.

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 MU supports Category B operation, the SITE address should be stored by the MU for use in addressing subsequent downlinks.

3.3.1.3 Onboard Routing

Two fields typically provide basic 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 MU must decode the Label field of each message to determine the basic routing and/or purpose of the message for further processing. The message may be for direct consumption by the ACARS MU or may need to be relayed to an onboard device such as a printer or an FMC. The Sublabel field, when used, provides the final address for an onboard system.

In addition to these, other 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.

3.3.2 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 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 SITE Address

When in a VHF Category B environment, the ACARS MU 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.

3.0 ACARS MESSAGE PROTOCOL (cont'd)

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 MU 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 Agency ID, 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 Agency ID 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.

3.3.3 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 multi-block downlink message.

Supplementary address(es) are located immediately following the Agency Flight Number in messages without Sublabels, and immediately following the Message Type Identifier in messages with Sublabels (H1).

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 MU or end system and then utilized in a downlink response back to the originator.

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 "interspersed" 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 MU 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.

3.4.1.1 Message Originator

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

Origin	ID Code	Notes
CFDIU	C	1
DFDAU	D	2
FMC 1	F	3
FMC 2	F	3
MU	M	4
System Control	S	5
OAT	O	6
Cabin Terminal 1	1	7
Cabin Terminal 2	2	7
Cabin Terminal 3	3	7
Cabin Terminal 4	4	7
User Defined	U	8
EICAS/ECAM/EFIS	E	9

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 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 MU: refers to the system performing the basic ACARS functionality of ARINC Characteristic 597, 724 or 724B.

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

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

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

⑧ User Defined: refers to any system interfacing with the MU 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.

3.4.1.2 Message Number

The Message Number is a 2 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.

3.4.1.3 Block Sequence Character

The Block Sequence character is a 1 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.

3.4.2 Uplink Message Sequencing

COMMENTARY

There are no 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 messages, one of which would be a partial message.

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 acknowledgement is not received at the sending station.

The ground station (uplink) or MU (downlink) is permitted to make several retransmissions. See Subsection 5.4 for a definition of the Retransmission counters (AC1 and GC1) and the description of retransmission timing is provided in Section 5.5.

COMMENTARY

Transmissions deemed a duplicate may contain an acknowledgement in the Technical Acknowledgement field, while the original transmission may have contained a <NAK> in this field. The Technical Acknowledgement 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 acknowledgement has not been received within a specified time period (GT1). See Section 5.4.1 for a description of the No ACK timer (GT1).

The MU 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 MU should compare the character found in the UBI position of each uplink with a reference character (see below) 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 (AT8) 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 (AT8).

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

When the MU 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 Detect

The ACARS MU is programmed to retransmit messages for which an acknowledgement has not been received from the ground station within a specified time period (AT7). See Section 5.4.2 for a description of the No ACK timer (AT7).

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.

3.0 ACARS MESSAGE PROTOCOL (cont'd)

3.6 Multi-Block Processing

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

Multi-Block Messages can be handled essentially in one of two ways. Which method is used depends on the aircraft, service provider, and user needs.

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.

Fundamentally, the difference is whether or not the MU provides a store-and-forward capability.

Store-and-forward designs mean the ACARS MU must buffer entire messages (all blocks) before forwarding to on-board systems or downlinking.

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

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

3.6.1 Store and Forward

The MU 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.

This specification enables an MU 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 can receive them.

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.

3.6.2.1 Incomplete Multiblock Downlink

The service provider should maintain an Incomplete Downlink Message Delivery timer (GT4) 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.

If the last downlink block received is not the last block of a multiblock message (does not contain an ETX) and the Incomplete Message Delivery timer (GT4) expires before the last block of the same message is received, then the service provider should identify the message as incomplete and deliver the partial message to the host.

The MU 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 AT10 has expired.

COMMENTARY

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

3.6.2.2 Nesting of Multiblock Downlinks

It is necessary for any multiblock downlink in progress to be completed before starting another multiblock downlink message. The MU should not interrupt a multiblock downlink message in order to downlink a higher priority multiblock message. See Section 3.8 for the order of prioritization.

3.0 ACARS MESSAGE PROTOCOL (cont'd)

3.6.2.3 Interleaving of Multiblock Downlinks

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

3.6.2.4 Aborting a Multiblock Downlink

To be supplied in a supplement.

3.6.3 Restart Multiblock Downlink

The MU should use the Multiblock Message timer (AT10) 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 (AT9) expires or 2) the MU loses contact with the ground station for a period of time such that NOCOMM timer (AT6) expires. See Section 5.4.2 for definitions of the timers.

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

When the MU 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 (AT10). In this case, the airline may elect for the MU to discard the message or take some other action.

3.6.4 Multiblock Uplinks

The case of uplink multiblocks is similar to that of downlinks. 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 and the ground service provider should implement a Message Assembly and an Interblock timer, which operate in conjunction with timers on the ground, to provide a consistent method for detecting incomplete multiblock uplinks.

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 MU 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 (AT4) 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 (GT1) is set very high because copies of the downlink from all ground stations within range must be collected and processed before the acknowledgement can be generated.

MORE COMMENTARY

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.

3.6.4.1 Message Assembly Timer

The airborne subsystem should contain a Message Assembly timer (AT4) in order to detect when a multiblock uplink is incomplete. See Section 5.4.2

If the Message Assembly timer (AT4) times out then the airborne subsystem should ASSUME that the next block received is the first block of a new message and process the partial message as specified by the user.

All uplink blocks of the same label/sublabel received prior to expiration of the Message Assembly timer (AT4) 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 (AT5). AT5 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. AT5 is active only while operating Category B.

If the Interblock timer (AT5) 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 (GT1) runs out, the service provider checks its retry logic to see whether the block must be resent.

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 ground station will hold onto the message and wait for either a downlink from the aircraft or the Message Reject timer (GT2) to time out.

3.6.4.4 Ground Message Reject Timer

The service provider should maintain a Message Reject timer (GT2) to determine the point at which an attempted uplink should be declared unsuccessful. See Section 5.4.2 for a description of the Message Reject timer (GT2). When the Message Reject timer expires, the service provider should send a message to the originator to report that the message could not be delivered. The report to the user should indicate the reason for non-delivery. This procedure is described in Section 2.2.5.2 of ARINC Specification 620.

Further, the service provider should not transmit any uplinks to that airborne subsystem until the Incomplete Message Interval timer (GT3) has expired in order to insure that the airborne subsystem's Message Assembly timer has expired and the MU 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.

3.6.4.5 Restart Multiblock Uplink

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

3.7 Unable to Handle Uplink

When the MU cannot handle an uplink block it should indicate this to the DSP. The downlink message should be a Label Q5 or other "cannot handle" message, as described in the following subsections. This response to the uplink should contain the technical acknowledgement 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 MU should respond to the receipt of an uplink message which temporarily can not be delivered to the designated destination with a downlink containing the Label Q5. The format of Label Q5 messages is provided in Section 4.6.20 of ARINC Specification 620.

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

3.7.2 Printer Reject Messages

The MU 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 4.6.12 of ARINC Specification 620. Specific error codes, including Labels CA through CF, are given in Section 3.3.3.2 of ARINC Specification 620.

3.7.3 Unusable Messages

The MU should send an intercept downlink containing the Label "QX" upon receipt of a message that is not supported 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 QX message is defined in Section 4.5.7 of ARINC Specification 620.

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

The MU 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 MU may provide user defined reject messages. In this case, the MU should Acknowledge the undeliverable block (and subsequent blocks, if multi-block) 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 MU 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 MU should initiate a downlink message to the airline host system, indicating that the acknowledged message was not delivered. The format of the Label HX message is provided in Section 4.6.36 of ARINC Specification 620.

COMMENTARY

> Note that the HX message is not a response to the

3.0 ACARS MESSAGE PROTOCOL (cont'd)

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 acknowledgement 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 MU should provide the capability to sort downlink messages by priority according to the message originator (See AEEC Project Paper 619). The sorting of downlink messages should be performed on message boundaries. The ground service providers will support at least one level of message interrupt. A multiblock downlink message should only be preempted by a higher priority single block downlink message.

Data link Service Providers should support at least one level of message interrupt. DSPs should prioritize uplinks on message boundaries except for Voice request uplinks (Label 54). Voice request uplinks will preempt a multiblock uplink. See Section 2.2.4 of ARINC Specification 620.

The following hierarchy is defined for ACARS downlink message priority:

Priority Level	Description
1	System Control
2	Highest User Priority
3	Medium User Priority
4	Lowest User Priority

3.8.1 Priority of System Control Messages

System control (Level 1) messages should be accorded first priority in the MU downlink message queue. System Control messages have highest priority because their transmission is used in maintaining the communications link. System Control downlink messages include, but are not limited to, 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

Generally, Level 2, 3, and 4 messages should not be interrupted because it is necessary for any transaction in progress to be completed before another is started.

When the MU retry counter limit is reached or the current message is acknowledged (all blocks) then 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.

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

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 MU 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 MU with access to the RF environment. The system parameters specified in this document are optimized for communications through this medium.

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 MU 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 are described in Chapter 6 of this document.

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 MU 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 MU 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 as specified in Characteristic 566A Section 6.4.1 and Characteristic 716 Section 3.7.10.	50 ms
Ground System MSK AGC settling and phase demodulator discrimination allowance.	35 ms
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 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 MU 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.

4.0 VHF ACARS (cont'd)

4.2.3 Character Synchronization

Two consecutive 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 control character DEL (7/15) 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 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.

4.4.3 Modulation

The MU 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 MU is used should be extremely broad. In certain approaches to the generation of the modulating waveform, therefore, bandwidth limiting of the MU 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 MU is held to less than 10 microseconds.

If the MU 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 MU should be 1 V rms 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 MU modulator:

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

4.4.5 Demodulation

The MU 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 MU 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 MU 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 MU 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.

4.0 VHF ACARS (cont'd)

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 V rms 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 Khz (±200 ppm) frequency drift

COMMENTARY

The goal of the MU 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.

4.5 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 MU and VHF ground stations to obtain channel access authorization. Prior to executing the channel access algorithm the ACARS MU 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 MU is Non-Persistent CSMA defined as follows:

- If the channel is sensed idle, the MU transmits the frame.
- If the channel is sensed busy, then the MU schedules the transmission some time later according to a uniform random distribution within the limits of 30 ms to 300 ms.
- 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 MU should be capable of keying the VHF transceiver as defined in ARINC 597/724/724B according to the appropriate MU form factor and type of VHF transceiver employed.

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

Simultaneously with keying, the MU 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.

Under no conditions should the MU contribute to the transmission of RF carrier from the VHF transceiver which is unmodulated. This requirement applies both at the beginning and the end of ACARS transmissions. Appendix B has been provided as a reference outlining the recommended test procedure to be used for verification of this provision.

At the end of the desired ACARS transmission (BCS Suffix) the MU 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 MU is given control of frequency selection. Such control should be accorded to the MU at all times when the unit is in Data mode. Depending on configuration, the MU may also perform frequency selection to support Voice mode (see Chapter 6).

The MU 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 MU should provide for activation and use, at airline option, the ability to enter the VHF operating frequency manually. The MU 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 MU must be able to support at least one of these two methods.

4.6.2.1 Serial Digital Tuning

The MU 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 MU 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 MU 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 Chapter 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 MU 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 MU is grounded.

5.0 VHF LINK MANAGEMENT

5.1 Functional Capability of the Airborne Sub-System

The ACARS Management Unit (MU) 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 MU can be programmed with the different available frequencies and attempt link establishment on each frequency as described in this Chapter.

COMMENTARY

> Each DSP will use one frequency, referred to herein as the 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 VHF 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 coverage area to another may result in a need for the MU 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 MU 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 (NOCOMM)

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

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

Upon entering the NOCOMM condition the NOCOMM timer (AT6) is started. All outstanding uplink/downlink traffic should be considered "interrupted" and retransmission may be required. The NOCOMM condition should remain in effect until a an error free uplink is detected. The crew may initiate a transmission command despite the existence of a NOCOMM condition. The 724B MU 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 MUs should be capable of a NOCOMM annunciation on the CDU as well as the NOCOMM 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.

5.4.1 Ground Based Timers

The ground based timers are as follows:

Name:	GT1, No ACK Timer
Value:	10 seconds
Start:	GT1 is started when the service provider uplinks a block.
Stop/Reset:	GT1 is stopped and reset on receipt of an acknowledgement for the same block.
On Expiration:	Retransmit the original block if the retry count limit has not been reached.

Name:	GT2, Message Reject Timer
Value:	80 seconds
Start:	GT2 is started when a ground station uplinks the first block of a multiblock message.
Stop:	GT2 should be stopped when an acknowledgement to the last uplink block is received.
Restart:	GT2 should restart when the ground station transmits the subsequent block of the multiblock message. (Retransmissions of an uplink block do not affect this timer).
On Expiration:	Service provider will reject message back to originator, inhibit uplinks to the aircraft and start GT3. See Section 3.6.4.4.

Name:	GT3, Incomplete Message Interval Timer
Value:	20 seconds
Start:	GT3 is started when GT2 expires.
On Expiration:	Enable uplinks to the aircraft.
Description:	GT3 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.

5.0 VHF LINK MANAGEMENT (cont'd)

Name:	GT4, Incomplete Downlink Message Delivery Timer
Value:	11 minutes
Start:	GT4 should be reset and started when the first block of a multiblock downlink is received.
Stop:	GT4 should be stopped when the last block of a multiblock message (containing ETX) is received.
On Expiration:	See Section 3.6.2.1
Description:	GT4 sets a limit to the time the DSP should wait to recover the remainder of a partial downlink message before giving up.

Name:	GT5, Q5 Timer
Value:	See Note.
Start:	GT5 is started when a Unable to Deliver downlink message, Label Q5, is received.
On Expiration:	Retransmit the message with new UBI.
Note:	The GT5 timer is service provider dependent.
Description:	GT5 is the time a ground service provider network waits before retransmitting a message which is temporarily undeliverable on the aircraft.

Name:	GT6, Squitter Timer #1
Value:	2 minutes
Restarted:	GT6 should be restarted each time an uplink message is transmitted in the area of coverage. See Note 1.
On Expiration:	When the GT6 timer expires the ground network should ensure that a squitter message is transmitted.
Description:	GT6 is the maximum time a ground service provider network waits before providing uplink traffic during periods of inactivity within a specific area of coverage.
Note 1:	In a Category B network the uplink must be a Category B uplink, i.e. Mode character with a value other than "2".

Name:	GT7, Squitter Timer #2
Value:	10 minutes
Restart:	GT7 should be restarted each time a squitter message or category B uplink is transmitted to the area of coverage.
On Expiration:	When the GT7 timer expires the ground network should ensure that a squitter message is transmitted.
Description:	GT7 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:	The GT7 timer must be active on all of the network's frequencies including alternate frequencies.

Name:	GT8, Temporary Suspension Timer
Value:	10 minutes
Start/Restart:	GT8 should be started whenever a 5P downlink is received.
Stop:	GT8 should be stopped and reset whenever a downlink is received (normally Q6).
On Expiration:	When the GT8 timer expires the DSP may resume uplinks to the aircraft.

5.4.2 Airborne Timers

The avionics subsystem timers are as follows:

Name:	AT1, Contact Timer
Value:	See Note 1
Start:	AT1 is started when the MU has established a link with the ground network on the base frequency of a Category A network and the aircraft is airborne.
Stop:	AT1 is stopped when the aircraft lands or is autotuned to an alternate frequency.
Restart:	AT1 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 AT1 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 AT1 is optional.

Name:	AT2, Scan Timer
Value:	See Note.
Start:	AT2 is started when the MU enters the Frequency Acquisition state.
Stop:	AT2 should be stopped when a valid uplink is received.
On Expiration:	See Section 5.6.2.1.3.
Note:	The timeout value for the AT2 timer may vary with the base frequency selected. The value chosen should be longer than GT6 (dependent upon service provider).

Name:	AT3, Tracker Timer
Value:	10 minutes
Start:	AT3 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:	AT3 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:	AT3 is maintained during Frequency Maintenance while operating Category A. AT3 is suspended while the aircraft is on the ground.

5.4.2 Airborne Timers (cont'd)

Name:	AT4, Message Assembly Timer
Value:	90 seconds
Start:	AT4 should be started when the airborne subsystem receives the first block of a multiblock uplink message.
Stop:	AT4 should be stopped when the last uplink block (terminated with an ETX) of the same message is received. See Note 2.
Restart:	AT4 should be restarted when the subsequent uplink block of the same message has been received (uplinked).
On expiration:	See Section 3.6.4.1.
Note 1:	AT4 is not stopped and restarted when a duplicate (retransmitted) block is received. AT4 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.

Name:	AT5, Interblock Timer
Value:	30 seconds
Start:	AT5 is started when the airborne subsystem receives the first block of a multiblock uplink.
Restart:	AT5 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:	AT5 is optional and would only be used while operating in a Category B environment.

Name:	AT6, NOCOMM Timer
Value:	10 minutes
Start:	AT6 is started when communications across the air-ground path are not available.
Stop:	AT6 is stopped and reset when communications across the air-ground path are restored. Only new uplinks, not retransmissions, should cause AT6 to be stopped.
On Expiration:	See Section 3.6.3.

Name:	AT7, No ACK timer
Values:	Variable, uniformly distributed between 10 and 25 seconds.
Start:	AT7 is started when a downlink block is transmitted or retransmitted.
Stop:	AT7 is stopped when a uplink containing an acknowledgement indicating no errors is received.
On Expiration:	Increment retransmission counter, AC1, and retransmit downlink if the value of AC1 is less than the limit.
Note 1:	Some DSPs have implemented a faster response time in their ground systems.

Name:	AT8, UBI Reset Timer
Value:	10 minutes
Start/Restart:	AT8 should be started when the MU receives an error-free uplink, including duplicates, excluding squitter uplinks.
On Expiration:	When the AT8 timer expires, the MU should set the reference UBI character to the control character <NUL>. See Section 3.5.1.

Name:	AT9, Voice Mode Timer
Value:	10 minutes
Start:	AT9 should be started when the MU enters VOICE mode.
Stop:	AT9 is stopped and reset when the MU is returned to the DATA mode.
On Expiration:	If the AT9 timer has expired on return to data mode, the MU should take the actions described in Section 6.7.2.

Name:	AT10, Multiblock Message Timer
Value:	10 minutes
Start:	AT10 should be started when the first block of a multiblock message is transmitted.
Stop:	The AT10 timer should be stopped and reset when the uplink acknowledgement to the last downlink block of the message is received.
On Expiration:	When the AT10 timer expires the multiblock message should be retransmitted beginning with the first block. Alternatively, other action may be specified by the user.
Description:	AT10 is used to reflect actions taken by the DSP when the Incomplete Downlink Message timer (GT4) expires.

Name:	AT11, Auto Return to Data Timer
Value:	User Defined
Start:	AT11 should be started when the MU changes to the Voice mode.
Restart:	The AT11 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 AT11 timer expires the MU should return to the Data mode. See Section 6.3.2.

5.4.3 Ground Counters

Name:	GC1, Retransmission Counter
Value:	3
Start:	GC1 is started the first time an uplink block is transmitted.

Count:	GC1 should be incremented by 1 each time the No ACK timer (GT1) expires.
Stop:	GC1 is stopped and reset when a downlink containing an acknowledged indicating no errors is received.
On Expiration:	Wait for one of the ground timers to expire.

5.4.4 Airborne Counters

Name:	AC1, Retransmission Counter
Value:	not less than three, nor greater than eight.
Enable:	AC1 should be enabled the first time a downlink block is transmitted.
Count:	AC1 should be incremented by 1 each time the No ACK timer (AT7) expires.
Stop:	AC1 is stopped when an uplink containing an acknowledgement indicating no errors is received.
On Expiration:	See Section 5.5.

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 MU 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 Retransmission counter (AC1) reaches its limit then the MU 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.

COMMENTARY

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 MU 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 (NOCOMM, 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 ground service provider operating parameters may be included with each

5.6.2.1.1 Frequency Selection Algorithm (cont'd)

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.

5.6.2.1.2 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 MU will have "Permission to Send", which allows the MU 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. See Section 5.4.2 for a definition of the Scan timer. When the Scan timer (AT2) timer expires without the MU 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 MU 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 MU 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 once every two minutes as specified by the ground timer GT6. Under heavy traffic conditions, the squitter message will be transmitted once every ten minutes as specified by ground timer GT7 for ground station identification purposes.

Definition of the timers needed to support this provision is included in Section 5.4.2. The format of the uplink squitter message is as defined in Section 5.2.5 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 acknowledgement 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 MU 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 MU 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, NOCOMM, etc) in the MU indicates that the MU 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.

5.7 Operation on Alternate Frequencies

5.7.1 Data Transceiver Autotune Command - Label :;

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 5.3.16 of ARINC Specification 620.

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

After completing the acknowledgement downlink transmission, the MU 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 2.3, 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 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 communication fails (retransmission logic) anytime during autotune acquisition or subsequent normal operation, the MU 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

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 acknowledgement (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 acknowledgements.

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.

Category A operation is identified with a "2" (3/2) in the Mode character position.

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 (AT1). See Section 5.4.2 for a definition of the Contact timer. When the Contact timer (AT1) exceeds the maximum value appropriate for the network, the airborne subsystem should take action to verify that contact still exists. The MU should transmit any message in the downlink queue or trigger a Link Test (Label Q0) downlink. Normal retransmission logic (specific to the DSP) should be used for this contact verification message.

5.8.3 Tracker Message

A Tracker timer (AT3) may be provided in the MU 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 (AT3) the MU 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

5.0 VHF LINK MANAGEMENT (cont'd)

5.9 Category B Network Operation (cont'd)

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 the 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 MU. 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 MU designer chooses that should provide efficient and timely handoffs between sites as they fall out of range.

The MU should be capable of monitoring 2 or more sites. If more sites are available than the MU table can manage, then the MU 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 MU to go from the Frequency Acquisition state to the Frequency Establishment state defines whether the MU initially establishes a Category B Logical Channel or reverts to Category A operation. If the uplink contains Mode character "2", the MU will establish a Category A link. If the uplink contains a site address, the MU 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 MU 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 set to zero (0). On receiving an acknowledgement for this downlink, the MU can consider the "Logical Channel" established. Subsequently, all downlink messages sent will contain the site address and specifically, all acknowledgements to uplinks must include the address of the site that originated the uplink message.

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

Category B operation can only be entered automatically since it must hear an uplink with the site address.

The MU should attempt to downlink existing messages in queue, or if there are none, send a Q0 downlink using appropriate retransmission protocol 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 MU should re-examine the Site Address table for any other active sites. If there are, the MU 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 MU 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 MU is unable to get an acknowledgement following Retransmission Protocol, another ground station should be chosen. After exhausting all ground stations in the table the MU should re-enter the Frequency Acquisition state.

5.9.4 Channel Maintenance State

After Channel Establishment has been achieved, the MU 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 MU should transmit a Technical

5.0 VHF LINK MANAGEMENT (cont'd)

Acknowledgement to the same site that originated the uplink.

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

6.0 VOICE MODE OPERATION

6.1 Introduction

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

COMMENTARY

As the ACARS MU 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 chapter is dedicated to what is meant by "disruptive".

The following summarizes some of the "variables":

1) Which type of MU - 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 MU 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 MU 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 MU should operate in DATA or VOICE mode. If the VOICE/DATA Mode Discrete input is grounded then the MU 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 MU 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 MU may implement an automatic return to DATA mode. The MU 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 MU 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 MU may detect keying of the radio from either the Voice Go-Ahead Reset Discrete input or the XMTR Voice PTT input.

When the MU enters VOICE mode, the Auto Return-to-Data timer (AT11) is started. The timer should be restarted upon keyline 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 MU 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 MU to identify various installation configurations and support user requirements. As an option the MU 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 MU is to be used to provide VOICE frequency selection the Voice Channel Control Program pin should be connected to Program Pin Common on the MU service connector.

6.0 VOICE MODE OPERATION (cont'd)

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 MU 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 MU 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 MU 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 MU may provide the capability to enable VOICE mode capabilities. When enabled, this function will cause the ACARS MU 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 Voice Channel Signalling

The ACARS MU may be used for bidirectional signaling for 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 4.5.2 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 MU 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 acknowledgement to the DSP, acknowledging the receipt of the Voice Go-Ahead (Label 54) uplink message. The Technical Acknowledgement may be included in either a Temporary Suspension (Label 5P) downlink or a Dedicated Transceiver Advisory (Label F3) downlink. The MU 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 MU 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 MU may provide the capability to tune the VHF radio to the Voice frequency. The MU 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 MU's should provide the capability to annunciate the SELCAL condition and associated frequency on the ACARS CDU.

All MU's 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 724B MU should provide a digital

6.0 VOICE MODE OPERATION (cont'd)

6.6.1 Voice Go-Ahead Advisories (cont'd)

annunciator of SELCAL in its Label 270 output word on its General Purpose buses.

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

The reset may also be activated within the MU 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 MU 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 MU 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 MU 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 MU 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 4.5.8 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 MU 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 4.5.4 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 MU 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 4.5.6 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)

a) Current DATA Frequency should be stored.
b) Auto Return to Data Timer (AT11) may be started. VOICE mode may be immediately entered. If Voice frequency is MU controlled, frequency should be available prior to transition.
c) Annunciate VOICE mode.

Case 2: System has Link Acquired, but is quiescent

a) Current Data Frequency should be stored.
b) A Temporary Suspension (Label 5P) downlink may be sent if the 5P/Q6 function is enabled.
c) The VOICE mode timer (AT9) should be started.
d) The Auto Return to Data timer (AT11) may be started. VOICE mode may be entered. If Voice frequency is MU controlled, frequency should be available prior to transition.
e) Annunciate VOICE mode.

Case 3: System has Link Acquired and traffic in progress

a) A Temporary Suspension (Label 5P) downlink, if enabled, is sent.
b) Current DATA Frequency should be stored.
c) MU should suspend current downlink traffic.
d) A VOICE Mode timer (AT9) should be started.
e) The Auto Return-to-Data (AT11) timer may be started. VOICE mode may be entered. If Voice frequency is MU controlled, frequency should be available prior to transition.
f) Annunciate VOICE mode.

If the VOICE Mode timer (AT9) expires during VOICE mode, then the MU should activate all NOCOMM logic. If a multiblock downlink was in progress then the MU should retransmit all blocks. If a multiblock uplink was in progress then the MU 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.

a) Last Base Data frequency should be reloaded as new frequency.
b) 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.

a) Last Data frequency should be reloaded as new frequency.
b) The MU 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 Chapter 2 of this document, are encapsulated, then sent to a 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 Chapter 3, and the VHF Link Management, as defined in Chapter 5 of this document, apply.

7.2 Data Bus Interface

The ACARS MU should be connected to the Satellite Data Unit (SDU) by a pair of ARINC 429 data buses. The ACARS MU should provide one ARINC 429 output port and one ARINC 429 input port for communications with the SDU. Additional port pairs should be provided if multiple SDU's 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.

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 MU and SDU as specified in Section 4.7.3 of ARINC Characteristic 741, Part 2.

7.3.1 SDU Subsystem Identifier (Label 172)

The SDU should transmit, at a rate of once per second on its output bus to the ACARS MU, as specified in Section 4.7.3 of ARINC Characteristic 741, Part 2, 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 MU to facilitate subsystem LRU identification without specific interwiring definitions. See ARINC Specification 429 for a definition of the Label 172 data word.

7.3.2 ACARS MU Status to SDU (Label 270)

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

7.3.3 SDU Status to ACARS MU (Label 270)

On the bus connected to the MU input, the SDU should transmit a Label 270 data word once per second.

The SDU status information carried in this data word is decoded as defined in Section 4.7.3 of ARINC Characteristic 741, Part 2. A copy of the data word format is listed in Attachment 8 for the reader's convenience.

7.4 Link Interface

The interface between the ACARS MU and SDU should use the ARINC 429 Bit-Oriented-Protocol (BOP) as published in ARINC Specification 429-12, except where noted within this section.

For BOP transmissions from the ACARS MU to SDU, the MU should use a System Address Label (SAL) reported previously by the SDU in its Label 172 data word output to the MU. SDU #1 is assigned the SAL of 307 octal and SDU #2 is assigned the SAL of 173 octal. Both SDUs use a destination code of "S". For all BOP transmission from the SDU to ACARS MU, the ACARS MU should accept a received SAL of 304 octal and a destination code "M".

All timer values for the MU/SDU 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 MU for the SDU interface (reference Table 10-3 of ARINC Specification 429):

OPTN	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	SDU	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 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 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 a ALR if a ALO is received as defined in O_{11}.

COMMENTARY

Since the primary purpose of the ALO/ALR words are to verify the BOP protocol between two systems and BOP is the only protocol used for this interface, transmission of the ALO word is not required and SYN may be used.

7.0 SATCOM INTERFACE (cont'd)

7.5 ACARS BOP Data File

Data Files sent between the ACARS MU and SDU using the ARINC 429 BOP interface will contain ACARS block. To support this, the General Format Identifier (GFI) of "E" or "1110" has been assigned in Table 11-7A 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 MU and SDU at power-up and incremented by one for each new ACARS block transmitted.

An ACARS block, as defined in Chapter 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. The File is limited to a single Link Data Unit (LDU). Therefore no multi-LDU file handling is required and the LDU Sequence number should always be zero.

> Note: The BCS data is merely pass-through data from the Satellite Data Link standpoint. The BCS data are evaluated by the ACARS MU 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 MU cannot accept a block from the SDU (received as an UPLINK) due to a BOP error or a Busy condition, the MU should report "Busy". The SDU will discard the ACARS block.

If the ACARS MU cannot deliver a block (to be sent as a DOWNLINK) to the SDU due to a BOP error, the MU may need to store or discard the block based on user requirements.

7.6 ACARS Message Protocol

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

Aircraft uplink address screening is performed by the SDU using the ICAO aircraft address. The ACARS MU should receive only uplink traffic that contain that address. The ACARS MU 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 an immediate response by the ACARS MU. The response should be a transfer to the SDU of either a QX - labelled or User Defined Reject message containing an embedded acknowledgement. The uplink block is discarded by the ACARS MU.

> AEEC STAFF NOTE: Following the adoption of this specification, the ACARS Working Group determined that the response of the MU to a bad BCS should be revised. The text of Supplement 1 is expected to be:
>
> 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 MU. The MU should not embed the "NAK" in a non-general response block. The uplink block should be discarded by the MU.

The MU should only send blocks to the SDU when Bit 11 of Label 270 status words is set to zero indicating that the SDU has logged ON and has a Data channel available. If the MU sends blocks to the SDU when it is not logged ON or in VOICE mode, the SDU should transmit a BUSY response to the ACARS MU.

7.6.1 Acknowledgement of a Downlink Block

If the DSP receives a downlink block which does not positively acknowledge a preceding uplink block, for which an acknowledgement 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 (GT1) defined in Section 7.7.1 or the receipt of a General Response containing a "NAK" (1/5) in the Technical Acknowledgement field. The retransmitted uplink block should retain the original UBI and contain a "NAK" (1/5) in the Technical Acknowledgement field.

COMMENTARY

> Is is essential to deliver messages inas 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 General ACK rather than an immediate retransmission with an embedded ACK due to time of delivery concerns and effective utilization of available RF resources.

7.6.2 Acknowledgement of a Uplink Block

If the MU receives an uplink block which does not positively acknowledge a preceding downlink block, for which an acknowledgement is outstanding, the MU should immediately acknowledge the uplink block just received. If AT7 expires or a General Response containing a NAK is received then the downlink block retransmission should retain the original DBI and contain a "NAK" (1/5) in the Technical Acknowledgement field.

COMMENTARY

> It is essential to deliver messages in as timely a 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 MU should provide an immediate

7.0 SATCOM INTERFACE (cont'd)

7.6.2 Acknowledgement of a Uplink Block (cont'd)

COMMENTARY (cont'd)

downlink ACK for the received uplink. This minimizes the queueing 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 satellite medium and to most effectively utilize available RF resources.

7.7 SATCOM Link Management

The following subsections describe basic protocol exceptions to Chapter 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 timer and counters for the 2400 baud MSK VHF link are defined in Section 5.4.

7.7.1 Ground Based Timers

The following timer values should be used.

TIMER	VALUE IN SECONDS	TIMER NAME
GT1	120	No ACK Timer
GT2	360	Message Reject Timer
GT3	20	Incomplete Message Interval Timer
GT4	1260	Incomplete Downlink Message Delivery Timer
GT5	Note 1	Q5 Timer
GT6	N/A	Squitter Timer #1
GT7	N/A	Squitter Timer #2
GT8	600	DBI Reset Timer

Note 1: This value is service provider dependent (same as VHF).

7.7.2 Airborne Timers

The following timer values should be used.

TIMER	VALUE IN SECONDS	TIMER NAME
AT1	N/A	Contact Timer
AT2	N/A	Scan Timer
AT3	N/A	Tracker Timer
AT4	370	Message Assembly Timer
AT5	N/A	Interblock Timer
AT6	600	NOCOMM Timer
AT7	180	NO ACK Timer
AT8	600	UBI Reset Timer
AT9	600	VOICE MODE Timer
AT10	1200	Multiblock Message Timer
AT11	N/A	Auto Return to DATA Mode

7.7.3 Ground Counters

The following counter values should be used.

COUNTER	VALUE	COUNTER NAME
GC1	2	Retransmission Counter

7.7.4 Airborne Counters

The following counter values should be used.

COUNTER	VALUE	COUNTER NAME
AC1	2	Retransmission Counter

7.7.5 SATCOM Channel Operation

To ensure complete message delivery the ACARS MU should treat the SATCOM link as a separate service provider operating Category A. This means that if VHF coverage is lost during an uplink or downlink, the ACARS MU should discard any partial uplinks and requeue any downlink traffic in progress for transmission over the SATCOM link. When switching back (when VHF is in-range) the ACARS MU should complete any traffic in progress using SATCOM. If SATCOM fails or reports logged OFF or VOICE while traffic is in progress it should be treated the same as losing VHF coverage and exhausting re-transmission logic.

Permission to send is provided by the SDU automatically when the logged ON state is set. No squitters or other traffic or manual override is available to cause transmission.

A SATCOM NOCOMM should be declared either when the SDU reports a LOGOFF condition, a VOICE condition, or the Retransmission Counter (AC1) expires as defined previously.

Upon entering the SATCOM NOCOMM condition, all outstanding uplink/downlink traffic should be considered interrupted and retransmission may be required. The SATCOM 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 the SDU logged on state changes from NOT SET to SET

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 SDU logged on state has remain SET.

Transmission of Contact Messages, as defined in Section 5.8.2 is not necessary in the SATCOM link. Transmission of Tracker messages, as defined in Section 5.8.3 is not necessary in the SATCOM link.

ATTACHMENT 1
AIR-GROUND COMMUNICATIONS

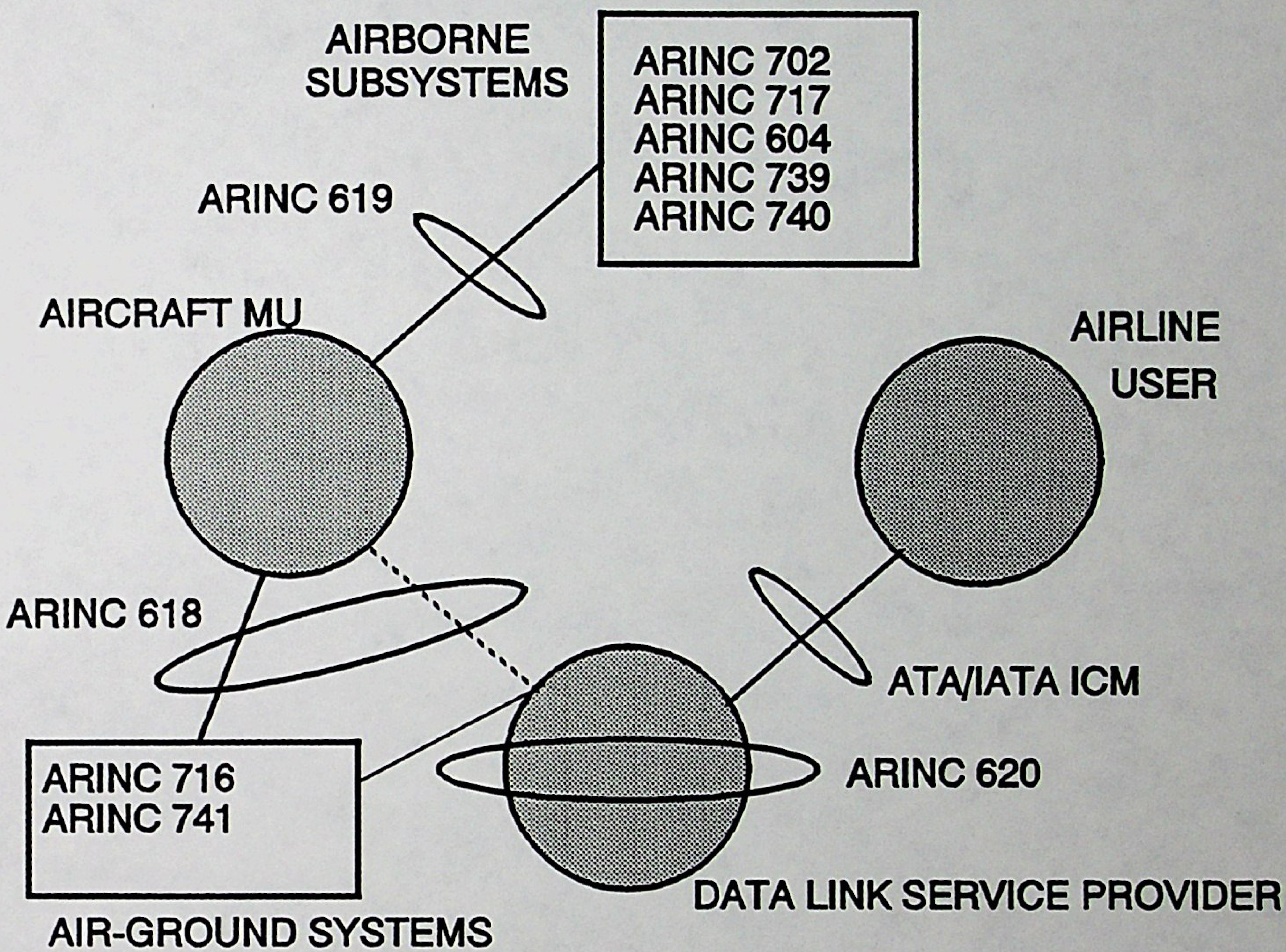


Figure 1-1 ACARS Documentation

ATTACHMENT 2
FREQUENCY MANAGEMENT DIAGRAMS

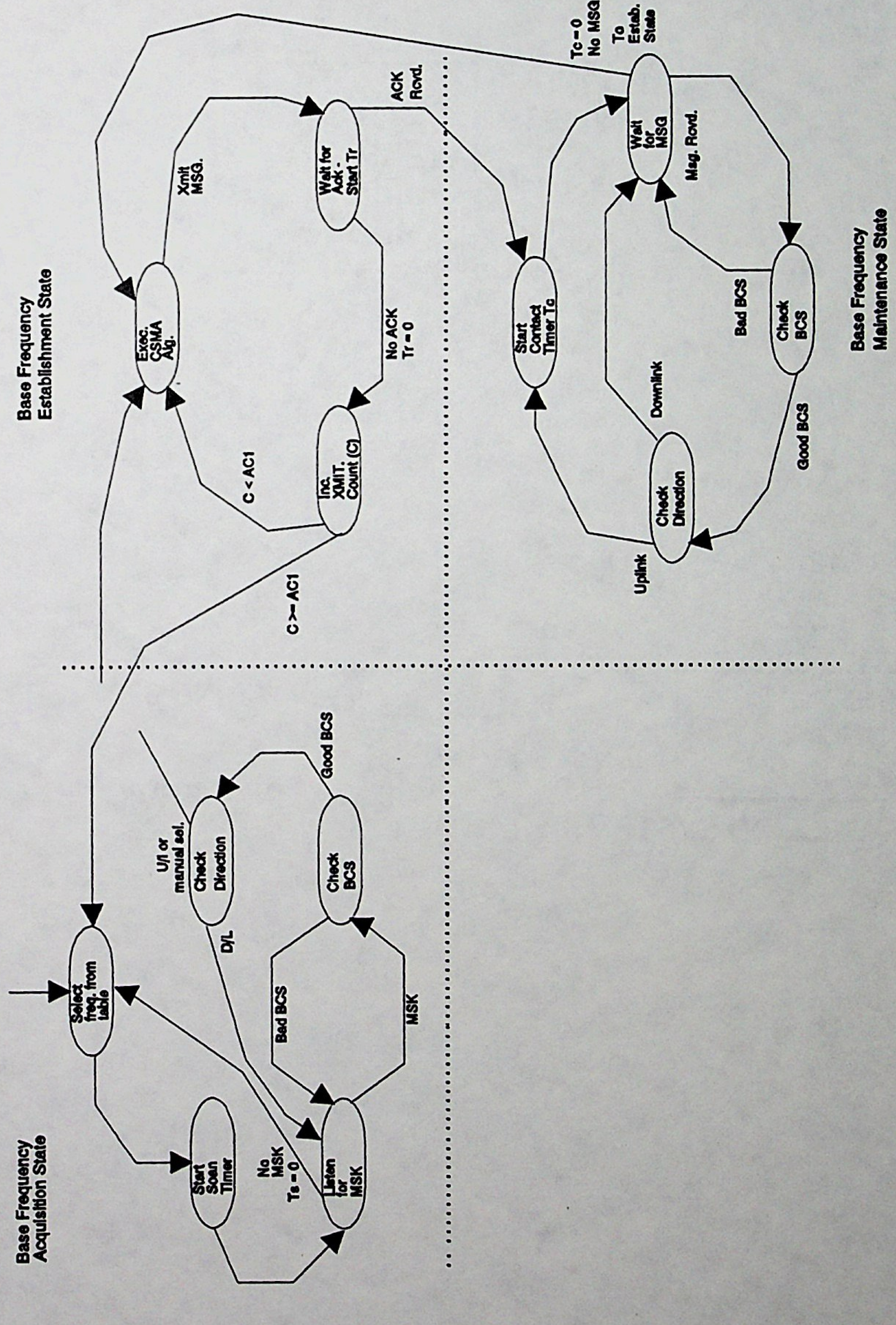
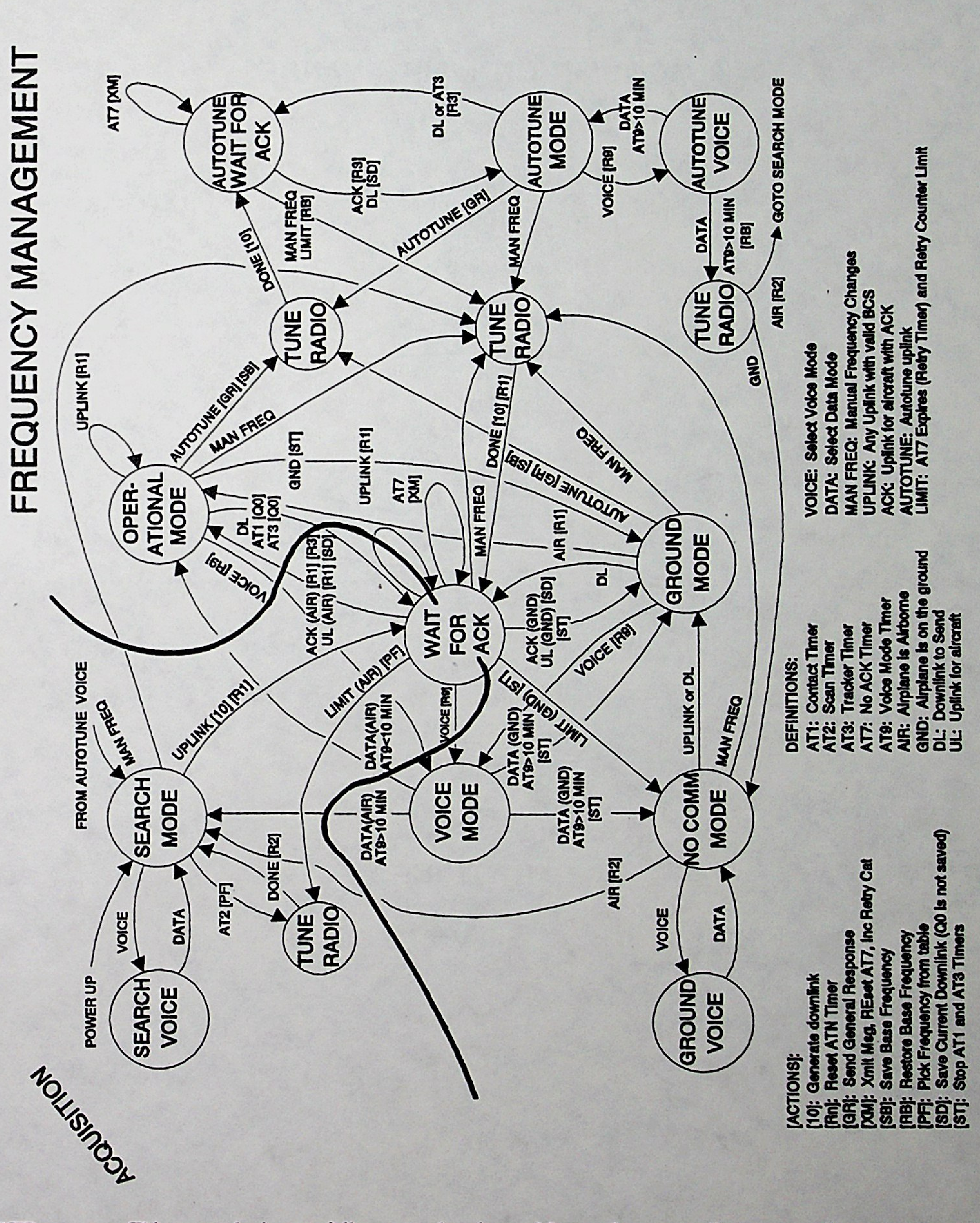


Figure 2-1 **Simplified State Diagram**

ATTACHMENT 2 (cont'd)
FREQUENCY MANAGEMENT DIAGRAMS



NOTE : This example is not fully comprehensive. Many other state diagram comfigurations could be developed to satisfy the provisions of this specification in response to the stated desires of the user.

Figure 2-2 **Example State Diagram**

ATTACHMENT 2 (cont'd)
FREQUENCY MANAGEMENT DIAGRAMS

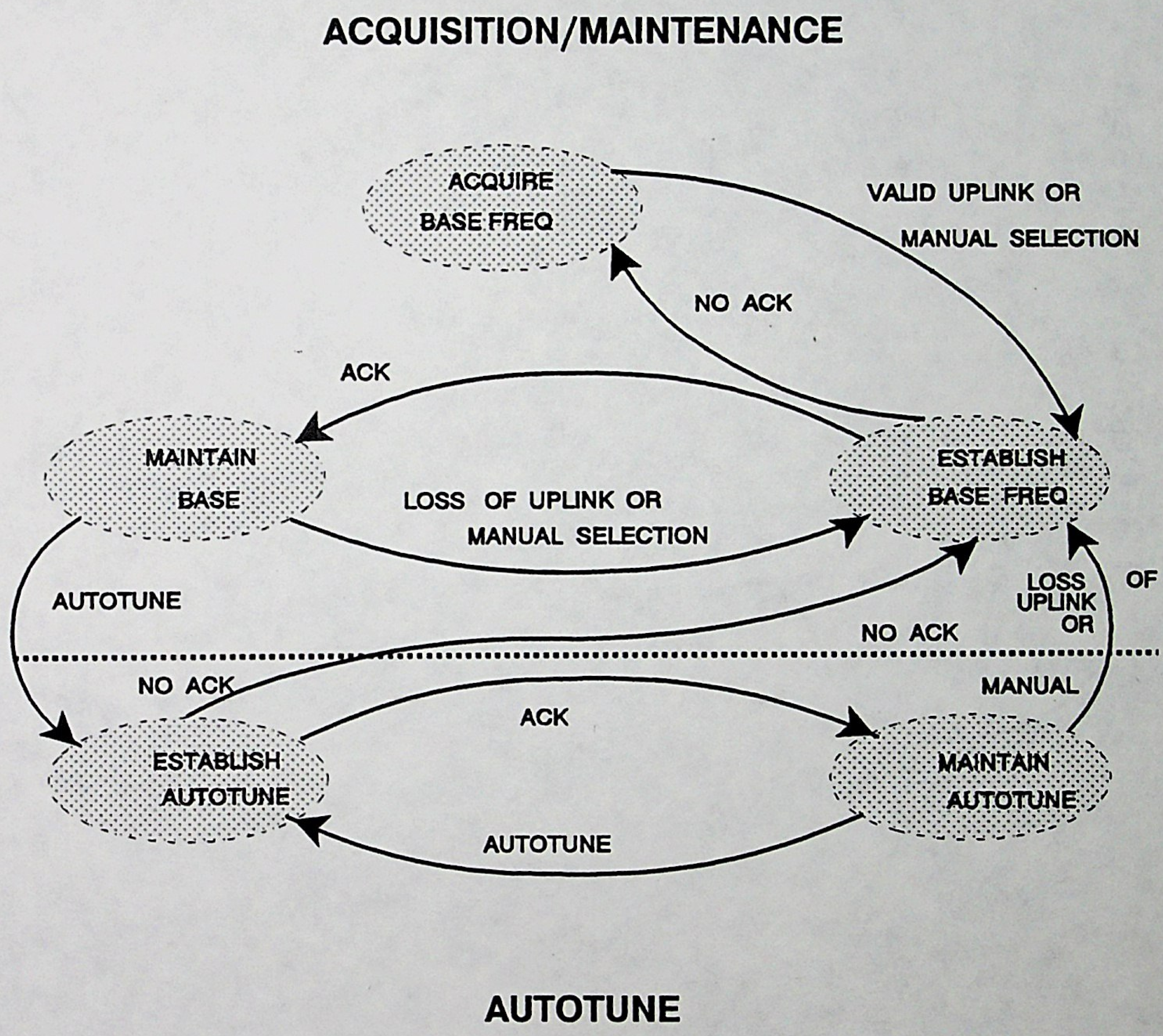


Figure 2-3 Base Frequency Acquisition/Autotune

ATTACHMENT 2 (cont'd)
FREQUENCY MANAGEMENT DIAGRAMS

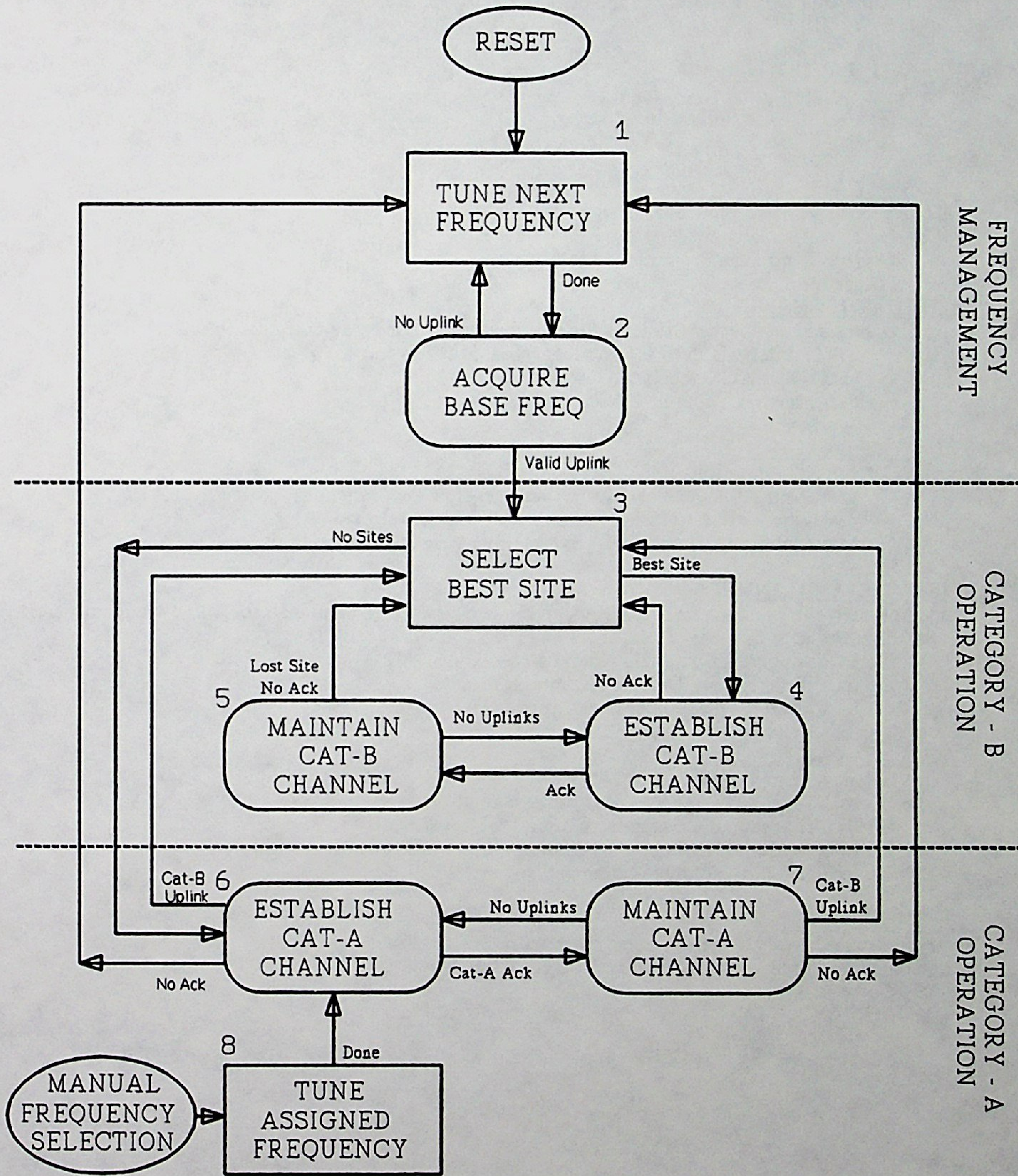


Figure 2-4 Logical Channel Management

ATTACHMENT 2 (cont'd)
FREQUENCY MANAGEMENT DIAGRAMS

1. TUNE NEXT FREQUENCY
   Command the transceiver to tune to the next frequency found in the user-defined primary frequency table.
      Go to 2.

2. ACQUIRE BASE FREQUENCY
   Listen for a valid uplink.
      Go to 3 if valid uplink detected.
      Go to 1 if none detected after Timer AT2 expires.

3. SELECT BEST SITE
   Evaluate reception performance of each ground station site.
      Go to 4 with best site.
      Go to 6 if no sites are acceptable.

4. ESTABLISH CAT-B CHANNEL
   Transmit a message in queue or link test using selected site for mode character and wait for acknowledgement. Retransmit at AT7 intervals until acknowledgement is received.
      Go to 5 when ACK received.
      Go to 3 after AC1 attempts have failed.

5. MAINTAIN CAT-B CHANNEL
   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. ESTABLISH CAT-A CHANNEL
   Transmit a message in queue or link test using mode character "2" and wait for acknowledgement. Retransmit up to AC1 times at AT7 intervals until acknowledgement 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. MAINTAIN CAT-A CHANNEL
   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. TUNE ASSIGNED FREQUENCY
   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 Descriptions

ATTACHMENT 3
ISO 5 CHARACTER FORMAT

	b7	0	0	0	0	1	1	1	1
	b6	0	0	1	1	0	0	1	1
b4 b3 b2 b1	b5	0	1	0	1	0	1	0	1
0 0 0 0		NUL	DLE	SP	0	@	P	`	p
0 0 0 1		SOH	DC1	!	1	A	Q	a	q
0 0 1 0		STX	DC2	"	2	B	R	b	r
0 0 1 1		ETX	DC3	#[1]	3	C	S	c	s
0 1 0 0		EOT	DC4	$	4	D	T	d	t
0 1 0 1		ENQ	NAK	%	5	E	U	e	u
0 1 1 0		ACK	SYN	&	6	F	V	f	v
0 1 1 1		BEL	ETB	'	7	G	W	g	w
1 0 0 0		BS	CAN	(	8	H	X	h	x
1 0 0 1		HT	EM	)	9	I	Y	i	y
1 0 1 0		LF	SUB	*	:	J	Z	j	z
1 0 1 1		VT	ESC	+	;	K	[	k	{
1 1 0 0		FF	FS	,	<	L	\	l	|
1 1 0 1		CR	GS	-	=	M	]	m	}
1 1 1 0		SO	RS	.[1]	>	N	^	n	~
1 1 1 1		SI	US	/[1]	?	O	_	o	DEL

Hex value → 04

Character → EOT

Character not recommended in "Free Talk" portion of uplink or downlink messages. See Section 2.2.8 for guidance on usage.

Table 3-1 ASCII CHARACTER SET

ATTACHMENT 3 (cont'd)
ISO 5 CHARACTER SET

b_7	0	0	0	0	1	1	1	1
b_6	0	0	1	1	0	0	1	1
b_5	0	1	0	1	0	1	0	1
$b_4 b_3 b_2 b_1$								
0000	NUL	DLE	SP	0	@	P	`	p
0001	SOH	DC1	!	1	A	Q	a	q
0010	STX	DC2	"	2	B	R	b	r
0011	ETX	DC3	#	3	C	S	c	s
0100	EOT	DC4	$	4	D	T	d	t
0101	ENQ	NAK	%	5	E	U	e	u
0110	ACK	SYN	&	6	F	V	f	v
0111	BEL	ETB	'	7	G	W	g	w
1000	BS	CAN	(	8	H	X	h	x
1001	HT	EM	)	9	I	Y	i	y
1010	LF	SUB	*	:	J	Z	j	z
1011	VT	ESC	+	;	K	[	k	{
1100	FF	FS	,	<	L	\	l	|
1101	CR	GS	-	=	M	]	m	}
1110	SO	RS	.	>	N	^	n	~
1111	SI	US	/	?	O	_	o	DEL

Hex value

04
EOT

Character

Character not recommended in "Free Talk" portion of uplink or downlink messages. See Section 2.2.8 for guidance on usage.

Table 3-2 BAUDOT CHARACTER SET

ATTACHMENT 4
MULTIBLOCK TIMING DIAGRAMS

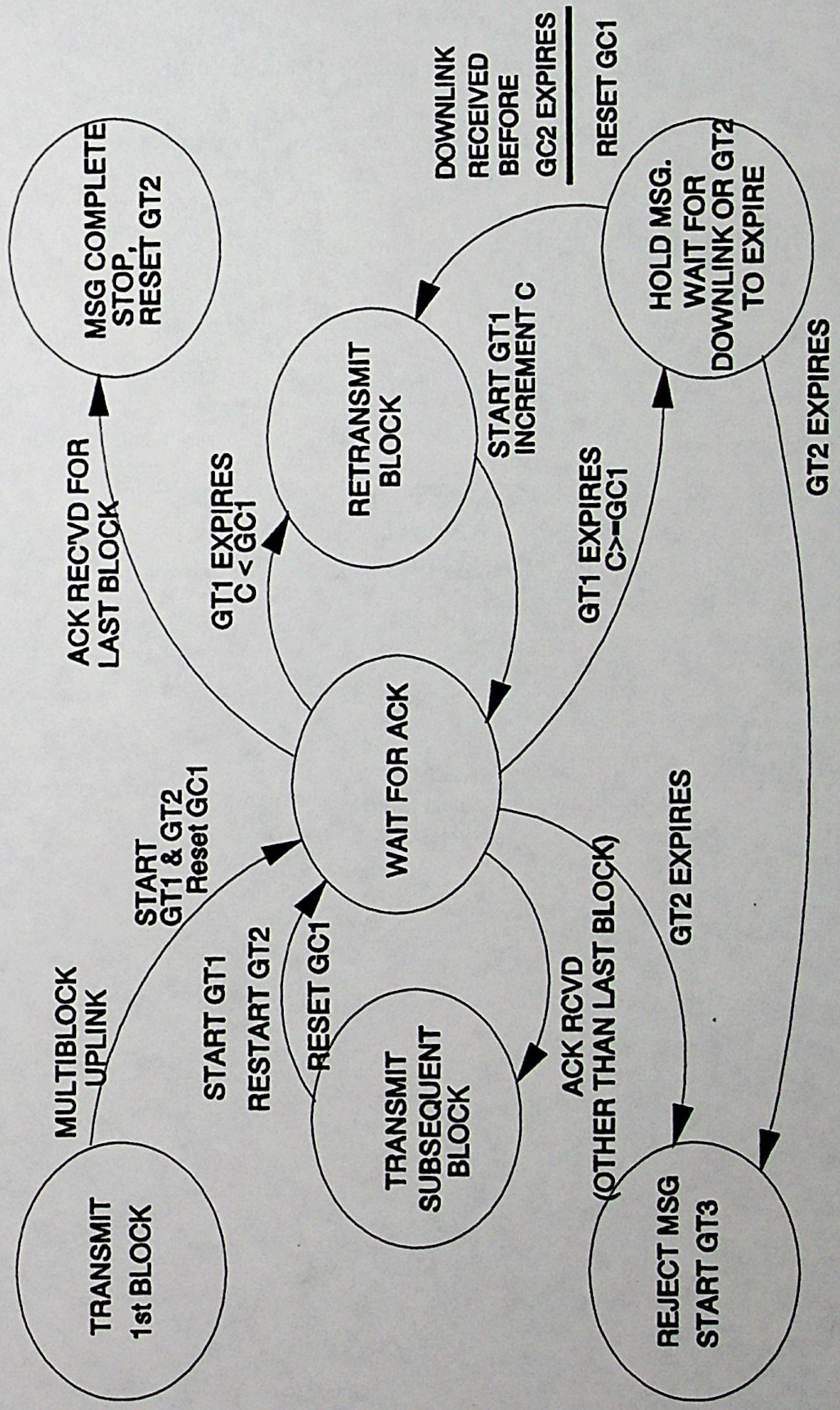


Figure 4-1 Ground Based Timers for Multiblock Uplinks

ATTACHMENT 4 (cont'd)
MULTIBLOCK TIMING DIAGRAMS

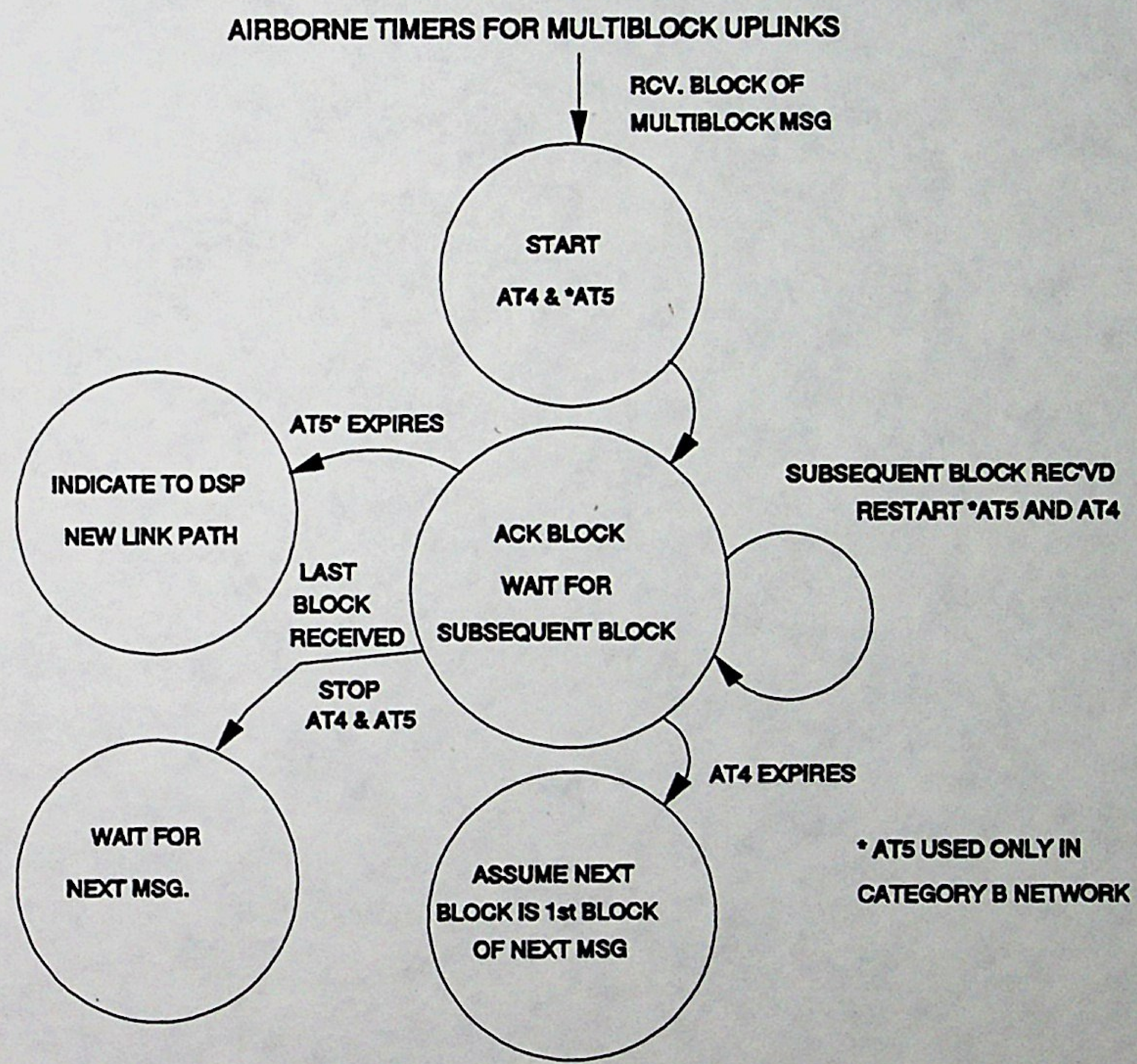


Figure 4-2 Airborne Timers for Multiblock Uplinks

ATTACHMENT 4 (cont'd)
MULTIBLOCK TIMING DIAGRAMS

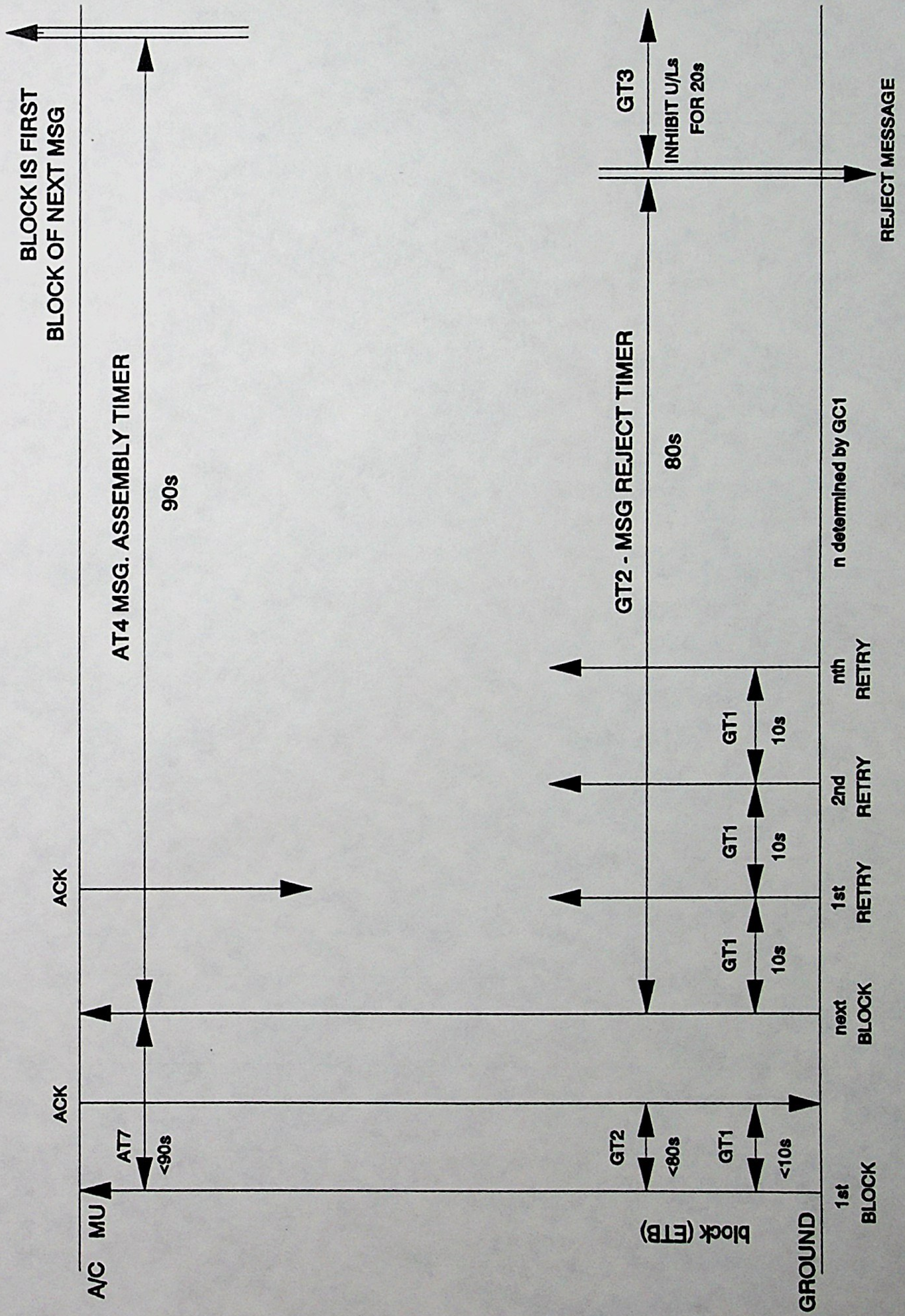


Figure 4-3 Category A VHF Multiblock Uplink Procedure

ATTACHMENT 4 (cont'd)
MULTIBLOCK TIMING DIAGRAMS

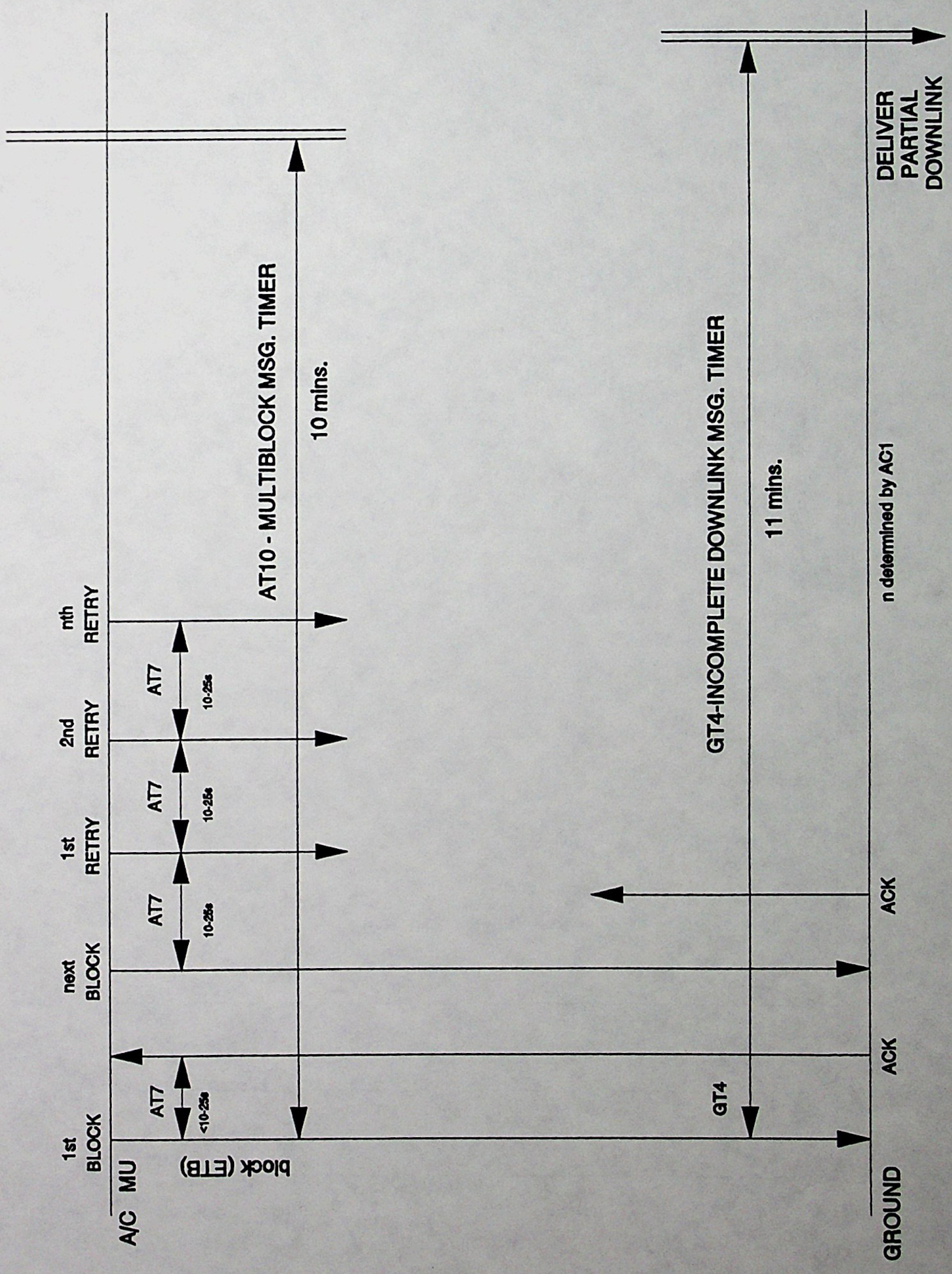


Figure 4-4 Category A VHF Multiblock Downlink Procedure

ATTACHMENT 4 (cont'd)
MULTIBLOCK TIMING DIAGRAMS

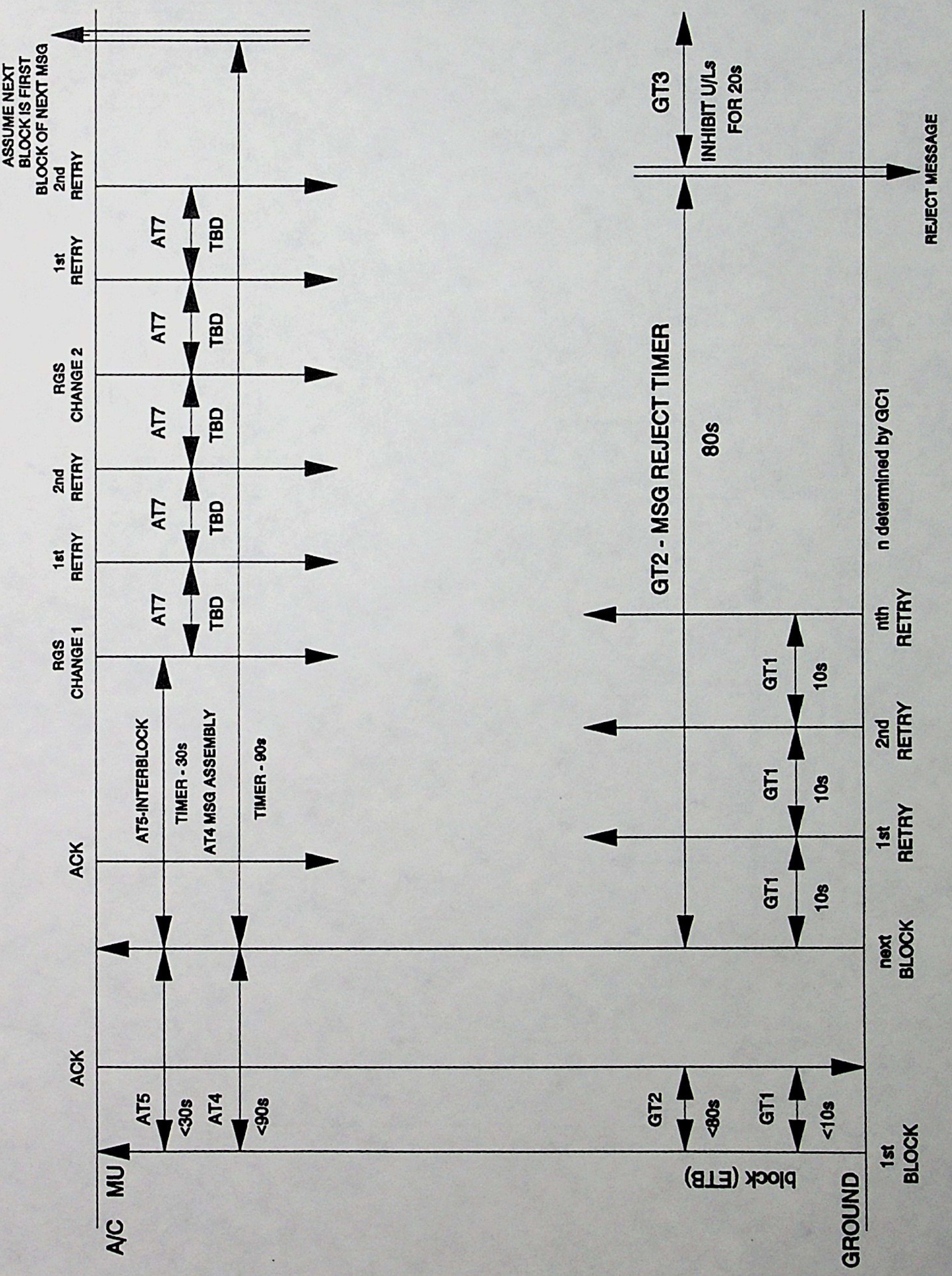


Figure 4-5 Category B VHF Multiblock Uplink Procedure

ATTACHMENT 4 (cont'd)
MULTIBLOCK TIMING DIAGRAMS

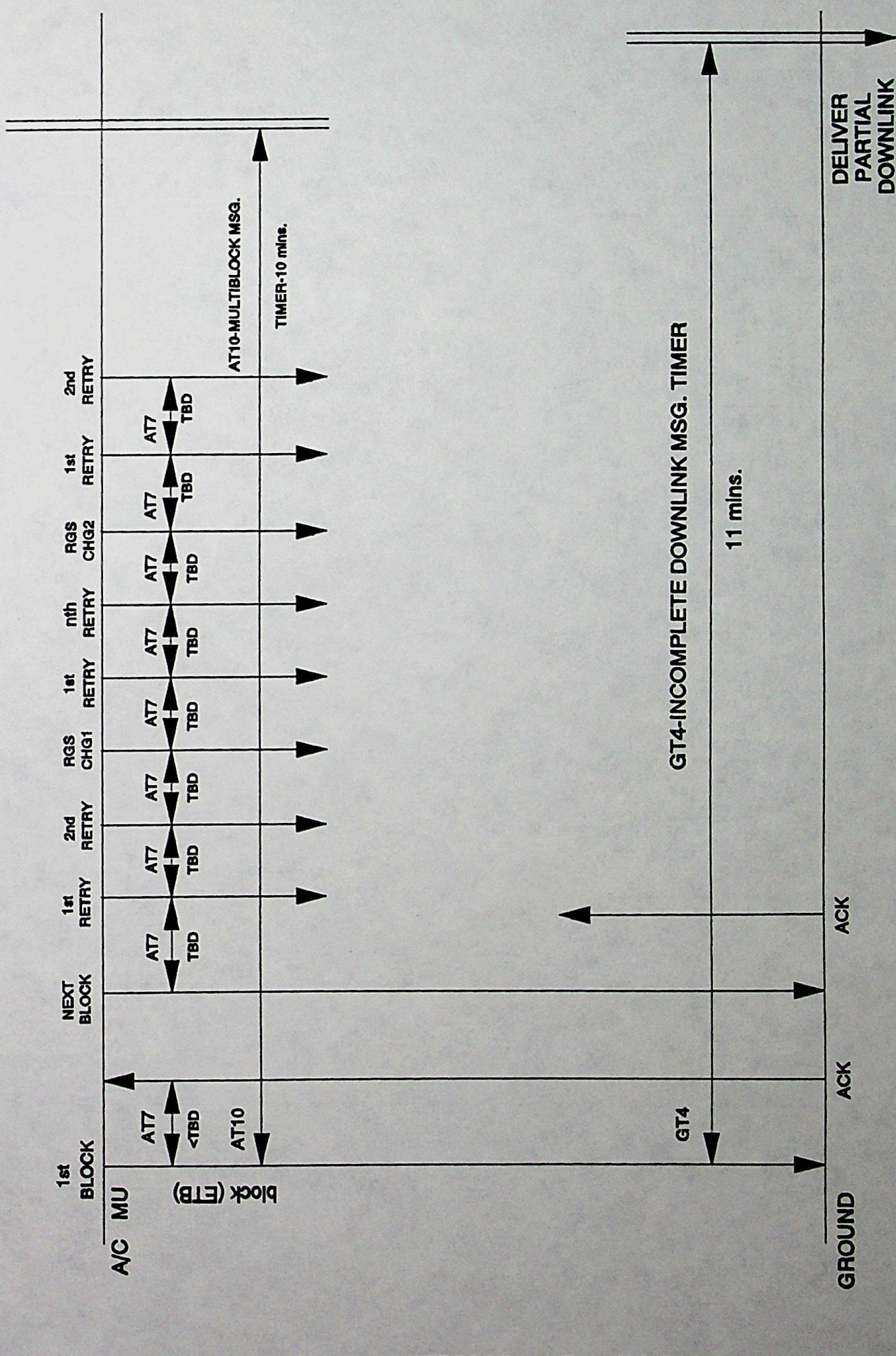


Figure 4-6 Category B VHF Multiblock Downlink Procedure

ATTACHMENT 4 (cont'd)
MULTIBLOCK TIMING DIAGRAMS

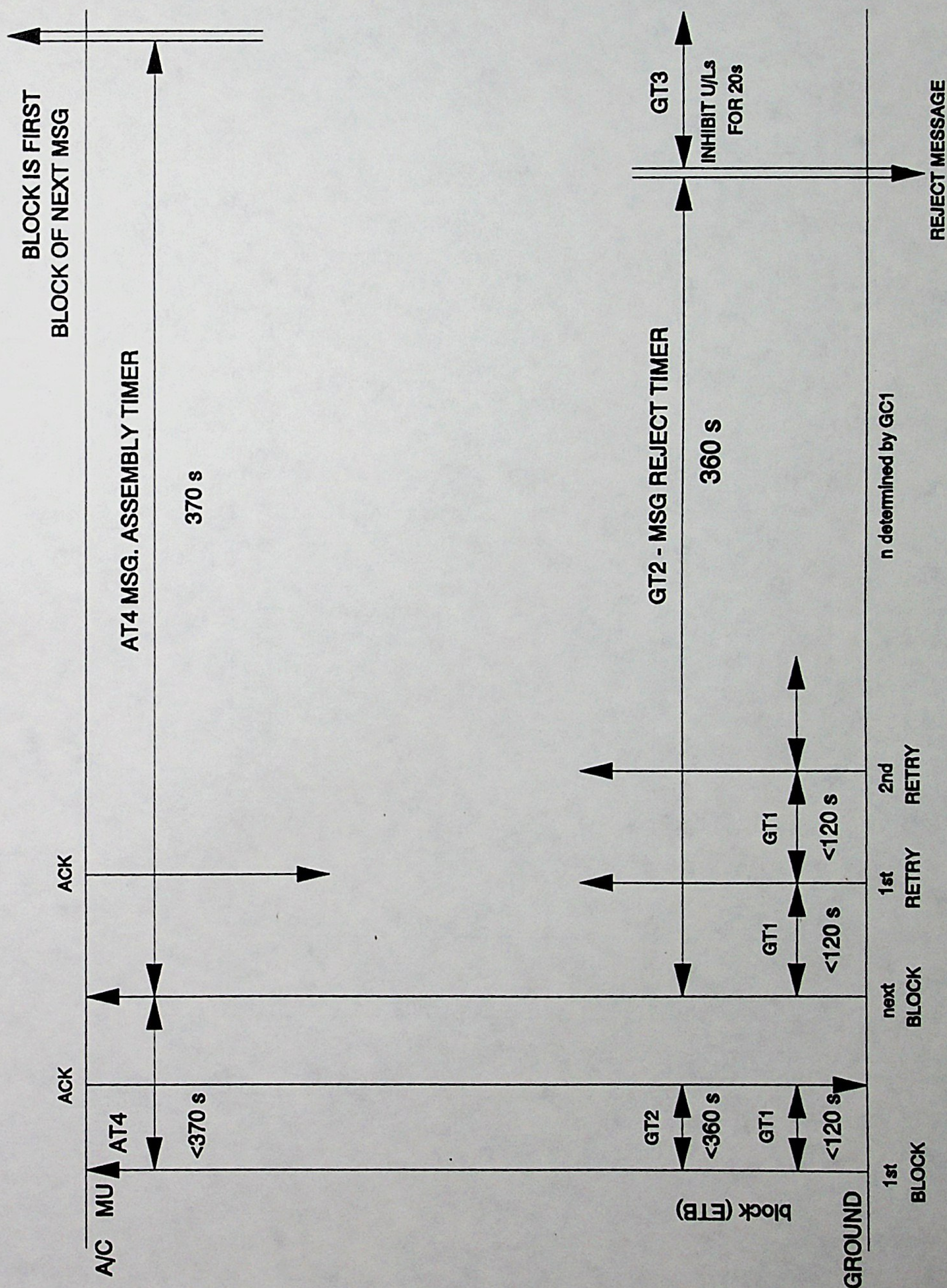


Figure 4-7 SATCOM Uplink Procedure

ATTACHMENT 4 (cont'd)
MULTIBLOCK TIMING DIAGRAMS

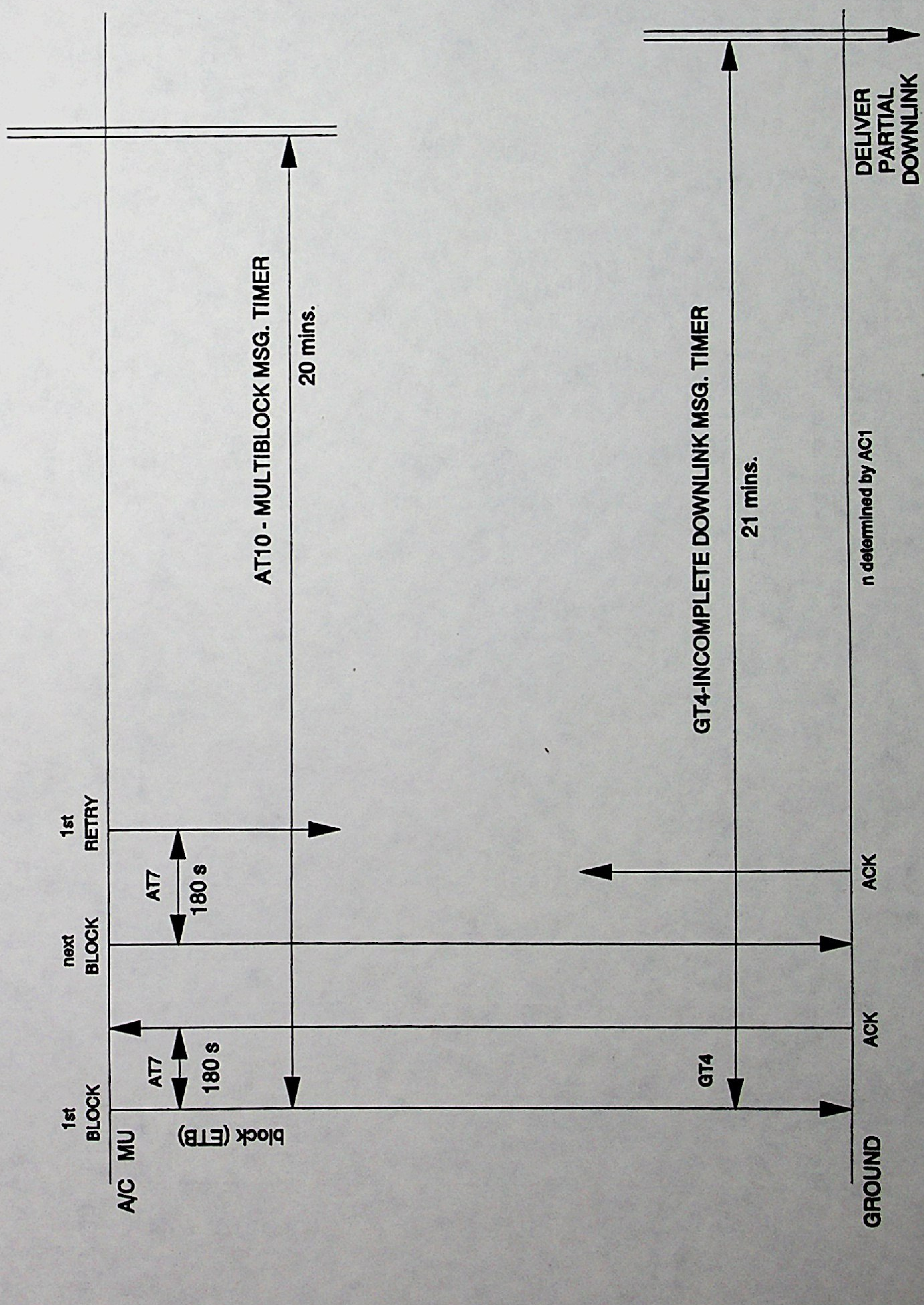


Figure 4-8 **SATCOM Multiblock Downlink Procedure**

ATTACHMENT 5
MSK WAVEFORM

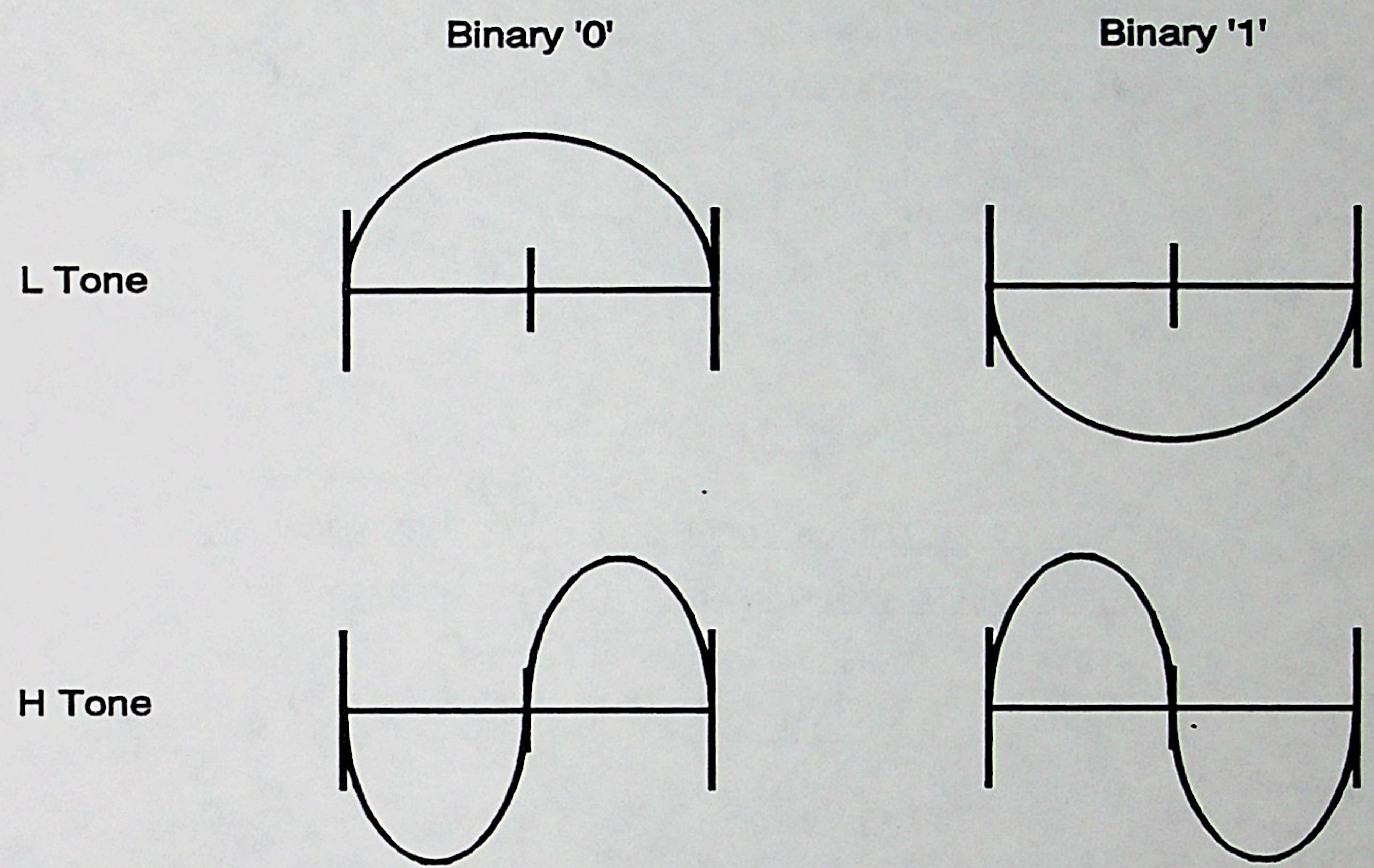


Figure 1 Sub-Carrier Signal Types

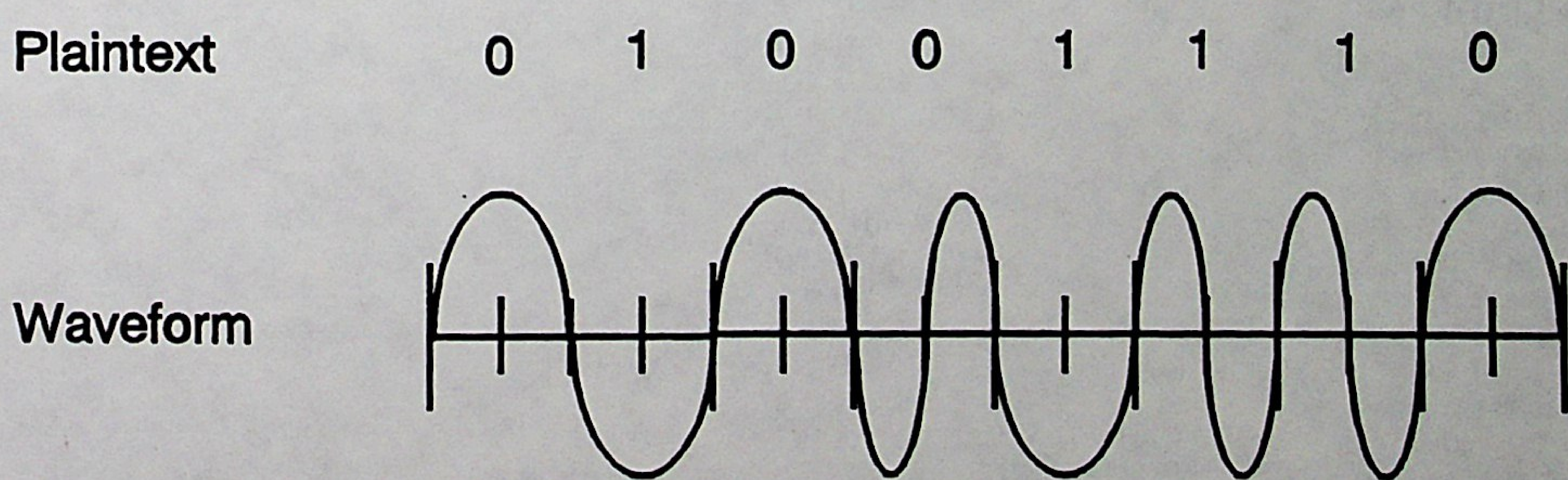


Figure 2 Encoded Sub-Carrier Waveform

ATTACHMENT 6
MODE CHARACTER

CATEGORY A - **ACARS STANDARD MODE CHARACTER**

0 0 1 1 0 0 1 0 — ISO code "2"
Transmitted bi-directional
No Preferred Air/Ground Data Path Selected

CATEGORY B - **BIT ORIENTED DEFINITION**

GROUND SYSTEM LOGICAL ACCESS CHANNEL IDENTIFICATION AND PREFERRED GROUND ACCESS CHANNEL SELECTION

Air to Ground (bit pattern) 8 7 6 5 4 3 2 1	ISO #5 code (char)	Ground to Air (bit pattern) 8 7 6 5 4 3 2 1	ISO #5 code (char)	Access Code logical path (Ground Station)
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
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
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
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
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	r	#16
0 1 0 1 0 0 0 1	Q	1 1 1 1 0 0 0 1	p	#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
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

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

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.

Figure 7-1 Voice/Data DSP Advisories

ATTACHMENT 8
MU/SDU DATA WORDS

LABEL 270 DATA WORD INFORMATION CODING

BIT	Description
11	Data Link Not Available If Set, then Data Link via SATCOM is not possible (either due to equipment failure, voice mode, or no LOGON). If not set, the ACARS MU should expect to be able to send data over SATCOM.
12	MU #1 Inactive This bit is set if the SDU is not receiving Label 270 status word from the ACARS MU #1 and has determined the input port INACTIVE.
13	VOICE Resources If set, the SATCOM has allocated all available resources for VOICE mode use. Bit 11 should also be set whenever this bit is set.
14	SELCAL If set, the SATCOM has detected a new flight deck voice channel established and the line ringing. When the call is answered, the bit should be cleared. This bit should cause the ACARS MU to annunciate aural/visual alerts associated with a SELCAL.
15	SATCOM with CHIME Setting this bit should cause the ACARS MU to set a "SATCOM ALERT" message and trigger an aural (Chime) annunciation. This bit is used to alert the crew to refer to the SATCOM MCDU Messages for timely information. The ACARS MU should annunciate the alert until Bit 15 is reset.
16	SATCOM without CHIME Setting this bit should cause the ACARS MU to set a "SATCOM ALERT" message without aural annunciation. This bit is used to alert the crew to refer to SATCOM MCDU messages for routine information. The ACARS MU should annunciate the alert until Bit 16 is reset.
17	SATCOM LOGON This bit should be set whenever the SATCOM is not logged onto a ground station.
18	SATCOM Master/Slave This bit should not be set if the originating SATCOM is the Master or if only one SATCOM is installed. This bit should be set when the originating SATCOM is the slave in a DUAL installation.
19	MU #2 Inactive This bit is set if the SDU is not receiving Label 270 status word from the ACARS MU #2 and has determined the input port INACTIVE.

This table is included for the convenience of the reader. ARINC Characteristic 741 has precedence over the above material.

ATTACHMENT X
FUTURE WORK

The following issues are to be resolved in future supplements:

1. Section 3.8.1 - Although Label Q6 is included in the class of system control messages, it need not be transmitted. Add text to clarify this fact.

2. Section 3.6.4.1 - A reference to material describing the treatment of a partial message received by the MU when the Message Assembly timer (AT4) expires. Normally, this partial message is printed.

3. Section 5.8 - Supplement 1 will clarify the functions of the DSP in Category A and Category B operation.

4. A definition should be provided as to what action should be taken when a Data-to-Voice (Label 54) uplink message containing a voice frequency is received by the MU.

5. Add definition of VOICE-to-DATA (TP-7E) and DATA-to-VOICE (TP-7F) functions to Chapter 6.

6. Resolve outstanding proposal for improvement of SATCOM protocol in "crisscross" condition (Chapter 7):

   7.6.1 Acknowledgement of a Downlink Block

   If the DSP receives a downlink block which does not positively acknowledge a preceding uplink block, for which an acknowledgement is outstanding, the DSP should immediately acknowledge the downlink block just received with either a General Response block or an embedded ACK in an immediate uplink retransmission. If GT1 expires or a general response containing an NAK is received then the uplink block retransmission should retain the original UBI and contain a "NAK" (1/5) in the Technical Acknowledgement field.

   COMMENTARY

   > Note that a key system performance requirement is the delivery of 95% of safety-of-life messages within a maximum specified time limit (defined as 3 minutes for end-to-end application acknowledgements). To achieve these requirements 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 General ACK rather than an immediate retransmission with an embedded ACK due to time of delivery concerns and effective utilization of available RF resources.

   7.6.2 Acknowledgement of a Uplink Block

   If the MU receives an uplink block which does not positively acknowledge a preceding downlink block, for which an acknowledgement is outstanding, the MU should immediately acknowledge the downlink block just received with either a General Response block or a retransmission of the block containing an embedded ACK for the received uplink. If AT7 expires or a General Response containing a NAK is received then the downlink block retransmission should retain the original UBI and contain a "NAK" (1/5) in the Technical Acknowledgement field.

   COMMENTARY

   > Note that a key system performance requirement is the delivery of 95% of safety-of-life messages within a maximum time limit (defined as 3 minutes for end-to-end application acknowledgements). Given this requirement, all reasonable efforts should be expended to provide the quickest resolution of a "criss-cross" condition. To achieve these requirements the MU should provide an immediate downlink ACK for the received uplink. This minimizes queuing delays of uplink messages. It is preferred that the downlink ACK be in the form of a General ACK to facilitate quickest delivery over the satellite medium and to most effectively utilize available RF resources.

7. Consider proposals for improvement of VHF protocol in "crisscross" condition (Chapter 5).

8. SATCOM protocol for bad BCS.

9. Technique for change of medium (SATCOM to VHF).

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. MU's 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 Multi-Block 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 Acknowledgement 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.

APPENDIX A (cont'd)
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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 Acknowledgement

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 Acknowledgement 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 acknowledgement character (ACK), of its responding downlink message. The MU should continue to report incorrectly received uplink messages with the negative acknowledgement character (NAK) in the Technical Acknowledgement field.

Except for the above mentioned differences in the use of the block identifiers and Technical Acknowledgement fields, the two formats are identical.

Original format uplink and downlink messages and new format uplink and downlink, should be constructed as follows:

Technical Acknowledgement implemented in the "Original" format is structured to support an acknowledgement 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

Messages for transmission with the original format environment should have the following format:

Name of Field	Characters	Notes
PREAMBLE		
Pre-key	"all ones"	
Bit synchronization	2	
Character Synchronization	2	
HEADER		
Start of Heading	1	
Mode Character	1	
Address	7	
Technical Acknowledgement	1	
Label	2	
Uplink Block Identifier	1	(Ground-to-Air only)
TEXT		
Start of Text	1	(for messages containing text)
Text	0-220	
SUFFIX		
Suffix	1	
Block Check Sequence	16 bits	
BCS Suffix	1	

Two methods of technical acknowledgment are supported: "Original" and "Positive Acknowledgment Protocol". The MU must support one of the two implementations with the latter being the preferred protocol.

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

APPENDIX A (cont'd)
PROTOCOL HISTORY

A1.8 Original Format Description (cont'd)

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 Acknowledgement implemented in the "Original" format is structured to detect an acknowledgement with the use of the "ACK" (0/6) control character alone in the Technical Acknowledgment field of the uplink.

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 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 MU'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.