

ARINC

ACARS PROTOCOLS FOR AVIONIC END SYSTEMS

ARINC SPECIFICATION 619

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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 INTRODUCTION

1.1 Purpose of this Document

The purpose of this document is to delineate, in an organized fashion, the protocols used by ACARS Management Units (MU) defined in ARINC Characteristics 597, 724 and 724B in their interactions with other onboard avionics equipment.

COMMENTARY

The interfaces described herein have evolved over time. The definitions are constrained to the most recent or most appropriate function. Some existing equipment, designed under earlier guidelines, will not comply with all of the provisions within this document. These interfaces should be updated by the user if practical, at his convenience, to the current standard to minimize interface incompatibilities.

1.2 Organization of this Document

This Chapter outlines the organization of the document.

Chapter 2 of this Specification defines the character-oriented protocol, data format and network functions required to interface with the Optional Auxiliary Terminal (OAT).

Chapter 3 of this Specification defines the character-oriented 429 protocol, data format and network functions required to interface with systems that use the character oriented protocols, such as: ACARS, ACMS, CMC, cabin terminal and FMC.

Chapter 4 of this Specification defines the character-oriented protocol, data format and network functions required to interface with the 597/724 dedicated printer and the protocol, data formats and network functions required to interface with ARINC 740 Multi Input Cockpit Printer (MICP).

Chapter 5 of this Specification defines the bit-oriented 429 protocol to be used to interface avionic units, such as ACMS, CMC, cabin terminals and FMC. The ARINC 429 bit-oriented file transfer protocol is included by reference. Chapter 5 also contains the description of the data formats and network functions required to interface with systems that use the ARINC 429 bit oriented protocol.

As they are developed, new data formats for the bit oriented protocol will be defined by the addition of new subsections to Chapter 5.

1.3 LRU Interface Definitions

The ACARS MU will provide interfaces for the exchange of data with onboard systems. The physical connections for these interfaces are identified in the associated ARINC Characteristic (597, 724, 724B and 748).

The FMC provides interfaces for the exchange of data with onboard systems. The physical connections for these interfaces are identified in ARINC Characteristic 702.

The ACMS provides interfaces for the exchange of data with onboard systems. The physical connections for these interfaces are identified in ARINC Characteristic 717.

1.4 Protocol Application

The protocols for transferring data between LRUs has evolved over the years. The OAT protocol, which was originally documented in ARINC 597 and is now defined in Chapter 2, was the original protocol. The OAT protocol was superseded by variations of the ARINC 429 DITS protocol. The protocols defined in ARINC Characteristic 724 and 724B were unique character-oriented protocols derived from the general file data transfer protocol described in ARINC Specification 429. This protocol is now defined in Chapter 3 herein.

The character oriented protocol is now being superseded by a bit-oriented file transfer protocol, often referred to as the "Williamsburg" protocol, introduced into ARINC Specification 429 with Supplement 12. Additional supplements will revise the requirements of the bit-oriented file transfer protocol as needed.

If the link layer protocol to be used is not known a priori then it can be determined as specified by ARINC 429. If the character oriented protocol is to be used then the appropriate protocol, 724 or 724B as defined in Chapter 3 herein, should be used.

1.5 Referenced Documents

ARINC Specification 429, "Mark 33 Digital Information Transfer System (DITS)"

ARINC Characteristic 597, "Aircraft Communications Addressing and Reporting System (ACARS)"

ARINC Specification 618, "Air-Ground Character-Oriented Protocol Specification"

ARINC Specification 620, "Data Link Ground System Standard and Interface Specification (DGSS/IS)"

ARINC Characteristic 702, "Flight Management Computer"

ARINC Characteristic 717, "Flight Data Acquisition and Recording System"

ARINC Characteristic 724, "Mark 2 Aircraft Communications Addressing and Reporting System (ACARS)"

ARINC Characteristic 724B, "Aircraft Communications Addressing and Reporting System (ACARS)"

ARINC Characteristic 740, "Multiple-Input Cockpit Printer"

ARINC Characteristic 744, "Full-Format Printer"

ARINC Characteristic 748, "Communications Management Unit (CMU)"

1.0 INTRODUCTION (cont'd)

1.6 Terminology

Various terms are used in this specification that may not be familiar to the reader or may be interpreted differently by readers experienced with the system. Therefore certain terms are defined below to remove any ambiguity as to the meaning to be applied within this specification.

Source/Sink:

In the context of this document, the terms "source" and "sink" refer to the 2 systems that are sending and receiving data over the interface. The source sends data to the sink, who receives it. The terms "source" and "sink" should not be confused with "origin" and "destination". The origin or originator is the system that created the message. The destination is the system for whom the message is intended. The source is not necessarily the originator and the sink is not necessarily the destination.

Pass-Through/Store and Forward:

If the MU does not attempt to buffer the individual blocks of a multiblock message before transferring the blocks, it is referred to as a pass-through system. An MU operating in this way will transfer each block of a message to the destination as soon as it is received from the source.

If the MU accumulates all blocks of a multiblock message before transferring the message to an end system or subnetwork, then the MU is said to be operating in a store and forward mode.

2.0 OPTIONAL AUXILIARY TERMINALS (OAT)

2.1 Introduction

This is a placeholder for the description of the interfaces of the ACARS MU with the Optional Auxiliary Terminal (OAT).

3.0 CHARACTER ORIENTED COMMUNICATIONS

3.1 ARINC 429 Character-Oriented File Transfer Protocol Characteristics

This chapter documents the character based protocol and message formats that are used by ACARS Management Units designed to ARINC Characteristics 724 and 724B that interface with onboard end systems, such as FMCs, ACMS, Cabin Terminals etc. This protocol is based on the character oriented file transfer provisions defined in ARINC Specification 429 (through Supplement 11).

COMMENTARY

Provisions for character-based file transfer were supported by Specification 429 up until Supplement 12 when they were replaced by the Williamsburg bit-oriented protocol. In Supplement 12, the earlier text describing character oriented file transfer was moved to an Appendix to retain the documentation for existing interfaces such as those described in the following sections.

Section 3.3 and Section 3.4 of this Specification define the character oriented ARINC 429 protocols. Section 3.6 describes the translation needed within the MU to convert uplink messages from the air/ground format to the output in a form compatible with the above ARINC 429 protocols. Section 3.8 describes the converse, preparing an ARINC 429 character oriented file transfer input into a form compatible with an ACARS downlink. See Sections 3.5 and 3.7 for routing and Section 3.9 for the format of documentary data messages.

3.2 Physical Interconnection

The interwiring will depend on whether the 724 or 724B architecture is used.

COMMENTARY

An aircraft that was originally wired per ARINC 724 may be upgraded with new avionics (including an ARINC 724B MU). Sometimes portions of the wiring are modified per ARINC 724B while some of the existing wiring is retained in its original ARINC Characteristic 724 configuration.

The voltage levels, waveforms and signal bit timing are as specified in ARINC Specification 429. Twisted and shielded pairs of wires should be used to connect the ACARS MU to each End System, for the transfer of information in each direction.

3.2.1 ARINC 724 Architecture

The primary feature of the ARINC 724 architecture is that the ACARS MU ARINC 429 wiring is point to point. In other words, each transmitter is connected to only one receiver as illustrated in Figure 3.2.1-1 below.

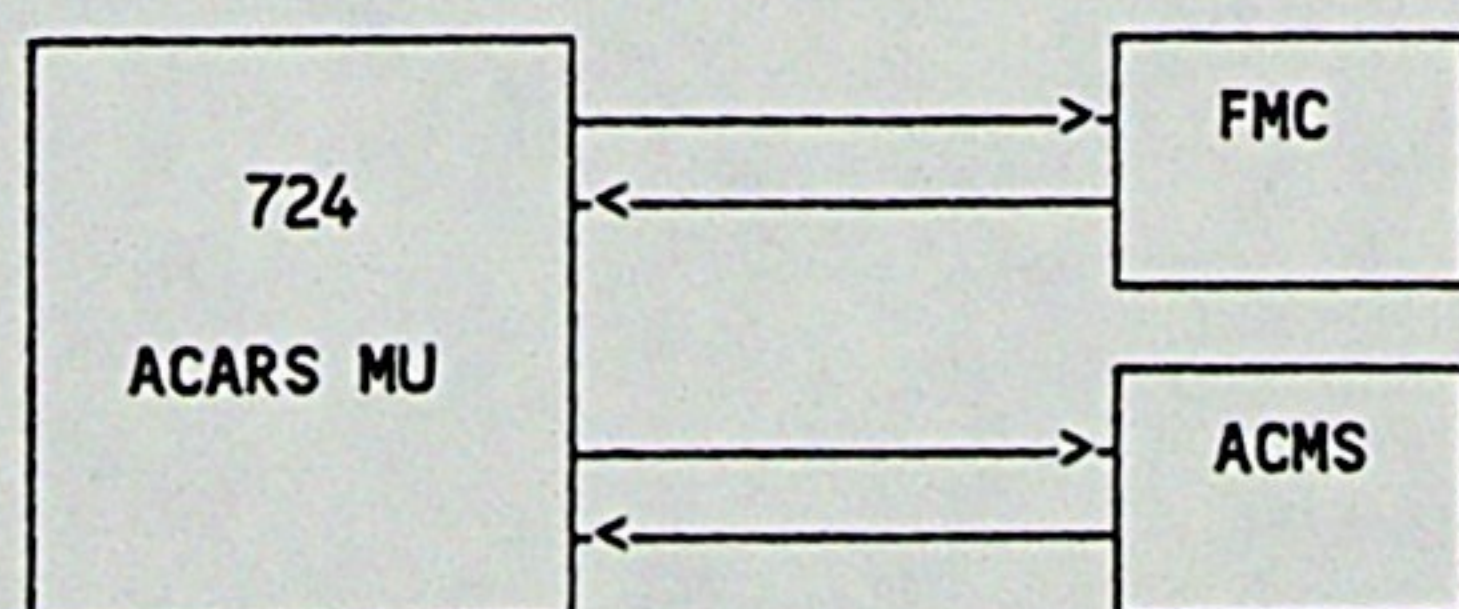


Figure 3.2.1-1
Example of ARINC 724 Architecture

3.2.2 ARINC 724B Architecture

The primary feature of the ARINC 724B architecture is that the ACARS MU ARINC 429 outputs are wired as buses as illustrated in Figure 3.2.2-1 below. In other words, each transmitter is connected to several receivers which necessitate the use of System Address Labels so that the receivers can determine which file transfers are for them.

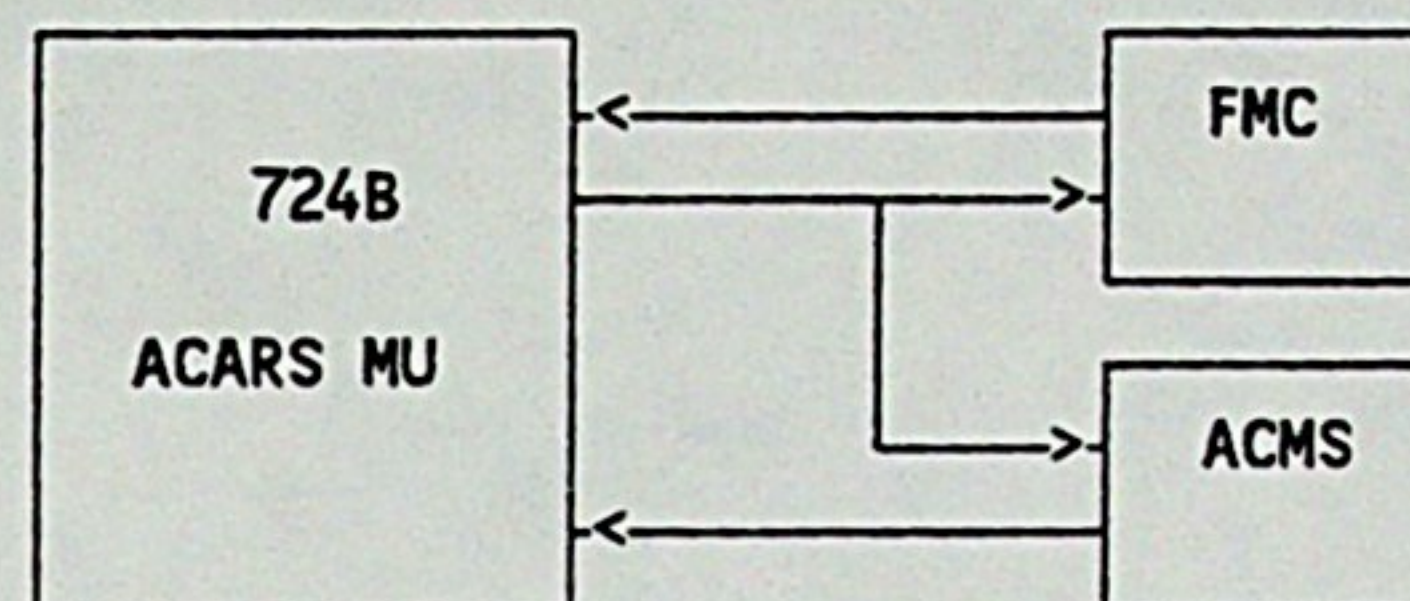


Figure 3.2.2-1
Example of ARINC 724B Architecture

3.3 Character Protocol, General Characteristics

The character-oriented file transfer protocol used for data transfer between the ACARS MU and the other on-board systems is based upon the ARINC Specification 429-1 through 429-11, "Mark 33 Digital Information Transfer System (DITS)". The protocol is documented in 619 because it is a variation of what was specified in ARINC Specification 429 and is not recommended for new systems.

3.3.1 Coding

Messages should be coded per the ISO Alphabet #5 subset set forth in Table 1-1 or Table 1-2 of Attachment 1, as appropriate. Seven bits per character should be used, i.e., an eighth parity bit should not be added or checked. Three such characters will occupy the information field of each ARINC 429 32-bit word as shown in Table 3.3.1-1 below.

Table 3.3.1-1 ARINC 429 Character Protocol Data Word Format

Bit	Description
1-8	Label (SAL of Sink)
9-15	Data Character 1
16	Pad Bit
17-23	Data Character 2
24	Pad Bit
25-31	Data Character 3
32	Parity Bit, odd

Before binary data can be transmitted over this link it should be converted into the ISO #5 characters. The standard method of converting binary data is called bit-to-hex (ISO 5) encoding. Each octet of binary data is divided into 2 four-bit nibbles. Each nibble is encoded into a seven-bit character field using its equivalent ISO #5 hexadecimal character. The value of each character,

3.0 CHARACTER ORIENTED COMMUNICATIONS (cont'd)

which will fall within the numeric range 0 through 9 or the alpha range A through F, is encoded for transmission per the ISO Alphabet #5 convention in the manner described above for free text.

COMMENTARY

Although the airborne equipment, the air-ground-air link and some of the ground communications links connecting users' data sources/sinks to the ACARS controlling processor are capable of handling the full ISO Alphabet #5 code set, many ground links do not have this capability. The restricted code set has been specified to ensure that all messages originating in a ground-based computer for delivery via ACARS to an airborne computer, and vice versa, are transparent to all ground communications links through which they might pass.

3.3.2 File Size

The maximum number of characters in a file is 3520 (16 blocks x 220 characters per block). The file size and number of characters available on any particular interface for data may also be subject to other restrictions. See Section 3.8.2.

3.3.3 Block Size

Data should be transferred in blocks containing a maximum of 77 ARINC 429 words. Each block will begin with a Data Follows (see Section 3.4.7), word followed by two data words containing the five character control/accountability header and the first text character. The block may contain up to 73 additional data words. Each block is terminated with either a "ETB" or "ETX" word. The total text handling capability will thus be 226 characters including all headers and a ETB/ETX character.

COMMENTARY

The initializing word (Data Follows word, see Section 3.4.7), the Control/Accountability header, a full uplink message block or 220 text characters, and the message suffix character ("ETX" or "ETB") can be accommodated in 77 ARINC 429 words.

Note that when the Block size is 77 ARINC 429 words that the last two character positions in the last word shall not be used.

If the data is less than 220 characters, then the file length can be reduced. There is no need for the suffix character to be accorded an ARINC 429 word of its own in these cases. If there is room, the suffix character should be placed in the final ARINC 429 word containing text characters.

The limit of 77 ARINC 429 data words maximum is imposed by the VHF protocol, see ARINC Specification 618.

The number of blocks used to transfer a multiple block message should be minimized.

3.3.4 Bit Rate and Word Timing

Data transfer should be conducted at the low bit rate defined in ARINC Specification 429. The source should introduce a word gap of at least 4 bit times between words and the average word gap spacing should be less than 64 bit times over the entire block. The word gap is the time between the end of one ARINC 429 word transmitted and the beginning of the next.

The sink should be able to receive an entire block transmitted with the minimum word spacing of 4 bit times.

COMMENTARY

The message word gap spacings are provided to allow realistic message throughput calculations by the sink. They should not be used to monitor the message transfer.

3.3.5 Labels

The Label field of the ARINC 429 word is used to identify the purpose of that word. There are two coding systems: Broadcast data and File Transfer. The file transfer mechanism is then divided into two implementations. Early units (units designed per the ARINC 724 interface architecture of Figure 3.2.1-1) use a single predefined data label. Later units (units designed per the arinc 724B interface architecture of Figure 3.2.2-1) use the preassigned System Address Label (SAL) of the recipient.

Each label must have a unique identity on the data bus. Thus, any one label can be used for only one purpose on an ARINC 429 bus; it cannot be used for both broadcast data and file transfer.

All ARINC 429 labels identified in this document (both broadcast and SALs) are expressed in octal with the least significant bit (LSB) displayed first in order to be consistent with the convention established in the ARINC Specification 429.

3.3.5.1 ARINC 429 Broadcast Words

ARINC 429 broadcast data words are used to transmit periodic data from one onboard system to one or more other onboard devices. Each broadcast word on an ARINC 429 data bus must have a unique label in order to uniquely identify it. Some broadcast data labels have multiple definitions. Since connection is limited to the physical interwiring, the same label may contain different data when used on a different interface (data bus).

The broadcast label identifies the data element (or elements) contained in the ARINC 429 word and the format in which the data element(s) is to be encoded. Refer to ARINC Specification 429 for a list of the broadcast labels that have been defined.

3.3.5.2 File Transfer Data Words - ARINC 724 MUs

When performing a file transfer with an ARINC 724 ACARS MU, the ARINC 429 label 357 (octal) should be

3.0 CHARACTER ORIENTED COMMUNICATIONS (cont'd)**3.3.5.2 File Transfer Data Words - ARINC 724 MUs (cont'd)**

used in each file transfer data word. Label 357 is used for both transmitting messages to an ARINC 724 ACARS MU and when receiving messages from an ARINC 724 ACARS MU.

3.3.5.3 File Transfer Data Words - ARINC 724B MUs

The interfaces utilized in installations with an ARINC 724B MU use System Address Labels (SAL) in order to identify the onboard system receiving the file transfer. All file transfer words used for transmission of data to the ACARS MU should contain the ACARS MU's System Address Label (SAL) of 304 Octal in the Label field (bits 1-8). The label code in the data words used for transmission of data from the ACARS MU to an on-board system will be the System Address Label (SAL) of the recipient LRU. See ARINC Specification 429 for a list of SAL assignments.

3.4 Character File Transfer Communications Protocol

The protocol used in the transfer of ACARS air-ground messages is a special (customized) version of the file data transfer protocol described in ARINC Specification 429 (up to Supplement 12). The elements of the protocol which are common to message exchanges between the ACARS MU and other onboard systems is described in this Section. This protocol applies to data transfer in either direction. Therefore, the definition is written in terms of "source" and "sink" operations. An example of a typical protocol transaction is shown in the figure below. Timing diagrams illustrating the interaction possibilities described in the following subsections are provided in Attachment 10.

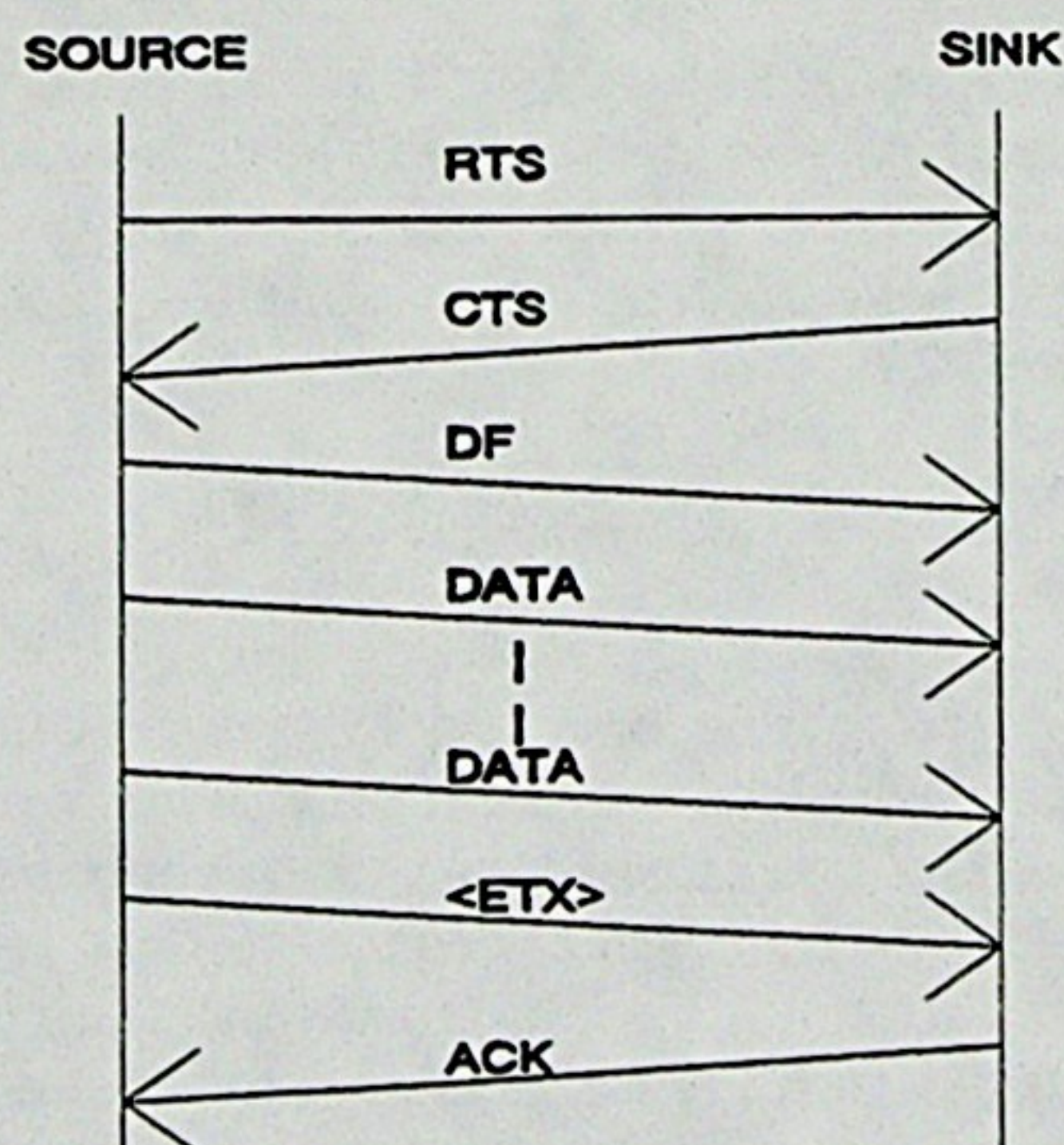


Figure 3.4-1
Typical Character Protocol Block Transfer

3.4.1 Request to Send

A file transfer is initiated when a source sends a "Request to Send" (RTS) word to the sink. The RTS word is an ARINC 429 32-bit word having the format shown in the table below.

Table 3.4.1-1 RTS Word Format

Bit Nos.	Field Content
1 thru 8	Label
9 thru 16	Block Word Count (binary)
17 thru 24	Destination Code
25 thru 31	ISO #5 Control Character DC2
32	Odd Parity

The Block Word Count contains the binary value of the number of ARINC 429 data words the source wishes to send to the sink. The Block Word Count includes all of the words from the Data Follows (DF) word to the ETX/ETB word inclusive.

A sink will ignore any file transfer words received that are not preceded by a valid RTS word.

The source starts timer T1 (see Section 3.4.13.1) when it transmits a RTS word. The source will restart timer T1 when it retransmits a RTS word. The RTS word is retransmitted up to C1 times, if acceptable responses are not received by the source. See Section 3.4.13 for timer and counter definitions.

A timing diagram illustrating this block transfer interaction is provided as Figure 10-1 of Attachment 10.

3.4.2 Normal Response to RTS

The sink's normal response to the RTS word is a "Clear To Send" (CTS) word within T1 milliseconds of receiving the RTS word. A timing diagram illustrating this interaction is provided as Figure 10-2 of Attachment 10.

The CTS word is an ARINC 429 32-bit word having the format shown in Table 3.4.2-1 below.

Table 3.4.2-1 CTS Word Format

Bit Nos.	Field Content
1 thru 8	Label
9 thru 16	Sink Status (see below)
17 thru 24	Pad (binary "Zero")
25 thru 31	ISO #5 Control Character <DC3>
32	Odd Parity

The sink status field indicates to the source whether or not the sink can accept data. Valid values for the sink status field are specified in Table 3.4.2-2.

Table 3.4.2-2 Sink Status Definition

Coding in Bits 9 thru 16	Content Meaning
Binary word count same as in RTS	Sink ready to accept block
Binary zeros	Sink Not Ready - sink momentarily not ready to accept data
ISO #5 Character "Q"	Sink Busy (sink temporarily cannot accept file)

3.0 CHARACTER ORIENTED COMMUNICATIONS (cont'd)

The sink should start timer T2 (see Section 3.4.13.3) when it transmits a CTS word indicating "ready to accept data" status. If the block transfer has not been completed before timer T2 expires then the sink should send a NAK word to the source and discard that block. A NAK response means Data Received Not OK. If a store and forward design is used then only the block which just timed out is discarded and any previously received blocks of the file are still stored.

3.4.2.1 Sink Ready

If the sink is capable of accepting all the data the source has to send, then the sink status field of the CTS word should contain the same value as the block word count field of the RTS word.

3.4.2.2 Sink Not Ready

If the sink is not ready to accept all of the data, then the CTS Sink Status field should be filled with binary zeroes. The criteria for available buffer space that is used by the sink to determine if it can accept the file are: one block for a pass-through design and a 16 block file for a store and forward design.

3.4.2.3 Sink Busy

If the sink temporarily, for reasons that will require longer than T1 milliseconds to resolve, cannot accept all of the data, then the Sink Status field of the CTS word should be coded with the ISO #5 character 'Q'.

The sink may not be able to accept a file for any one of several reasons, such as because its buffer is full with the previous file or the communication channel with the destination indicated in the RTS word is not functioning at this time.

A timing diagram illustrating this interaction is provided as Figure 10-3 of Attachment 10.

3.4.3 Source Response to Sink Unavailable

Occasionally, as described above, the sink will not be able to accept the file. When the source is informed of the sink's status, an appropriate action should be taken.

3.4.3.1 Source Response to Sink Not Ready

If the CTS word received by the source indicates that the sink is not ready to receive data (bits 9-16 are binary "zeros"), the source should wait T1 milliseconds from the time of the RTS transmission and then retransmit the RTS word and increment the RTS retry counter C1. If the CTS response again indicates that the sink is not ready, the source should again wait T1 milliseconds and then retransmit the RTS word and increment the RTS retry counter C1. If a "ready" response is not received from the sink before the limit of counter C1 is reached then the source should deem the message undeliverable. If the ACARS MU is the source and the message is an uplink then it should process the message as specified in ARINC Specification 618.

Note that the response indicated by ARINC Specification 618 is different for a pass through implementation versus a store and forward implementation.

If the source is an on-board computer, it should react to the situation in the manner specified by its users.

3.4.3.2 Source Response to Sink Busy

The response of the source to a CTS word from the sink containing a Busy indication depends on whether the message is an uplink that the ACARS MU is trying to deliver to an on-board system or a message created onboard.

3.4.3.2.1 Message is an Uplink

If the ACARS MU is the source, the message is an uplink and a CTS word received from the sink indicates that the sink is Busy then the ACARS MU should process the message as specified in ARINC Specification 618. If the ACARS MU is operating in the pass-through mode, then no on-board retransmissions should be attempted.

3.4.3.2.2 Message is Not an Uplink

If the sink responds to the source with "Q" (destination Busy), then the source should increment the Busy Retry counter C3 and wait at least T4 seconds after receiving the CTS word before attempting to initiate the message transfer with a new RTS word. If this attempt also produces a "Q" response, then the source should increment the Busy retry counter C3 and wait a further T4 seconds before sending a another RTS. If the limit of the Busy Retry counter, C3, is reached before a Sink Ready Clear To Send (CTS) response is received, then the message is deemed undeliverable.

The data throughput for VHF downlinks (2400 bps for MSK) used by the ACARS MU is substantially slower than either of the ARINC 429 data bus (12.0-14.5 kbps low speed or 100 kbs high speed) throughput rates. This means that the ACARS MU will end up storing a multiblock message for several minutes before it finishes downlinking all of the blocks. The data throughput differences are due to the different data rates and the fact that the VHF is a multiple user medium while the 429 bus is not. If an on-board system attempts to gain access to the ACARS MU while it is in the process of downlinking a multiblock message then the onboard system may receive enough busy responses to reach the retry limit. In this event, the originating system should react in the manner specified to its manufacturer by its users. Among the options are: (1) to re-initiate another sequence of access requests at some specified later time or (2) abandon altogether the attempt to downlink this particular message.

3.4.4 Source Receives No Response to RTS

If the source does not receive a valid CTS word within T1 milliseconds (nominal) it should retransmit the RTS word and increment the RTS retry counter (C1). If this retransmission also elicits no response within T1 milliseconds, then another RTS transmission should be made and counter C1 should be incremented. If counter C1 reaches its limit and there is still no response from the

3.0 CHARACTER ORIENTED COMMUNICATIONS (cont'd)**3.4.4 Source Receives No Response to RTS (cont'd)**

sink, then the source should alert the message originator to the communications break-down. If the source receives any response other than a valid CTS or conflicting RTS (see Section 3.4.5), it should ignore that response and continue waiting for a valid response. The source should only transmit the block when a CTS word containing the same block word count as the RTS is received.

A timing diagram illustrating this interaction is provided as Figure 10-5 of Attachment 10.

3.4.5 Conflicting RTS Transmissions

If an onboard device detects an incoming RTS transmission from the ACARS MU it should abort any transmission in progress to the ACARS MU and respond as specified in Section 3.4.2 above. The aborted message may be retransmitted following the completion of the message being initiated by the ACARS MU. If the ACARS MU detects an RTS from an on-board device after having initiated an RTS to that device and prior to completing the message transaction, it should ignore the RTS and continue the transaction in progress.

The sink should not send an RTS after sending a CTS until the transfer of that block is completed, i.e. ACK or NAK word sent or timer T2 expires.

3.4.6 RTS Response by Source to CTS Transmission

If a sink receives an RTS word in response to a CTS word, it should transmit a new CTS word to the source in response to the new RTS word as specified in Section 3.4.2 above. Any response by the source to the new CTS word other than a repeated RTS or a valid DF word should elicit a "NAK" response to the source as specified in Section 3.4.10.2.

3.4.7 Data Follows Word

If the sink responds to an RTS word with a CTS word indicating that the sink is ready to accept data, then the source should send a DF word to the sink. The DF word is an ARINC 429 32-bit word having the format specified in the table below.

Table 3.4.7-1 Data Follows Word Format

Bit Nos.	Field Content
1 thru 8	Label
9 thru 16	Block Word Count should contain the same value as the RTS word
17	Optional Header Flag (see Section 3.8.1.1)
18 thru 24	Binary "Zeros"
25 thru 31	ISO #5 Control Character "STX"
32	Odd Parity

The Block Word Count field of the Data Follows (DF) word should contain the same value as the Block Word Count field of the RTS and CTS word.

3.4.8 Data Word

The data is transmitted in data words following the Data Follows (DF) word subject to the word spacing requirement specified in Section 3.3.4. The data words are ARINC 429 32-bit words with the format specified in Section 3.3.1.

The data characters should be transmitted in the order received by the ACARS MU in the case of uplinked data and in the order determined by the originator in the case of data originated on-board the aircraft. The binary states of the pad bits are immaterial.

3.4.9 ETX/ETB Word

The last data word transmitted should contain an ETB or ETX character in order to indicate the end of block or end of file, respectively. The data word is an ARINC 429 32-bit word with the format specified in Section 3.3.1.

3.4.10 Sink Responses to Data Transfer

The sink should respond to the data transfer as specified in the following paragraphs.

The sink should check parity on each word received. When the sink detects a word with a parity error then the sink should either:

- 1) transmit a NAK word and discard the block
- or
- 2) discard the word containing the parity error and not include it in the word count.

When the sink receives the final word or timer T2 expires then the sink should:

- 1) Compare the number of words actually received with the word count transmitted in the DF word.
- 2) Generate either an ACK or NAK response, if a NAK has not all ready been sent.

3.4.10.1 No Errors

If none of the errors enumerated in Section 3.4.10.2 are detected then the sink should send a "Data Received OK" (ACK) word to the source within T3 milliseconds of receiving the final word. The ACK word is an ARINC 429 32-bit word with the format specified in the table below.

Table 3.4.10.1-1 ACK Word Format

Bit Nos.	Field Content
1 thru 8	Label
9 thru 16	Block Word Count (binary) of words received
17	Binary "One"
18 thru 24	Binary "Zeros"
25 thru 31	ISO #5 Control Character ACK
32	Odd Parity

3.0 CHARACTER ORIENTED COMMUNICATIONS (cont'd)

Upon receipt of an ACK word, the source should close out the communications transaction for that block and send the RTS for the next block, if there is one.

PASS THROUGH: If the source is the ACARS MU and the delivered block is an uplink, then the ACARS MU should transmit the appropriate air-ground acknowledgment to the ground as specified in ARINC Specification 618.

STORE AND FORWARD: If the source is the ACARS MU and the delivered message is an uplink, then no additional action required.

3.4.10.2 Errors Detected

If any of the conditions listed below occur, then the sink should send the Data Received Not OK (NAK) word: (1) within T2 seconds (nominal) of transmitting the CTS word or (2) within T3 seconds of receiving a data word containing ETB or ETX, whichever occurs first. The error conditions are as follows:

1. Word count in CTS word does not match word count in Data Follows word.
2. Actual word count does not match expected word count from CTS and Data Follows words.
3. Block received from source is not properly terminated with an ETB or ETX.
4. The final word is not received before timer T2 expires.
5. Word received by sink after transmitting a CTS word is not a RTS word or a DF word.
6. OPTIONAL: A NAK may be sent upon detection of a parity error.

COMMENTARY

Some systems transmit a NAK when an invalid Control/Accountability header (see Section 3.5.1) is detected:

- a) Unit separator is not 1F hex.
- b) Origin code not valid for originator.
- c) Destination code not valid.
- d) The Block Sequence Character is less than 40 hex.

COMMENTARY

A NAK is transmitted by some sinks when parity errors or invalid Control/Accountability header characters are detected in accordance with early versions of ARINC Characteristic 724 and 724B. It is recommended that checking to validate Control/Accountability header characters be done on a "reasonability" basis since each sink has expectations concerning the message Purpose/Nature and Origin codes of received transmissions. Also, the Unit Separator and Destination

codes occur in fixed locations and have bit patterns known to each sink. Care should be taken, however, to avoid over-confidence in rejecting messages on the basis of a failure of the reasonability check alone.

NAK transmission immediately following sink power-up and resets will speed up the transmission reinitiation process. Otherwise, the NAK will be sent to the source only when transmission of the now unusable message has been completed.

The NAK word is an ARINC 429 32-bit having the format shown below.

Table 3.4.10.2-1 ARINC 429 Character Protocol NAK Word Format

Bits	Function
1-8	Label
9-16	Optional Error Code
17	Binary "One"
18-24	Binary "Zeros"
25-31	ISO #5 Control Character <NAK>
32	Odd Parity

Note: The Optional Error Code (bits 9-16) is for engineering purposes only and should not be examined by the source.

3.4.11 Source Response to a NAK Word

The source should be capable of receiving a NAK while in the process of transmitting a data block. If a NAK is received, the source should abort the block transmission in progress, increment the Block Retry counter (C2) and if C2 has not exceeded its limit then repeat the complete block transmission starting with the RTS word. If the limit of counter C2 is exceeded then the source should classify the block undeliverable.

In the case where the message is an uplink then the ACARS MU should respond according to ARINC Specification 618. ARINC Specification 618 specifies a different response for the store and forward and pass through implementation.

If the ACARS MU is relaying a message from an onboard source to an onboard sink, it should simply dump the message. The message originator, which is not necessarily the same as the source, should recognize the communications failure when it receives no response from the destination. If the message originator is an on-board device attempting to communicate with the ACARS MU, it should react to the situation in the manner specified by its users.

3.4.12 No Sink Response to Data Transfer

If the source does not receive a valid ACK or NAK from the sink within T5 seconds of receipt of the CTS word,

3.0 CHARACTER ORIENTED COMMUNICATIONS (cont'd)**3.4.12 No Sink Response to Data Transfer (cont'd)**

then the source should increment the block Retry Counter (C2) and if C2 has not exceeded its limit then the source should repeat the complete block transmission process starting with the RTS word. If the limit of C2 is exceeded then the source should deem the message undeliverable.

PASS THROUGH: If the source is the ACARS MU and the block is an uplink, then the ACARS MU should respond as specified in ARINC Specification 618 when the retries have been exhausted.

STORE AND FORWARD: If the source is the ACARS MU and the message is an uplink, then the ACARS MU should respond as specified in ARINC Specification 618 when the retries have been exhausted.

If the ACARS MU is relaying a message from an on-board source to an on-board sink, then it should discard the message. The message originator, which is not necessarily the same as the source, should recognize the communications failure. If the message originator is an on-board device attempting to communicate with the ACARS MU, then the source should react to the situation in the manner defined by its users.

If the source receives any response other than a valid ACK or NAK or conflicting RTS (see Section 3.4.5), it should ignore the response and continue waiting for a valid response until timer T5 expires.

3.4.13 Summary of Character Protocol Timers and Counters**3.4.13.1 Source Timers**

Name: T1, RTS Retransmit Timer
Value: 200 milliseconds
Start: when RTS word is transmitted
Restart: when RTS word is retransmitted
Stop: CTS word received or counter C1 limit reached.
On Expiration: retransmit RTS if C1 limit not reached.
Reference: Section 3.4.1, 3.4.3.1, and 3.4.4

Name: T4, Sink Busy Delay Timer
Value: 15 seconds
Start: when a CTS word containing a "Q" in the block word count field is received.
Restart: none
Stop: none
On Expiration: retransmit RTS word and increment count C3 if limit not exceeded
Reference: Section 3.4.3.2.2

Name: T5, Block Retransmission Timer
Value: 1.7 seconds
Start: when a CTS word is received
Restart: none
Stop: when an ACK or NAK word is received
On Expiration: increment C2 and retransmit block beginning with RTS if retry limit (C2) has not been reached.
Reference: Section 3.4.12

3.4.13.2 Source Counters

Name: C1, RTS Retry Counter
Value: 2
Enabled: C1 is enabled and reset when the first RTS word is transmitted.
Count: C1 is incremented by 1 when (the time the T1 timer expires) or (CTS word with a block word count is received and (the block word count does not match RTS word and block word count is not "Q").
Stop: C1 is stopped and reset when a CTS word with a block word count matching the RTS is received.
On Expiration: The block is considered undeliverable.
Reference: Sections 3.4.3.1 and 3.4.4

Name: C2, Block Retry Counter
Value: 2
Enabled: when a CTS word is received
Count: incremented by 1 when a NAK word is received or T5 expiration.
Stop: C2 is stopped and reset when a ACK word is received or the limit is reached.
Expiration: The block is considered undeliverable.
Reference: Section 3.4.11 and 3.4.12

Name: C3, Busy Retry counter for Busy response.
Value: 2
Enabled: C3 is enabled and reset when the first RTS word is transmitted.
Count: C3 is incremented by 1 when a CTS word containing a "Q" character in the block word count field is received
Stop: C3 is stopped and reset when a CTS word with a block word count matching the RTS is received.
On Expiration: The block is considered undeliverable.
Reference: Section 3.4.3.2.2

3.4.13.3 Sink Timers and Timing Constraints

Name: T2, NAK Timer
Value: 1.5 seconds
Start: when sink transmits CTS word
Restart: none
Stop: when ETX or ETB word is received.
On Expiration: transmit NAK word
Section reference: 3.4.2, 3.4.5, and 3.4.10.2

3.0 CHARACTER ORIENTED COMMUNICATIONS (cont'd)

Name: T3, ACK/NAK Response Timer
 Value: 100 milliseconds
 Start: when ETX/ETB is received
 Restart: none
 Stop: when ACK/NAK word is transmitted
 On Expiration: N/A
 Section reference: Section 3.4.10.2 and 3.4.10.1

3.4.13.4 Sink Counters

This is a placeholder to ease the documentation of any for future definition. However, there are no sink counters defined at this time, nor are any contemplated.

3.4.14 Message Transfer Failure Notification

Other than the protocols established in Section 3.4 for communications, there are no provisions for message transfer failure notification. It is the responsibility of the message originator to establish alternate communications or protect critical information when communications cannot be established.

When communications are established but the message text is not intelligible to the destination, then the destination may initiate a failure message to the originator.

3.5 ARINC 429 Character Message Routing

The character protocol is used for several different types of messages: uplink to end system, end system to downlink, and end system to end system. Section 3.5.1 contains the Character protocol message format. Section 3.5.2 contains the end system to the downlink requirements. Attachment 6 contains character file transfer message formats for downlinks and uplinks between an FMC and ACARS MU.

3.5.1 ARINC 429 Character Protocol Message Format

Each block of a Character protocol message has the format specified herein. The first five characters contain the character Control/Accountability header. The format of the character Control/Accountability header is defined in Table 3.5.1-1 below.

Table 3.5.1-1 ARINC 429 Character Control/Accountability Header

Character No.	Character Content
1	Unit Separator character
2	Origin Code
3	Message Purpose/Nature Code
4	Destination Code
5	Block Sequence Character

3.5.1.1 Origin Code

The origin code is used to indicate where the message came from or originated. See Attachment 3 for the Origin/Destination codes.

3.5.1.2 Destination Code

The destination code is used to indicate where the message should be sent. See attachment 3 for the Origin/Destination codes.

3.5.1.3 Message Purpose/Nature Code

The message purpose/nature is used to indicate the message type to the destination. See Attachment 4 for the message Purpose/Nature codes.

3.5.1.4 Block Sequence Character

The block sequence character is used to detect duplicate blocks. The source should increment the Block Sequence character for each block. The initial value at power up should be hexadecimal 40. When value hexadecimal 7F has been used then the next value should be hexadecimal 41.

The sink should compare the block sequence character in the block received to the block sequence character contained in the previous block. Each time a sink receives a data block, it compares the block sequence character to that contained in the previous block. If the two block sequence characters are the same, then the sink treats the block as a duplicate and discards the duplicate block and send an ACK, except for documentary data requests.

If the block is a documentary data request then the block sequence character is not checked and the block is not considered a duplicate even if the block sequence character is the same as the previous block.

3.5.2 Uplink to End System, ARINC 429 Character Protocol

When the ACARS MU receives uplinks which should be delivered to an end system using the Character Oriented ARINC 429 protocol then there is a one to one correspondence between uplink blocks and ARINC 429 blocks regardless of whether a pass through or store and forward implementation is used.

The ACARS MU transmits the individual uplink blocks to the destination end system after reformatting the block according to Section 3.6.

3.5.2.1 Uplink Routing

See ARINC Specification 618 and 620 for the format of uplinks blocks and messages respectively. Each uplink to be routed to an End System using the character protocol contains a sublabel per ARINC Specification 620. The sub-label indicates which End System the message the message should be delivered (see Table 3.5.2.1-1 below). Table 3.5.2.1-1 specifies the sublabels and corresponding End Systems that have been defined. ARINC Specification 620 describes how to locate the sublabel within an uplink and which uplinks contain sublabels.

Table 3.5.2.1-1 H1 Sub-Label

Sublabel	Destination Code	End System
CF	F	CFDIU/CMC
DF	D	ACMS/DFDAU/DMU
M1	A	FMC Left (1)
M2	B	FMC Right (2)
MD	Note 1	Master FMC
S1	S	Left SDU
S2	S	Right SDU
S3	S	Active SDU
Tn	n	Cabin Terminal n where n = 1 to 8

3.0 CHARACTER ORIENTED COMMUNICATIONS (cont'd)**3.5.2.1 Uplink Routing (cont'd)**

Note 1: This value will be the Destination code for current Master FMC.

COMMENTARY

The definition of TO and its use for "all call" will be provided in a future Supplement. This feature is one of the expanded capabilities that were beyond the scope of this first version of the standard.

The criteria for determining which FMC is master is specified in Section 3.5.2.2.1.

The ACARS MU will respond to an uplink with an unknown sublabel as specified under Section 3.7 of ARINC Specification 618.

3.5.2.2 Addressing Dual Systems

Some onboard systems have redundant components to ensure the availability of its function in the event that one unit fails. The FMC is typical of this class of equipment. As reflected in the table above, there can be left and right units installed. In addition, a message may be routed to a logical address, e.g., the unit that is currently active; the other unit is presumed to be in Standby mode.

3.5.2.2.1 Master FMC Selection

If the MU receives an uplink message containing the Sublabel 'MD' then the ACARS MU should deliver the message to the active FMC. The MU determines the destination by examining the Master/Slave bit (bit 17) in the Label 270 status words broadcast by the FMCs (at approximately 1 second intervals per ARINC Specification 429 and ARINC Characteristic 702) and examining the FMC Select Discrete input at the service connector.

The incoming Label 270 broadcast status word is considered reliable when it is received for at least 3 consecutive transmission periods and the SSM bits (bits 30-31) indicate Valid or Normal for the condition of the source.

Table 2-1 of Attachment 2 summarizes the logic for determining which FMC is the present master FMC for the purposes of routing uplink messages with sublabel MD. Table 2-2 of Attachment 2 describes the FMC Label 270 word.

The ACARS MU checks the activity of the status words from the FMCs in order to determine the master FMC for the purpose of routing an uplink with the Sublabel MD. The following hierarchy is used by the ACARS MU:

- (1) If the status word for both FMCs is inactive then the ACARS MU uses the discrete input FMC Active Port Select in order to determine which FMC the uplink should be routed to. When the discrete is open circuit then the uplink should be routed to FMC1. When the discrete is grounded then the uplink should be routed to FMC2.
- (2) If only FMC1 is active then FMC1 is considered the master regardless of the status of the discrete and regardless of the status of bit 17.

(3) If only FMC2 is active then FMC2 is considered the master regardless of the status of the discrete and regardless of the status of bit 17.

(4) If the status word for both FMCs is active, then the ACARS MU will use bit 17 in order to determine which FMC is the master regardless of the discrete input. If bit 17 has the value 1 in one and only one status word then the FMC which transmitted the word with bit 17 set to one is considered the master.

(5) If the status word for both FMCs is active, then the ACARS MU will use bit 17 in order to determine which FMC is the master regardless of the discrete input. If bit 17 has the value 1 in both words or neither word then the FMC1 is considered the master.

3.5.2.2.2 Master/Slave Swaps

From time to time the selection of the FMC to act as the master may be changed. This change may occur during the receipt of an uplink message and complicate the delivery if the designated recipient is the "active" FMC.

In a pass-through implementation, the ACARS MU may continue to route the remaining blocks of a message being transferred to either the old or the new master after a Master/Slave swap when the Sublabel is MD.

Master/slave swaps must be treated differently when store and forward is used on uplinks to end systems.

3.6 Translation of Uplink Message Text to ARINC 429 Character File Transfer Format

When an uplink message is received from one of the RF paths (currently VHF and Satellite), the ACARS MU will transfer the entire Text field of the uplink block to the text portion of the ARINC 429 block.

3.6.1 Control/Accountability Header

The ACARS MU will insert the Control/Accountability header at the beginning of the ARINC 429 Text field. The format of the Control/Accountability header is defined in Table 3.5.1-1.

3.6.1.1 Origin Code

The Origin code will be set to indicate which air/ground link delivered the message to the ACARS MU. See Table 3-1 of Attachment 3 for the Origin/Destination codes.

3.6.1.2 Destination Code

The Destination code will be set to the value determined by the sublabel as described in Section 3.5.2.1. See Attachment 3 for the Origin/Destination codes.

3.6.1.3 Message Purpose/Nature Code

The ACARS MU will set the message Purpose/Nature code to "V" in order to indicate that the message is an uplink being relayed by the ACARS MU.

3.0 CHARACTER ORIENTED COMMUNICATIONS (cont'd)

3.6.2 Uplink Message Buffering

Two different buffering schemes have been implemented in ACARS MUs over the years.

3.6.2.1 Uplink Pass Through Buffering

Originally all ACARS MUs used pass through buffering. Pass through buffering means that the ACARS will transmit each uplink block as soon as it is received. When pass through buffering is implemented then the ACARS MU should contain at least one buffer of sufficient size to accommodate a maximum size block. Additional buffers or larger buffers may be provided at manufacturer option.

When the block is successfully transmitted to the end system then the buffer is cleared. If the ACARS MU is unable to establish communications it will respond as specified in ARINC Specification 618.

3.6.2.2 Uplink Store and Forward Buffering

Store and Forward buffering means that the ACARS MU will store all of the blocks of an uplink until it has received the last block before starting to transmit the message to an end system. When Store and Forward buffering is implemented then the ACARS MU should contain at least one buffer of sufficient size to accommodate the maximum file size.

When the file is successfully delivered then the buffer is cleared. If the ACARS MU is unable to establish communications it will respond as specified in ARINC Specification 618.

3.7 Routing Messages Received From End Systems

The ACARS MU will route the file or blocks to the destination specified by the destination field in the RTS word. The destination field in the Control/Accountability header should contain the same value as the RTS word. However, when the two Destination fields do not match then the value in the RTS word should be used.

3.7.1 Control/Accountability Header

The originator which creates the message should divide the message into blocks and add a Control/Accountability header to each block.

The format of the Control/Accountability header is shown in Table 3.5.1-1. The Origin code, Destination code and message Purpose/Nature code fields of each block of a single message should contain the same value.

3.7.1.1 Origin Code

The originator should set the origin code to the value assigned to it. The ACARS MU uses the Origin code to determine where to send the Network ACK message.

The Origin codes are defined in Attachment 3.

3.7.1.2 Destination Code

The end originator should set the Destination code in the RTS word and the Control/Accountability header to correspond to the destination that it wants the ACARS MU to route the message to.

The ACARS MU uses the Destination code in the RTS word to determine where to send the block or file.

The Origin/Destination codes are defined in Attachment 3.

COMMENTARY

The ACARS MU will typically use the following type of routing logic for a downlink message with a Destination code of 'G':

- 1) Use the VHF link if available.
- 2) If the VHF link is Not-Available, then use the SATCOM link if it is available.
- 3) If both the VHF and SATCOM links are unavailable then the ACARS MU will save the message for transmission when the first qualified link becomes available. At the time the link is established (or before) the ACARS MU may determine if the message still has value. The MU MAY discard a message deemed to be worthless. In this case, it is the responsibility of the originating End System to detect that the message has been discarded.

The user may specify other routing logic.

3.7.1.3 Message Purpose/Nature Code

If the sink is not the final destination as specified in the RTS word then it will ignore the message Purpose/Nature code.

If the sink is the final destination then the Purpose/Nature code indicates what data is being requested or delivered. The message Purpose/Nature codes are listed in Table 4-1 of Attachment 4.

3.8 Downlinks

The ACARS MU will route files to the VHF and satellite air/ground channels. The message is downlinked using label H1 and the sublabel according to Table 3.5.2.1-1 unless a user defined format has been specified.

3.8.1 Downlink File Format

Blocks which are to be downlinked should contain a downlink message sequence number immediately following the block sequence character. The message creator should fabricate a 4 character downlink message sequence number according to the format specified in ARINC Specification 618. If the ACARS MU reblocks the downlink message then it must also create new downlink message sequence numbers and save the original downlink message sequence number of the last block for use in the ground acknowledgement message, see Section 3.8.3.

3.0 CHARACTER ORIENTED COMMUNICATIONS (cont'd)**3.8.1 Downlink File Format (cont'd)**

The ACARS MU may start downlinking data before it has received all blocks of a file.

All characters between the Control/Accountability header and the ETX/ETB character should be mapped into the text field of the ACARS air/ground block.

3.8.1.1 Downlink Header Options

Bit 17 of the Data Follows word indicates whether the ACARS MU or the originating End System supplies the downlink header on a file transfer from an end system to the ACARS MU. When bit 17 is '0', the ACARS MU supplies the downlink header, and when bit 17 is '1', the originating End System supplies the downlink header.

Bit 17 is always set to 1 for file transfer from the ACARS MU to an end system.

3.8.1.1.1 ACARS MU Supplies Downlink Header (bit 17 = 0)

The ACARS MU inserts the Flight Number, Sublabel, and Message Type immediately after the downlink Message Sequence Number (MSN) of the block. The formats of these fields are shown in the table below.

Table 3.8.1.1.1-1 ACARS MU Generated Downlink Header

Character Position		
ARINC 429 Data Field	Downlink RF Text Field	Description
6-9	1-4	Downlink MSN
	5-10	Flight Identifier
	11	Poundsign <#>
	12-13	Sublabel
	14	Character B
10	15	Data

The message type field is as specified in ARINC Specification 620.

The flight identifier format is specified in ARINC Specification 618. The maximum ARINC 429 block size is limited to 216 characters, including Control/Accountability header and ETB/ETX, when bit 17 is '0', in order to leave room for the ACARS MU generated downlink header.

3.8.1.1.2 END SYSTEM Supplies Downlink Header (bit 17 = 1)

When bit 17 = 1, then the End System supplies the downlink header and no action is required by the ACARS MU. The format of the downlink header is the same as specified in Section 3.8.1.1.1. The maximum ARINC 429 block size is limited to 226 characters, including

Control/Accountability header, MSN, downlink header and ETB/ETX, when bit 17 is '1'.

Table 3.8.1.1.2-1 Originator Generated Downlink Header

Character Position		
ARINC 429 Data Field	Downlink RF Text Field	Description
6-9	1-4	Downlink MSN
10-15	5-10	Flight Identifier
16	11	Poundsign <#>
17-18	12-13	Sublabel
19	14	Character B
20	15	Data

3.8.2 Block Size

The maximum file size depends on whether the end system or the ACARS MU supplies the downlink header (see Sections 3.4.8 and 3.8.1.1.1). The maximum amount of data in a file is the same regardless of who supplies the downlink header.

Each block of the file, with overhead, is constructed as follows:

D F	C/A HEADER	OPTIONAL HEADER	206 DATA CHARACTERS
--------	---------------	--------------------	------------------------

**Figure 3.8.2-1
Block Structure**

The maximum number of data characters is 3296 (16 blocks x 206 data characters per VHF block). The file size and number of characters available on any particular interface for data may also be subject to other restrictions. It is the ACARS MU responsibility to ensure that it does not downlink a block that violates ARINC Specification 618. The ACARS MU should be prepared to cope with a block that exceeds the limits specified in Sections 3.8.1.1.1 and 3.8.1.1.2.

COMMENTARY

Several methods have been identified to handle a block that is too large:

1. Divide the block into 2 blocks or reblock the entire message if store and forward is used.
2. Truncate the end of the block.
3. Discard the block.

There may be other solutions also. It is left to the designer to select a solution to this problem.

3.0 CHARACTER ORIENTED COMMUNICATIONS (cont'd)

3.8.3 Ground Acknowledgement

The ACARS MU should generate a ground acknowledgement message when the last block of a file is successfully downlinked to the ground.

The ground acknowledgement message consists of the Control/Accountability header followed by the downlink message sequence number of the last block. The format is shown in Table 3.8.3-1 below.

Table 3.8.3-1 Ground Acknowledgement Message

<u>Character</u>	<u>Description</u>
1	Unit Separator character
2	Origin Code
3	Message Purpose/Nature Code
4	Destination Code
5	Block Sequence Character
6-9	Downlink Message Sequence Number created by the originator for the last block of the message

The Origin code should be set depending on which air/ground link was used to deliver the message. The message Purpose/Nature code should be set to acknowledge ('K'). The Destination code is set to the Origin code that was in the Control/Accountability header of the ARINC 429 message.

If the ACARS MU is unsuccessful at delivering the ground acknowledgement message, then the ACARS MU will discard the message. The ACARS MU should not consider failure to deliver the ground acknowledgement message a communication failure.

3.8.4 Flow Control

For store and forward implementations the ACARS MU will regulate the flow of incoming data blocks in order to prevent one end system from consuming all of the available memory.

The ACARS MU should only open one downlink file for each end system. The end system should be prepared to buffer any additional downlink messages until the ACARS MU is ready. If an end system attempts to send another downlink message before the ACARS MU is ready, then the ACARS MU response to an RTS word is a CTS word containing the BUSY signal. The ACARS MU may accept other files, such as documentary data, even when it has a downlink message in its buffer.

3.8.5 Downlink Message Buffering

Two different buffering schemes have been implemented in ACARS MUs over the years. Originally all ACARS MUs used pass through buffering. More recent ACARS MU are capable of store and forward operation.

COMMENTARY

Downlink pass through buffering will result in a larger percentage of lost and incomplete messages. It is strongly recommended that store and forward be used.

3.8.5.1 Pass-Through Buffering

Pass through buffering means that the ACARS will downlink each block as soon as it is received from the end system. When pass through buffering is implemented then the ACARS MU should contain at least one buffer of sufficient size to accommodate a maximum size block. Additional buffers or larger buffers may be provided at manufacturer option.

When the block is successfully downlinked then the buffer is cleared. If the ACARS MU is unable to establish communications it will hold the undelivered message and respond "busy" to all block transfer requests until the block is delivered or cleared according to user defined requirements.

3.8.5.2 Store and Forward Buffering

Store and Forward buffering means that the ACARS MU will store all of the blocks of a message until it has received the last block before starting to downlink the message. When Store and Forward buffering is implemented then the ACARS MU should contain at least one buffer of sufficient size to accommodate the maximum file size. Additional buffers may be provided at manufacturer option.

When store and forward is implemented then the ACARS MU should buffer and hold a maximum of one and only one file per End System for downlink. When the file is successfully downlinked then the buffer is cleared. If the ACARS MU is unable to establish communications it will hold the undelivered file and respond "busy" to all file transfer requests from that end system until the file is delivered or cleared according to user defined requirements.

3.9 Documentary Data Function

Requests for, and transmission of, documentary data should always be responded to normally without regard to possible duplication. This will allow systems to send or request documentary data upon reinitialization after a power interrupt without the possibility of rejection due to the duplication of the initial block sequence character.

3.9.1 Documentary Data Request

An onboard avionic unit may request documentary data from the ACARS MU. The format of a documentary data request message is shown in Table 5-1 of Attachment 5 and consists of the Control/Accountability header and no additional data. The message Purpose/Nature code is set to D in order to indicate documentary data and the Destination code is set to 'M' for ACARS MU. A documentary data request message can be distinguished from a documentary data message by whether the ACARS MU is transmitting or receiving the message. If the ACARS MU is receiving the message then it is a documentary data request message. If the ACARS MU is transmitting the message then it is a documentary data message.

3.0 CHARACTER ORIENTED COMMUNICATIONS (cont'd)

3.9.2 Documentary Data Message Format

The ACARS MU will create and transmit a documentary data of the format specified herein when requested. The format for Version 1 of the standard documentary data message is shown in Table 5-2 of Attachment 5. Many existing systems use a different format because there was no standard format prior to this document.

4.0 PRINTERS

4.1 Introduction

This Chapter describes the interface to various printers for the three configurations of ACARS Management Units (MU) in service.

4.2 597/724 Dedicated Printer Protocol

ARINC Characteristic 597 provides for an interface to an optional ACARS printer that has only one input port and is dedicated to an ARINC 597 or 724 ACARS Management Unit (MU). This section defines the protocol which should be used by those Management Units when communicating with the ARINC 597/724 dedicated single-port printer. Information regarding the electrical interface between the MU and the printer can be found in Section 4.1.5.5 of ARINC Characteristic 597. Information regarding the physical characteristics of the printer can be found in Chapter 6 of ARINC Characteristic 597.

The interaction with the printer is different if the MU is operating in "pass-through" mode than it is if the MU is operating in "store and forward" mode. See Section 1.6 for a description of these modes. Some MUs may have the capability to operate in different modes for each connected system.

COMMENTARY

The printer control and operational characteristics for ARINC 597 and 724 dedicated printers described in Section 4.2.4 below apply to a installation in which the ACARS MU is operating in a "pass through" mode. Printer control and operation under "store and forward" mode operation will be provided in Section 4.2.5 in a future supplement.

4.2.1 Printer Status

The dedicated printer may have one or three status lines. Single-status printers provide only a ready/busy indication. Three-status printers provide an indication of eight different status conditions by setting status lines A, B and C as shown below.

Status Lines			Status Condition
A	B	C	
1	1	1	Printer Power Off
1	1	0	Error in Printer
1	0	1	Printer Busy
1	0	0	Printer in Local Test Mode
0	1	1	Printer Out of Paper
0	1	0	Printer Buffer Overrun
0	0	1	Printer Initialized
0	0	0	Printer Ready

4.2.1.1 Printer Off

A status of 1-1-1 will be indicated when the printer power is off or the printer is not installed or inoperative.

4.2.1.2 Error in Printer

A status of 1-1-0 will be indicated when the printer has detected an error in the transmission of the data from the MU. Errors may include parity or block check errors.

4.2.1.3 Printer Busy

A status of 1-0-1 will be indicated when the printer is busy. The printer will go busy after the start of the transmission of an individual character, and then return to ready when it has finished storing the character. If the character has triggered the printing of a single line or a buffer, the status will return to ready after the text has been printed.

4.2.1.4 Printer in Local/Test Mode

A status of 1-0-0 will be indicated when the printer is off-line or in test mode. The printer will return to ready when it goes back on line or completes the test.

4.2.1.5 Printer Out of Paper

If equipped with a paper sensor, a status of 0-1-1 will be indicated when the printer is out of paper.

4.2.1.6 Printer Buffer Overrun

A status of 0-1-0 will be indicated when the printer has received more data than it can hold in its buffer.

4.2.1.7 Printer Initialized

A status of 0-0-1 will be indicated when the printer is first powered up. This status is to be considered the same as ready when the MU wants to initiate a printout. This status is considered an error if it occurs during a transfer of data.

4.2.1.8 Printer Ready

A status of 0-0-0 will be indicated when the printer is on-line and ready to accept data.

4.2.2 Printer Data Transfers

When the MU has data to send to the printer, it must examine the printer status lines to determine the printer availability. If the printer is determined to be in the ready or initialized state, the MU will transfer one character at a time to the printer, pausing after each byte until the printer status indicates ready again. Each character is transmitted in a ten-bit word with start and stop bits as defined in ARINC Characteristic 597. Data to the printer must be sent in blocks of text no greater than 220 characters and must be preceded by the control character STX (0/2) and followed by ETX (0/3) or ETB (1/7). If the message is greater than 220 characters long, each block but the last must terminate with ETB. The last block of text must terminate with ETX.

4.2.2.1 Successful Printer Data Transfers

In order for a printer data transfer to be successful, the printer must begin in either ready (0-0-0) or initialized (0-0-1) state. Throughout the transfer, only the busy (1-0-1) and ready (0-0-0) states are valid. The MU must wait for the printer to complete its printing after each block of a multiblock printout.

4.0 PRINTERS (cont'd)**4.2.2.2 Unsuccessful Printer Data Transfers**

If the MU detects a printer status other than ready or busy throughout the transfer of the data, the transfer is considered unsuccessful. Repeated transmissions may be attempted as required.

4.2.3 Format Control

Most dedicated printers are capable of printing in 40-column, 66-column, or 80-column modes. The 80-column mode is printed sideways down the paper. In order to accommodate standard uplink printer message formats, the format control is determined by the content of the first two characters of the fourth line of text (following the third line feed). If the first four characters of the fourth line are a Dash (2/13) and Space (2/0), followed by two Slashes (2/15), then the printer will print in the 80-column side-writing mode. If the first character after the Dash and Space is a Slash but the next character is not, then the printer will print 66 characters per line. If the first character is not a Slash, then the printer will print 40 characters per line. In any case, the first three lines including the Format Control characters, will always appear in the printout as normal text.

4.2.4 Uplink Printer Messages Pass Through MU Operation

Uplink printer messages can contain the label characters C1 or any other label designated by the user for passing messages directly to the printer. They can be single block or multiblock messages. Multiblock messages are delivered to the printer one block at a time, as received. A store and forward type operation is not normally used in conjunction with this type of printer.

COMMENTARY

Users of airborne printers should be aware that unless formatted otherwise at the airline source, messages for the printer may be uplinked in a format reflecting the international standard line length of 69 characters. If this is not compatible with the line length of the printer, line feed occurrence in the middle of a word can be expected. If this is to be avoided, users formatting the messages prior to delivery to the Datalink Service Provider for uplink. It is only the users who have any knowledge of their printers' capabilities as the MU is insensitive to printer line length.

4.2.4.1 Uplink Response Determination

When a block of an uplink printer message is received, the MU should deliver, or attempt to deliver, the block to the printer before responding to the ground. If an uplink printer message is received at a time the printer is unable to accept data, the MU should respond with a downlink containing label characters Q5 or other reject messages, as specified below.

4.2.4.2 Uplink Message Transfers

The MU should deliver data to the printer only when the BCS check on the uplinked message shows it to be error-free and the printer status indicates the printer is ready to accept data. The MU should deliver only the text portion of the uplink block, starting with the STX character and ending with the ETX or ETB. However, some printers are designed to validate uplink blocks by recalculating and verifying the uplink block check sequence. When delivering an uplink message block to such a printer, the MU should send the entire transmission block, starting with the SOH character and terminating with the message suffix (ETX/ETB, Block Check Sequence, and DEL characters). This enables the printer to validate the message before printing. Only the text between the STX and ETX/ETB will be printed. If the BCS check fails, the printer status will indicate 1-1-0 instead of ready following the transfer of the final byte.

4.2.4.3 Incomplete Printer Messages

In multiblock message uplinks to the printer, receipt of the control character <ETB> by the printer will immobilize the print head until released by the MU with the next message block. If such a message should be broken for any reason, the aircrew should be advised that the printed material constitutes an incomplete message. In order to do this, the MU should, on receipt of each <ETB> character, start a 1.5 minute timer. If the next block is not received by the end of this time, it should close out the current message and deliver an "incomplete message" advisory to the printer consisting of the control character <STX>, the text of the advisory, and the control character <ETX>. The text content of the advisory will be negotiated between each printer user and his avionics supplier. An example advisory follows:

```
<STX> <CR> <LF> ***MESSAGEINCOMPLETE
***<ETX>
```

4.2.4.4 Successful Delivery to Printer

If the MU is successful in delivering the message block to the printer, it will then transmit an acknowledgement message to the ground as defined in ARINC Specification 618.

4.2.4.5 Unsuccessful Delivery to Printer

If an error occurs in the transmission of the message block to the printer, or the block check sequence validation fails, the printer will set the status lines to 1-1-0 (error in printer) at the completion of the transfer of the block. If for this, or any other reason, the MU is not successful in delivering the message block to the printer, the MU will then transmit the appropriate Printer Reject Message. If the printer does not provide the ABC status lines, the MU should transmit the Unable to Deliver message (Label Q5) to the ground. If the ABC status lines are provided, then the appropriate printer reject message (Label CA thru CF) should be sent, according to the error condition indicated by the status lines as shown in the table below. Refer to Section 3.7 in ARINC Specification 618.

4.0 PRINTERS (cont'd)

Status Lines			Reject Label
A	B	C	
1	1	1	Q5
1	1	0	CA
1	0	1	CB
1	0	0	CC
0	1	1	CD
0	1	0	CE
0	0	1	CF

4.2.5 Uplink Printer Messages Store and Forward MU Operation

This section is a placeholder for text to be added in a future supplement.

4.3 ARINC 740/744 Printer Interface

The protocols that may be used for communicating with a Multiple-Input Cockpit Printer (MICP) are specified in ARINC Characteristics 740, 744 and 744A.

4.3.1 Uplinks Message to ARINC 740/744 Printer

Uplinks printer messages can be single block or multiblock. The MU must be operating in the store and forward mode to process multiblock messages. The ACARS MU collects all blocks of a multiblock uplink before sending the message to the printer.

The maximum number of uplink blocks is 16 ACARS RF blocks as defined in ARINC Specification 618.

4.3.1.1 Uplink Response Determination

When the ACARS MU receives an uplink to be printed, then the ACARS MU should generate a downlink response indicating its ability to process the individual blocks per ARINC Specification 618.

4.3.1.1.1 Incomplete Printer Message

If the Message Assembly timer defined in ARINC Specification 618 expires, then the printer uplink message is classified as incomplete and the ACARS MU should perform the following:

- a. Print the partial message received thus far.
- b. Treat the next printer uplink block as the first block of a new message.

4.3.1.2 Attempt Delivery to Printer

When the ACARS MU has a complete message, identified by receipt of the final (ETX) block, then the ACARS MU will attempt to deliver the message to the printer. The following subsections describe the possible conclusion of this process.

4.3.1.2.1 Delivery Successful

If the ACARS MU successfully delivers the message to the printer, then it may discard its internal copy of the message based on user requirements.

4.3.1.2.2 Delivery Unsuccessful

If the ACARS MU is not successful in delivering the message to the printer then the ACARS MU should respond per ARINC Specification 618. The ACARS MU may make additional attempts to deliver the message to the same printer or attempt to deliver the message to an alternate display device(s).

4.3.2 NON Uplink Printer Messages

The ACARS MU may have the capability of generating printer messages from its own internal data. Furthermore, the ACARS MU may be programmed to accept printer messages from other end systems on the aircraft. When an end system routes a message to the printer via the ACARS MU then the destination code in the message should be set to 'P'.

When the ACARS MU is routing a message received from another end system to the printer then the Control/Accountability header(s) used to deliver the message to the ACARS MU should be removed by the ACARS MU before passing the message on to the printer. The ACARS MU should collect and store all of the blocks or LDUs (see Chapter 4) of the message before passing the message on to the printer. The message should be reblocked by the ACARS MU if the blocks or LDUs received by the ACARS MU are not compatible with the printer protocol as specified in ARINC Characteristics 740 and 744. The message originator should format the message for printing.

5.0 GENERAL BIT-ORIENTED COMMUNICATIONS PROTOCOL

5.1 Data Transfer System

The protocols defined in this chapter are intended to accommodate data transfer between the ACARS MU and other onboard End Systems such as the FMC, ACMS, SDU and Cabin Terminals using a Link layer protocol compatible with binary data. The protocol definition is patterned after the OSI model.

The interaction of the ACARS MU and an End System (ES) is illustrated in Figure 9-1 of Attachment 9. As seen in this diagram, the ACARS MU/ES interface concerns itself with the lower three layers of the OSI model, i.e., Physical, Link, and Network. These layer descriptions and assignments are given in the following sections.

5.2 Physical Medium

The physical interface is described in ARINC Specification 429, "Mark 33 Digital Information Transfer System (DITS)". The definition includes connection via a two wire twisted shielded pair. Outgoing traffic is carried on a different wire pair than incoming traffic.

5.3 Physical Layer

The Physical Layer provides the functions necessary to activate, maintain and release the physical link which will carry the bit stream of the communication. The electrical interface, voltage, timing, etc. described in ARINC Specification 429 is used by the ACARS MU when interfacing with the other onboard avionics systems.

5.3.1 Bit Rate

ARINC Specification 429 provides for data transfer at two rates. Unless specified otherwise, the interface should operate at "Low Speed" as defined in ARINC Specification 429.

5.3.2 Word Timing

Word timing is as specified in ARINC Specification 429.

5.4 Link Layer

The link layer is responsible for transferring information from one logical network entity to another and for annunciating any errors encountered during transmission. The Data Link Layer provides a virtual channel and some flow control mechanisms.

At the Link Layer, data is transferred using a data transparent bit-oriented data file transfer protocol designed to permit the source to send and the sink to receive information in multiple word packets. It is structured to allow the transmission of any binary data organized into a data file composed of octets.

The procedure for protocol determination is described in ARINC Specification 429 starting with supplement 12 in Section 2.5, Bit Oriented File Transfer Protocol. The bit oriented protocol definition is commonly referred to as the "Williamsburg" protocol. There are several versions of the 429 bit oriented protocol. Each LRU should perform 429 bit oriented protocol determination as specified in ARINC Specification 429.

5.5 Network Layer

The Network layer functions require knowledge regarding the format of the Network header and data packets received from the link layer. The bit oriented protocol contains a field called the General Format Identifier (GFI) in the Start of Text (SOT) word so that the format of each packet can be explicitly identified. ARINC Specification 429 contains a table listing all of the GFI values that have been allocated. ARINC Specification 429 does not define the Network layer functions, it defines only the Link layer functions. ARINC Specification 429 has precedence if there are any discrepancies between ARINC Specification 429 and this document. The formats which are defined in this document are listed in Table 5.5-1.

Table 5.5-1 General Format Identifier Table

<u>GFI</u>	<u>Title</u>
0011	General Purpose Bit Oriented Protocol (GPBOP)

The sink will determine the Network Header for data encoding schemes by examining the GFI field of the SOT word. Refer to ARINC Specification 618 for the definition of GFI '1110'.

5.5.1 GPBOP 'GFI 0011' File Format

The GFI '0011' file format supports both single and multiple LDU files. The first LDU of every file contains a Control/Accountability header. The other LDUs in a multiple LDU file do not contain Control/Accountability headers. The smallest file that can be sent consists only of a Control/Accountability header. Example files in GPBOP format are provided in Attachments 7 and 8.

In some applications an end to end integrity check is desirable in order to validate the correct transfer of a data file from the message originator to the its final destination. For further information the reader should refer to the applicable ARINC Equipment Characteristic, such as ARINC Characteristic 702, "Flight Management Computer System".

5.5.1.1 GPBOP Control/Accountability Header

The format of the Control/Accountability header for GFI of '0011' is shown in Table 5.5.1-1.

Table 5.5.1.1-1 GFI 0011 Control Accountability Header

<u>Character No.</u>	<u>Character Content</u>
1	Origin Code
2	Message Purpose/Nature Code
3	Destination Code
4	Reserved (binary zero)
5	Reserved (binary zero)

5.5.1.1.1 Origin Code

The Origin code should be set to indicate the origin of the message. See Attachment 3.

5.0 GENERAL BIT-ORIENTED COMMUNICATIONS PROTOCOL (cont'd)**5.5.1.1.2 Message Purpose/Nature Code**

The message Purpose/Nature code indicates the message type. The source should set message Purpose/Nature code to indicate the message type.

If the sink is not the final destination as specified in the Control/Accountability header then it will ignore the message Purpose/Nature code.

If the sink is also the destination then the Purpose/Nature code indicates what data is being requested or delivered.

The message Purpose/Nature codes are defined in Attachment 4.

5.5.1.1.3 Destination Code

The Destination code should be set to indicate the end system to which the message should be delivered. See Attachment 3.

5.5.1.1.4 Reserved Fields

The 2 reserved fields are reserved for future use and should contain binary zeros until a use is defined for them.

5.5.1.2 Format of Data in Octets

Before binary data can be transmitted over this link it should be converted into the ISO #5 characters. The standard method of converting binary data is called bit-to-hex (ISO 5) encoding. Each octet of binary data is divided into 2 four-bit nibbles. Each nibble is encoded into a seven-bit character field using its equivalent ISO #5 hexadecimal character. The value of each character, which will fall within the numeric range 0 through 9 or the alpha range A through F, is encoded for transmission per the ISO Alphabet #5 convention in the manner described above for free text.

Data should be encoded such that only the subset of ISO Alphabet #5 characters identified in ARINC Specification 618 are transmitted across the air-ground data link. The ISO #5 character sets are reproduced in Attachment 1 of this specification for the reader's convenience.

Clear text messages should be coded per the ISO Alphabet #5 subset set forth in Attachment 1 to this document. Seven bits per character should be used, i.e., an eighth parity bit should not be added. Instead, a pad bit should be used to complete the octet. Two and one half such characters will occupy the bit-oriented information field of each ARINC 429 32-bit word.

COMMENTARY

Most ACARS MUs, air-ground-air links and some of the ground communications links connecting users' data sources/sinks to the ACARS controlling processor are capable of handling the full ISO Alphabet #5 code set. However, some ground links may not have this capability. Therefore, the restricted code set specified for the character-only environment have been retained in this definition to

ensure that all messages originating in a ground-based computer for delivery via ACARS to an airborne computer, and vice versa, are transparent to all ground communications links through which they might pass.

5.5.1.3 Uplinks to End Systems (GFI '0011')

The ACARS MU will gather all blocks of a file before attempting to deliver it using the bit oriented Link-layer protocol.

The ACARS MU will combine the data from all of the uplink blocks that constitute a message and divide the data into link data units (LDU) so that the number of LDUs is minimized.

LDUs do not have to be completely filled.

An octet (data byte) will not be split across a LDU boundary.

The ACARS MU will transfer the text field of the uplink message, removing the characters preceding and including the sublabel, to the text portion of the 429 bit file.

The ACARS MU will add the Control/Accountability header specified by GFI '0011' to the beginning of the text field of the first LDU.

5.5.1.3.1 Routing Uplinks

Routing of uplinks is the same as Section 3.5.2.1 except as delineated below.

In a store and forward implementation, that when a file transfer of an uplink with sublabel MD is in progress and a master/slave change is detected, then the MU should restart the file transfer with the new master.

If the ACARS MU detects a Master/Slave swap, while in the process of transmitting a file to the "master" end system and the sublabel is M1 or M2, then the ACARS MU will ignore the Master/Slave swap and continue to try to deliver the file as directed by the Sublabel.

5.5.1.3.2 Uplink Flow Control

If the previous file transfer has been completed then the ACARS MU will accept and acknowledge the UPLINK blocks. If the ACARS MU has not delivered the previous file then it will generate a Q5 downlink and reject the block.

A label HX downlink should be sent when the ACARS MU has all ready ACKed all of the uplink blocks and then was unsuccessful at delivering the message. The undelivered message should be discarded.

5.5.1.3.3 Translation of an Uplink Message to a GPBOP Message

The end system does not need logic to skip over the service provider header, because it is removed from uplinks by the ACARS MU. The ACARS MU will strip out (remove) the dash (-), space (), pound sign (#) and

5.0 GENERAL BIT-ORIENTED COMMUNICATIONS PROTOCOL (cont'd)**5.5.1.3.3 Translation of an Uplink Message to a GPBOP Message (cont'd)**

sub-label from each block, including the first. All blocks are then combined to create a full message to the end system. The ACARS MU will add an five octet header containing: the Origin code, Purpose code, destination code and two reserved octets, set to zero, to the front of the message. The ACARS MU will transmit this message to the end system, employing the bit oriented protocol, breaking the message into LDU's if necessary.

The header information is still considered to be a part of the data over which the ARINC 429 Link Layer CRC is computed. The link layer CRC value is found in the EOT word. If there is an end-to-end CRC then the header is not protected by the end-to-end CRC because the header is not part of the application message.

5.5.1.4 Downlinks From End Systems (GFI '0011')

The requirements specified in the following sections should be implemented in the End systems and the ACARS MU in order to downlink a message from the end system.

Downlinks will employ the same convention as uplinks. The sequence number, the flight number and the sub-label are not included inside the message. The ACARS MU must add them (the sequence number, the flight number and the sub-label) prior to downlinking the message on VHF.

If the end system wants to add an address(es), then the address(es) should be preceded by a slash and terminated by a period. If multiple addresses are added, spaces are used as delimiters to separate the addresses. The slash should be the first character following the five-character accountability header. The address (including the slash and the period) are not protected by the end-to-end CRC, if present; neither is the five character accountability header.

5.5.1.4.1 GPBOP File Size

The maximum file size delivered to the sink should not exceed 3296 characters. Sources should not create files larger than 3301 characters, including the Control/Accountability header.

COMMENTARY

Maximum file size was determined from 16 ACARS blocks X 206 characters/block + 5 Control/Accountability header characters per file = 3301.

If a file exceeds the maximum character limit, then the ACARS MU should not send a SYN word because that would cause the source to transmit the same file again. The ACARS MU may generate a status message per Figure 8-2 of Attachment 8 (status code = 'O') to be sent back to the originator. The ACARS should truncate the message to 3301 characters, add an <ETX> character and then downlink the modified message.

The ACARS MU should route the entire file to the destination specified by the destination field of the RTS word. The destination field of the Control/Accountability field in the first LDU should contain the same value as the RTS word. If the destination fields contain different values then the value in the RTS word should be used.

5.5.1.4.1.1 GPBOP Control/Accountability Header

Format of the control/accountability header specified by GFI '0011' is defined in paragraph 5.5.1.1.

5.5.1.4.1.2 Origin Code

The end system should set the Origin code to the value assigned to it.

The Origin codes are defined in Attachment 3.

5.5.1.4.1.3 Message Purpose/Nature Code

The End System should set the Message Purpose/Nature code to indicate that this is a downlink message.

The Message Purpose/Nature codes are defined in Attachment 4.

5.5.1.4.1.4 Destination Code

The end system should set the destination code to indicate the desired routing of the message. The destination code in the Control/Accountability header should be the same as the destination code in the RTS word.

5.5.1.4.1.5 Air/Ground Downlink Message Format

The ACARS MU will collect all LDUs before attempting to downlink the file.

The ACARS MU will remove the five character Control/Accountability header from the first LDU and append the data from the remaining LDUs. Then the ACARS MU should partition the data into the minimum number of 206 character, or smaller, blocks as required by ARINC Specification 618.

The ACARS MU adds the downlink Message Sequence Number (Downlink Message Sequence Number is computed per ARINC Specification 618), Flight Number and Sublabel field, to the beginning of the Text field of each ACARS block.

The Sublabel field is a four character field composed of the Poundsign '#', the two character Sublabel and the character 'B'. The Sublabel code indicates the origin of the message. Appendix C of ARINC Specification 620 contains the sublabels assigned to the various end systems. (The MD Sublabel is not used in Label H1 downlinks.)

COMMENTARY

The character 'B' was used in previous formats and has been retained to promote interoperability with older units.

5.0 GENERAL BIT-ORIENTED COMMUNICATIONS PROTOCOL (cont'd)**5.5.1.4.2 Ground Acknowledgement Message**

The ACARS MU should send a Ground Acknowledgement message to an End System when the last block of a file it generated is successfully downlinked to the ground.

For dual End System configurations, the ACARS MU will route the ground acknowledgement file to the designated "Master" End System.

COMMENTARY

In a dual end system configuration a "Master/Slave" swap may occur while the ACARS MU is downlinking the file to the ground. In this scenario, the ACARS MU will send the Ground Acknowledgement to the new master end system.

The Ground Acknowledge file consists of a Control/Accountability header, with the origin set to the value of the ACARS MU and the message Purpose/Nature field with the code set to Acknowledge, followed by the File Sequence Number. See Figure 8-1 of Attachment 8 for a pictorial illustration of the coding of the Ground ACK Message.

The File Sequence Number can have a binary value between 0 and 255, therefore it is an exception to the GPBOP format.

5.5.1.5 Documentary Data Function

Requests for, and transmission of, documentary data should always be responded to normally without regard to possible duplication. This will allow systems to send or request documentary data upon reinitialization after a power interrupt without the possibility of rejection due to the duplication of the block file sequence number.

5.5.1.5.1 Documentary Data Request

An onboard avionic unit may request documentary data from the ACARS MU. The format of a GPBOP (GFI '0011') Documentary Data Request message is shown in Table 5-3 of Attachment 5 and consists of the Control/Accountability header and no additional data.

The message Purpose/Nature code is set to 'D' in order to indicate documentary data and the destination code is set to M for ACARS MU.

A Documentary Data Request message can be distinguished from a documentary data message by whether the ACARS MU is transmitting or receiving the message. If the ACARS MU is receiving the message then it is a Documentary Data Request message. If the ACARS MU is transmitting the message then it is a Documentary Data message. See Table 5-3 for the format of GPBOP (GFI '0011') Documentary Data Request message.

5.5.1.5.2 Documentary Data Message Format

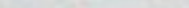
The ACARS MU will create and transmit a GPBOP (GFI '0011') Documentary Data message when a Documentary Data request is received. See Table 5-4 of Attachment 5 for the format of GPBOP Documentary Data response message.

$$\begin{array}{cccccccccccccccccccc} & b_7 & 0 & & 0 & & 0 & & 0 & & 1 & & 1 & & 1 & & 1 \\ & b_6 & & 0 & & 0 & & 1 & & 1 & & 0 & & 0 & & 1 & & 1 \\ b_4 \ b_3 \ b_2 \ b_1 & b_5 & & 0 & & 1 & & 0 & & 1 & & 0 & & 1 & & 0 & & 1 \end{array}$$

0 0 0 0	NUL	DLE	20 SP	30 0	40 @	50 P	60 >	70 D
0 0 0 1	SOH	DC1	21 !	31 1	41 A	51 Q	61 a	71 q
0 0 1 0	STX	DC2	22 "	32 2	42 B	52 R	62 b	72 r
0 0 1 1	ETX	DC3	23 #	33 3	43 C	53 S	63 c	73 s
0 1 0 0	EOT	DC4	24 \$	34 4	44 D	54 T	64 d	74 t
0 1 0 1	ENQ	NAK	25 %	35 5	45 E	55 U	65 e	75 u
0 1 1 0	ACK	SYN	26 &	36 6	46 F	56 V	66 f	76 v
0 1 1 1	BEL	ETB	27 '	37 7	47 G	57 W	67 g	77 w
1 0 0 0	BS	CAN	28 (	38 8	48 H	58 X	68 h	78 x
1 0 0 1	HT	EM	29)	39 9	49 I	59 Y	69 i	79 y
1 0 1 0	LF	SUB	2A *	3A :	4A J	5A Z	6A j	7A z
1 0 1 1	VT	ESC	2B +	3B ;	4B K	5B [	6B k	7B {
1 1 0 0	FF	FS	2C ,	3C <	4C L	5C \	6C l	7C
1 1 0 1	CR	GS	2D -	3D =	4D M	5D]	6D m	7D }
1 1 1 0	SO	RS	2E .	3E >	4E N	5E ^	6E n	7E ~
1 1 1 1	SI	US	2F /	3F ?	4F O	5F _	6F o	7F DEL

Character

04	EOT
----	-----

 Character not allowed in Uplink or Downlink Messages.

¹Refer to ARINC Characteristic 597 for special uses of these characters.

NOTE: The ACARS Subcommittee is attempting to expand the range of air/ground message content to the characters available in Table 1-2.

ATTACHMENT 1 (cont'd)
ASCII CHARACTERS

Table 1-2 ACARS Ground/Ground Subset ASCII (ISO #5) Encoding

	b ₇	0	0	0	0	1	1	1	1	1				
	b ₆	0	0	1	1	0	0	1	1	1				
b ₄ b ₃ b ₂ b ₁	b ₅	0	1	0	1	0	1	0	1	0	1			
0 0 0 0	NUL	DLE	20	SP	30	0	40	@	50	P	60	-	70	p
0 0 0 1	SOH	DC1	21	!	31	1	41	A	51	Q	61	a	71	q
0 0 1 0	STX	DC2	22	"	32	2	42	B	52	R	62	b	72	r
0 0 1 1	ETX	DC3	23	# ¹	33	3	43	C	53	S	63	c	73	s
0 1 0 0	EOT	DC4	24	\$	34	4	44	D	54	T	64	d	74	t
0 1 0 1	ENQ	NAK	25	%	35	5	45	E	55	U	65	e	75	u
0 1 1 0	ACK	SYN	26	&	36	6	46	F	56	V	66	f	76	v
0 1 1 1	BEL	ETB	27	'	37	7	47	G	57	W	67	g	77	w
1 0 0 0	BS	CAN	28	(	38	8	48	H	58	X	68	h	78	x
1 0 0 1	HT	EM	29	)	39	9	49	I	59	Y	69	i	79	y
1 0 1 0	LF	SUB	2A	*	3A	:	4A	J	5A	Z	6A	j	7A	z
1 0 1 1	VT	ESC	2B	+	3B	;	4B	K	5B	[	6B	k	7B	{
1 1 0 0	FF	FS	2C	,	3C	<	4C	L	5C	\	6C	l	7C	
1 1 0 1	CR	GS	2D	-	3D	=	4D	M	5D	]	6D	m	7D	}
1 1 1 0	SO	RS	2E	.	3E	>	4E	N	5E	^	6E	n	7E	~
1 1 1 1	SI	US	2F	/ ¹	3F	?	4F	O	5F	_	6F	o	7F	DEL

Hex value

Character

04
EOT

 Character not allowed in Uplink or Downlink Messages.

¹Refer to ARINC Characteristic 597 for special uses of these characters.

NOTE: In case of any difference, the table in ARINC Specification 618 has precedence over the table shown above.

ATTACHMENT 2
MASTER FMC SELECTION LOGIC

Table 2-1 Master FMC Selection Logic

FMC1 Status	FMC2 Status	Discrete Status	Master FMC
inactive status word	inactive status word	Open	FMC1
inactive status word	inactive status word	Ground	FMC2
bit 17 = 1	inactive status word	don't care	FMC1
bit 17 = 0	inactive status word	don't care	default to FMC1 abnormal condition
inactive status word	bit 17 = 1	don't care	FMC2
inactive status word	bit 17 = 0	don't care	default to FMC2 abnormal condition
bit 17 = 1	bit 17 = 0	don't care	FMC1
bit 17 = 0	bit 17 = 1	don't care	FMC2
bit 17 = 1	bit 17 = 1	don't care	default to FMC1 abnormal condition
bit 17 = 0	bit 17 = 0	don't care	default to FMC1 abnormal condition

Note: FMC1 is the Left FMC
FMC2 is the Right FMC

ATTACHMENT 2 (cont'd)
MASTER FMC SELECTION LOGIC

Table 2-2 FMC STATUS WORD (From FMC to MU)

3 2	3 3 1 0	2 2 2 2 2 2 2 2 2 1 1 9 8 7 6 5 4 3 2 1 0 9 8	1 7	1 1 1 1 1 1 1 6 5 4 3 2 1 0 9	8 7 6 5 4 3 2 1
P	SSM	STATUS DATA	MASTER/ SLAVE	SOURCE SAL	LABEL

BIT	FUNCTION	LEFT FMC CODING		RIGHT FMC CODING	
1	Label	2	1	2	1
2			0		0
3		7	1	7	1
4			1		1
5			1		1
6		0	0	0	0
7			0		0
8			0		0
9	Source SAL	3	0	3	0
10			0		0
11		0	0	0	0
12			0		0
13			0		0
14		0	0	1	0
15			0		0
16			0		1
17	Master/Slave	0 = Slave FMC 1 = Master FMC		0 = Slave FMC 1 = Master FMC	
18 thru 29	Spare	Pad		Pad	
30	SSM	See Note 1		See Note 1	
31					
32	Parity	Odd		Odd	

ATTACHMENT 2 (cont'd)
MASTER FMC SELECTION LOGIC

① SSM Coding:

BIT		STATUS	COMMENT
31	30		
0	0	Normal Operation	Necessary for M/S determination in Bit 17
0	1	No Computed Data	
1	0	Functional Test	
1	1	Failure	

ATTACHMENT 3
ORIGIN/DESTINATION CODES

Table 3-1 Origin/Destination Codes

ORIGIN OR DESTINATION	CODE	NOTE
Cabin Terminal (1-4) User Terminal (5-8)	1-4 5-8	
Control/Display Unit	C	
CFDIU	F	
EICAS/ECAM/EFIS	I	
FMC, Left Side	A	
FMC, Right Side	B	
DFDAU	D	
XPDR (ASAS/DABS)	T	
Ground Station	G	
Optional Auxiliary Terminal (OAT)	O	
Printer	P	
VHF Link	V	
ACARS Management Unit (MU)	M	
HF Link	H	
Keyboard/Display	K	
Satellite Data Unit (SDU)	S	
Automatic Dependent Surveillance Unit (ADSU)	J	

NOTE: The onboard message handling and accountability code assignments defined in this Attachment reflect the needs of ACARS applications identified so far. Additional assignments will be made as new applications arise. Please advise the AEEC staff of any new needs so that appropriate action may be taken.

ATTACHMENT 4
PURPOSE/NATURE CODES

Table 4-1 Message Purpose/Nature Codes

PURPOSE/NATURE	CODE	NOTES
Flight Number	A	
Aircraft Registration	B	
Uplink	V	
Downlink	W	
DABS/ASAS Uplink	T	
Not a Response	N	
Acknowledgement	K	
Busy	Q	
Documentation Data	D	
Engine Data	E	
Failed Message	F	
HF Downlink "NOCOMM"	Z	
Data Bus Check	C	
Fuel Data	G	
Landing Data	L	
Position Report	P	
User Defined	X	
Status Message	S	

NOTE: The onboard message handling and accountability code assignments defined in this Attachment reflect the needs of ACARS applications identified so far. Additional assignments will be made as new applications arise. Please advise the AEEC staff of any new needs so that appropriate action may be taken.

ATTACHMENT 5
DOCUMENTARY DATA FORMATS

Table 5-1 ARINC 429 File Transfer Documentary Data Request Message

<u>Character</u>	<u>Content</u>	<u>Description</u>
1	<US>	Unit Separator character
2	X	Origin Code
3	'D'	Message Purpose/Nature Code
4	'M'	Destination Code
5	X	Block Sequence Character

Table 5-2 ARINC 429 File Transfer Documentary Data Message Format

<u>Character</u>	<u>Content</u>	<u>Description</u>
1	<US>	Unit Separator character
2	'M'	Origin Code
3	'D'	Message Purpose/Nature Code
4	X	Destination Code
5	X	Block Sequence Character
6	'+'	(unique ID)
7	A	Version Identifier, e.g. '1'
8-9	ZZ	Airline Identifier See ARINC Specification 618
10-13	ZZZZ	Flight Number See ARINC Specification 618
14-17	XXXX	Departure Station (IATA or ICAO)
18-21	XXXX	Destination Station (IATA or ICAO)
22-25	NNNN	Fuel on Board, units not specified
26-30	NNNNN	Boarded Fuel, units not specified
31-36	YYMMDD	Scheduled date of flight Y represents 2 least significant digits of year {94,95,96...} M represents month {01,02,03...12} D represents day {01,02,03...31}
37-42	YYMMDD	Actual date of flight (same as above)
43-48	HHMMSS	Time {211234} where: H=hours, M=minutes and S=seconds
49-55	ZZZZZZZ	Aircraft Registration See ARINC Specification 618
56	N	OOOI state {1,2,3,4} where: 1 represents OUT, 2 represents OFF, 3 represents ON and 4 represents IN

Where:

- A alphanumeric character, left justified and space filled.
- N numeric characters, right justified and zero filled.
For example: a value of 93 in a NNNN field would be '0093'.
- X alpha characters only, left justified and space filled.
For example: a value of XY in a XXXX field would be 'XY '.
- Z see Section 2.2.3 of ARINC Specification 618 for format.

ATTACHMENT 5 (cont'd)
DOCUMENTARY DATA FORMATS

Table 5-3 GPBOP (GFI 0011) Documentary Data Request Message Format

<u>Character</u>	<u>Content</u>	<u>Description</u>
1	X	Origin Code
2	D	Message Purpose/Nature Code
3	M	Destination Code
4-5	00	Reserved

Table 5-3 GPBOP (GFI 0011) Documentary Data Message Format

<u>Character</u>	<u>Content</u>	<u>Description</u>
1	'M'	Origin Code
2	'D'	Message Purpose/Nature Code
3	X	Destination Code
4-5	00	Reserved
6	'+'	(unique ID)
7	A	Version Identifier, e.g. '1'
8-9	ZZ	Airline Identifier See ARINC Specification 618
10-13	ZZZZ	Flight Number See ARINC Specification 618
14-17	XXXX	Departure Station (IATA or ICAO)
18-21	XXXX	Destination Station (IATA or ICAO)
22-25	NNNN	Fuel on Board, units not specified
26-30	NNNNN	Boarded Fuel, units not specified
31-36	YYMMDD	Scheduled date of flight Y represents 2 least significant digits of year {94,95,96...} M represents month {01,02,03...12} D represents day {01,02,03...31}
37-42	YYMMDD	Actual date of flight (same as above)
43-48	HHMMSS	Time {211234} where: H=hours, M=minutes and S=seconds
49-55	ZZZZZZZ	Aircraft Registration See ARINC Specification 618
56	N	OOOI state {1,2,3,4} where: 1 represents OUT, 2 represents OFF, 3 represents ON and 4 represents IN

Where:

- A alphanumeric character, left justified and space filled.
- N numeric characters, right justified and zero filled.
For example: a value of 93 in a NNNN field would be '0093'.
- X alpha characters only, left justified and space filled.
For example: a value of XY in a XXXX field would be 'XY '.
- Z see Section 2.2.3 of ARINC Specification 618 for format.

ATTACHMENT 6
CHARACTER FILE TRANSFER MESSAGE FORMATS

The following is an example of a single block downlink message from an FMC to an MU. (P = Pad bit)

STX	BLOCK SEQUENCE NUMBER = 1	BLOCK WORD COUNT = 13	DATA WORD LABEL
P0000010	P0000001	P0001101	11110111
Purpose/Nature VHF Downlink = W	Origin Code Left FMC = A	<US>	357
P1010111	P1000001	P0011111	11110111
Downlink Message Sequence Code = F	Block Sequence Character = 40 H	Destination VHF Link = V	357
P1000110	P1000000	P1010110	11110111
ONE 1	ZERO 0	ZERO 0	357
P0110001	P0110000	P0110000	11110111
Flight Number 0	Flight Number A	Flight Number A	357
P0110000	P1000001	P1000001	11110111
Flight Number 5	Flight Number 6	Flight Number 4	357
P0110101	P0110110	P0110100	11110111
Sublabel Character #2 1	Sublabel Character #1 M	Poundsign #	357
P0110001	P1001101	P0100011	11110111
PLAN P	FLIGHT F	MESSAGE TYPE A	357
P1010000	P1000110	P1000001	11110111
COMPANY C	SEPARATOR /	REQUEST R	357
P1000011	P0101111	P1010010	11110111
L	K	ROUTE R	357
P1001100	P1001011	P1010010	11110111
K	X	A	357
P1001011	P1011000	P1000001	11110111
X	H	P	357
P1011000	P1001000	P1010000	11110111
ETX	sp	sp	357
P0000011	P0100000	P0100000	11110111

Figure 6-1 Character File Format

ATTACHMENT 6 (cont'd)
CHARACTER FILE TRANSFER MESSAGE FORMATS

The following is an example of a single block uplink message from an MU to an FMC. (P = Pad bit)

STX	BLOCK SEQUENCE NUMBER = 1	BLOCK WORD COUNT = 10	DATA WORD LABEL
P 0 0 0 0 0 1 0	P 0 0 0 0 0 0 1	P 0 0 0 1 0 1 0	1 1 1 1 0 1 1 1
Purpose/Nature VHF Uplink = V	Origin Code VHF Link = V	<US>	357
P 1 0 1 0 1 1 0	P 1 0 1 0 1 1 0	P 0 0 1 1 1 1 1	1 1 1 1 0 1 1 1
First Character of Preamble = -	Block Sequence Character = 40 H	Destination Code Left FMC = A	357
P 0 1 0 1 1 0 1	P 1 0 0 0 0 0 0	P 1 0 0 0 0 0 1	1 1 1 1 0 1 1 1
Sublabel Character #1 M	Poundsign #	sp	357
P 1 0 0 1 1 0 1	P 0 1 0 0 0 1 1	P 0 1 0 0 0 0 0	1 1 1 1 0 1 1 1
Wind W	Predicted P	Sublabel Character #2 1	357
P 1 0 1 0 1 1 1	P 1 0 1 0 0 0 0	P 0 1 1 0 0 0 1	1 1 1 1 0 1 1 1
Descent D	SEPARATOR /	Data D	357
P 1 0 0 0 1 0 0	P 0 1 0 1 1 1 1	P 1 0 0 0 1 0 0	1 1 1 1 0 1 1 1
Nine 9	Flight Level Two 2	Winds W	357
P 0 1 1 1 0 0 1	P 0 1 1 0 0 1 0	P 1 0 1 0 1 1 1	1 1 1 1 0 1 1 1
Seventy 7	From One Hundred 1	Zero 0	357
P 0 1 1 0 1 1 1	P 0 1 1 0 0 0 1	P 0 1 1 0 0 0 0	1 1 1 1 0 1 1 1
Sixty 6	Magnitude Zero 0	Five Degrees True 5	357
P 0 1 1 0 1 1 0	P 0 1 1 0 0 0 0	P 0 1 1 0 1 0 1	1 1 1 1 0 1 1 1
<NUL>	<ETX>	Two Knots 2	357
P 0 0 0 0 0 0 0	P 0 0 0 0 0 1 1	P 0 1 1 0 0 1 0	1 1 1 1 0 1 1 1

Figure 6-2 Character File Format

Note 1: The range of data characters is limited to those identified in ARINC Specification 618 and reproduced here as Table 1-1 of Attachment 1.

ATTACHMENT 7
GPBOP MESSAGE FORMATS

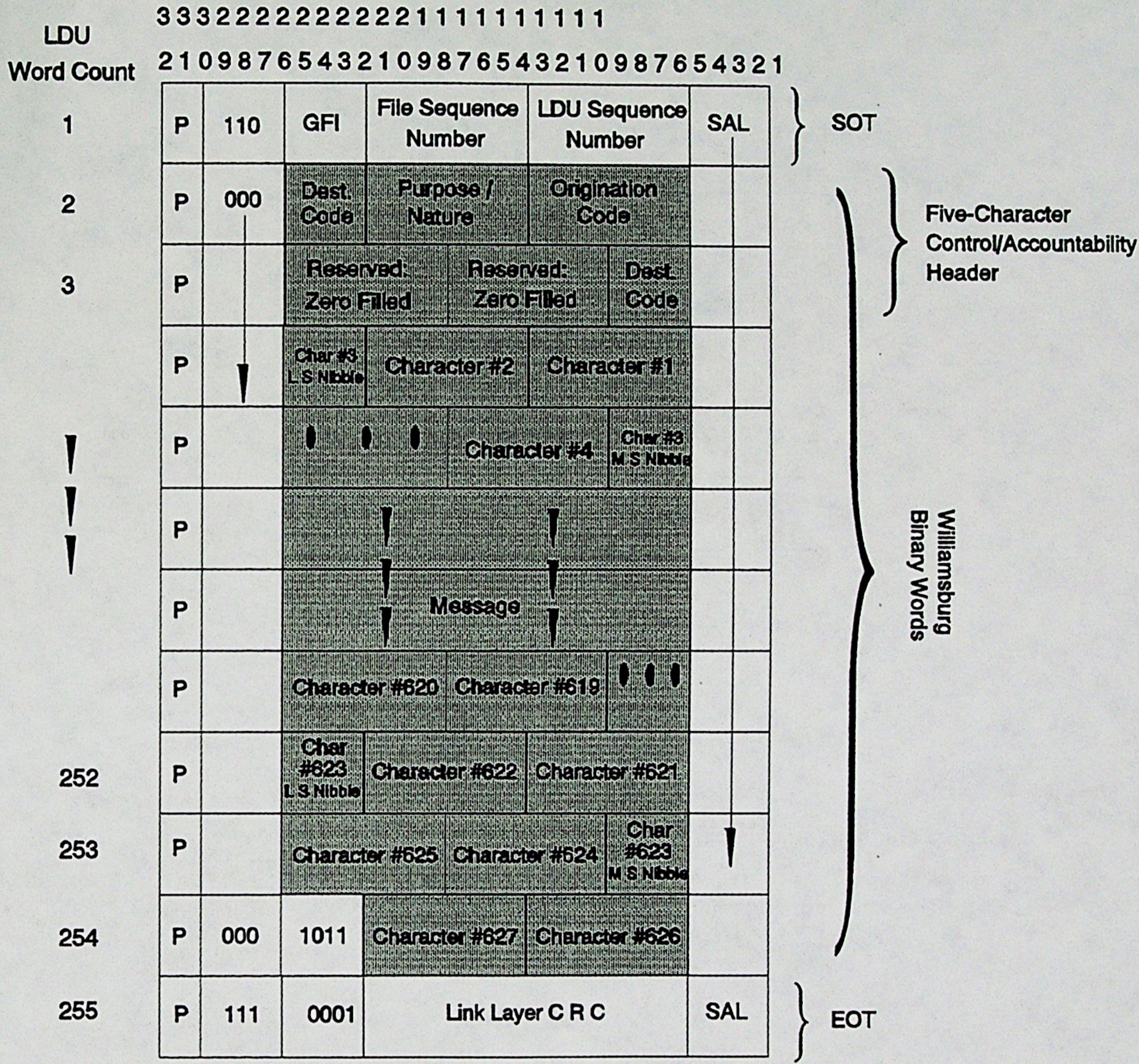


Figure 7-1 GPBOP File Format

Note 1: The range of data characters is limited to those identified in ARINC Specification 618 and reproduced here as Table 1-X of Attachment 1.

Note 2: The Link Layer CRC will be computed over the shaded area.

ATTACHMENT 8
FORMAT OF WILLIAMSBURG SERVICE MESSAGES

When the MU has confirmed that the message has been successfully received by the DSP on the ground, the MU should send a report to the End System using the following format:

LDU		3332222222221111111111										
Word Count		21098765432109876543210987654321										
1	P	110	GFI	File Sequence #26		LDU Sequence #0		SAL		Williamsburg Binary Words		
2	P	000	Dest. Code	Purpose / Nature		Origination Code						
3	P	000	Reserved: Zero Filled		Reserved: Zero Filled		Dest. Code					
4	P	001	1001	0000	0000	File Sequence #						
5	P	111	0001	Link Layer C R C				SAL		EOT		

Figure 8-1 Ground ACK Report from MU to End System

Note 1: The Link Layer CRC will be computed over the shaded area.

Note 2: The Origin Code will be M. The Purpose/Nature code will be K (ACK) and the Destination Code will be set to that of the downlink originator (see Attachment 3). The File Sequence # will reflect the FSN of the Williamsburg file as it was received by the ACARS MU.

ATTACHMENT 8 (cont'd)
FORMAT OF WILLIAMSBURG SERVICE MESSAGES

When the MU has determined that the message cannot be forwarded to the DSP on the ground, the MU may send a report to the End System using the following format:

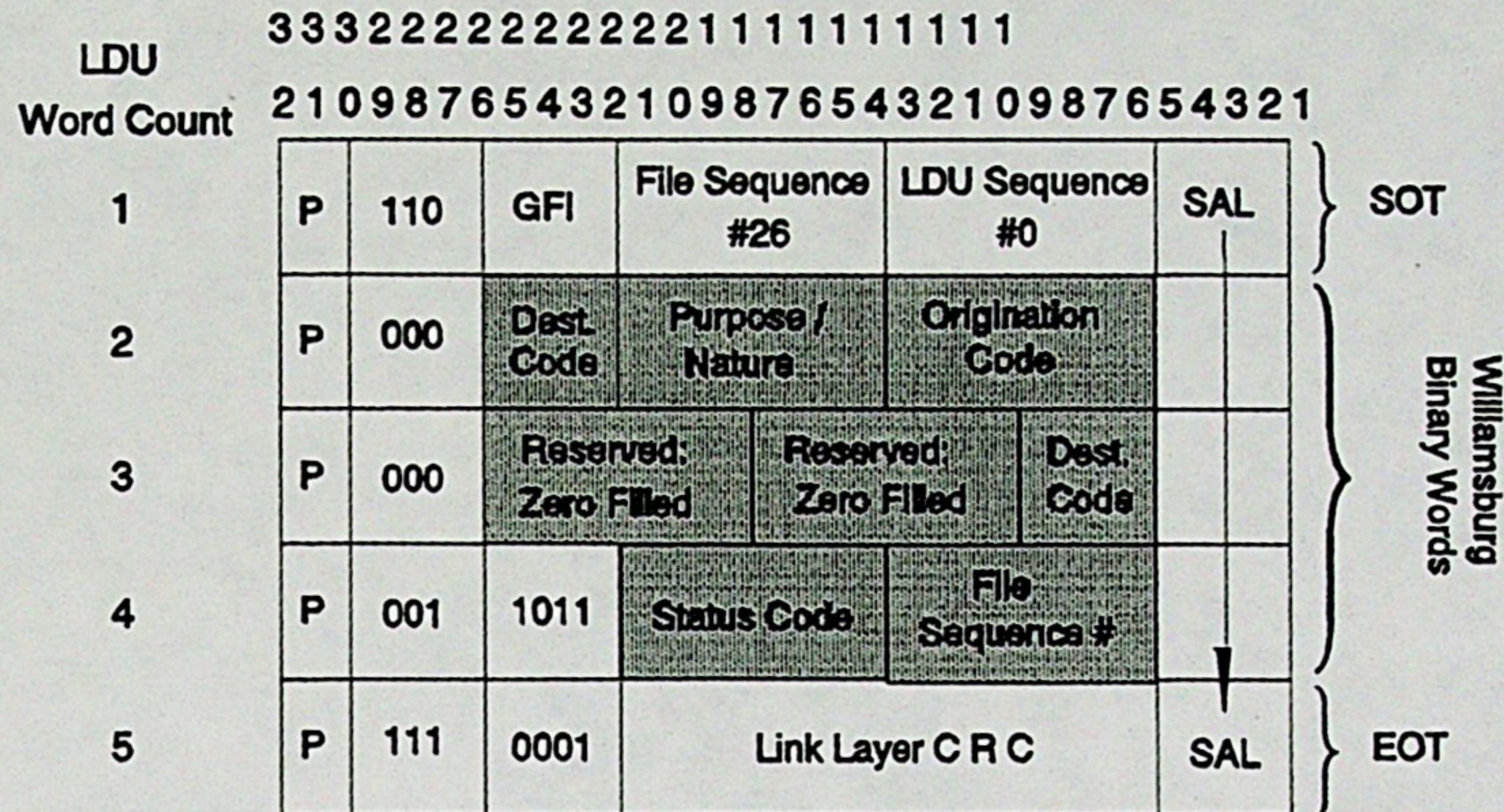


Figure 8-2 File Status Message from MU to End System

Note 1: The Link Layer CRC will be computed over the shaded area.

Note 2: The Origin Code will be M. The Purpose/Nature code will be S and the Destination Code will be set to the downlink originator. The File Sequence # will reflect the FSN of the Williamsburg file as it was received by the ACARS MU.

Note 3: Attention System Integrators - Some End Systems may not support this message.

The Status Code field will reflect the file transfer status and the file will be identified by the FSN. The defined values for the Status Code are:

<u>Code</u>	<u>Meaning</u>
O	File too large

ATTACHMENT 9
INTERACTION OF END SYSTEMS

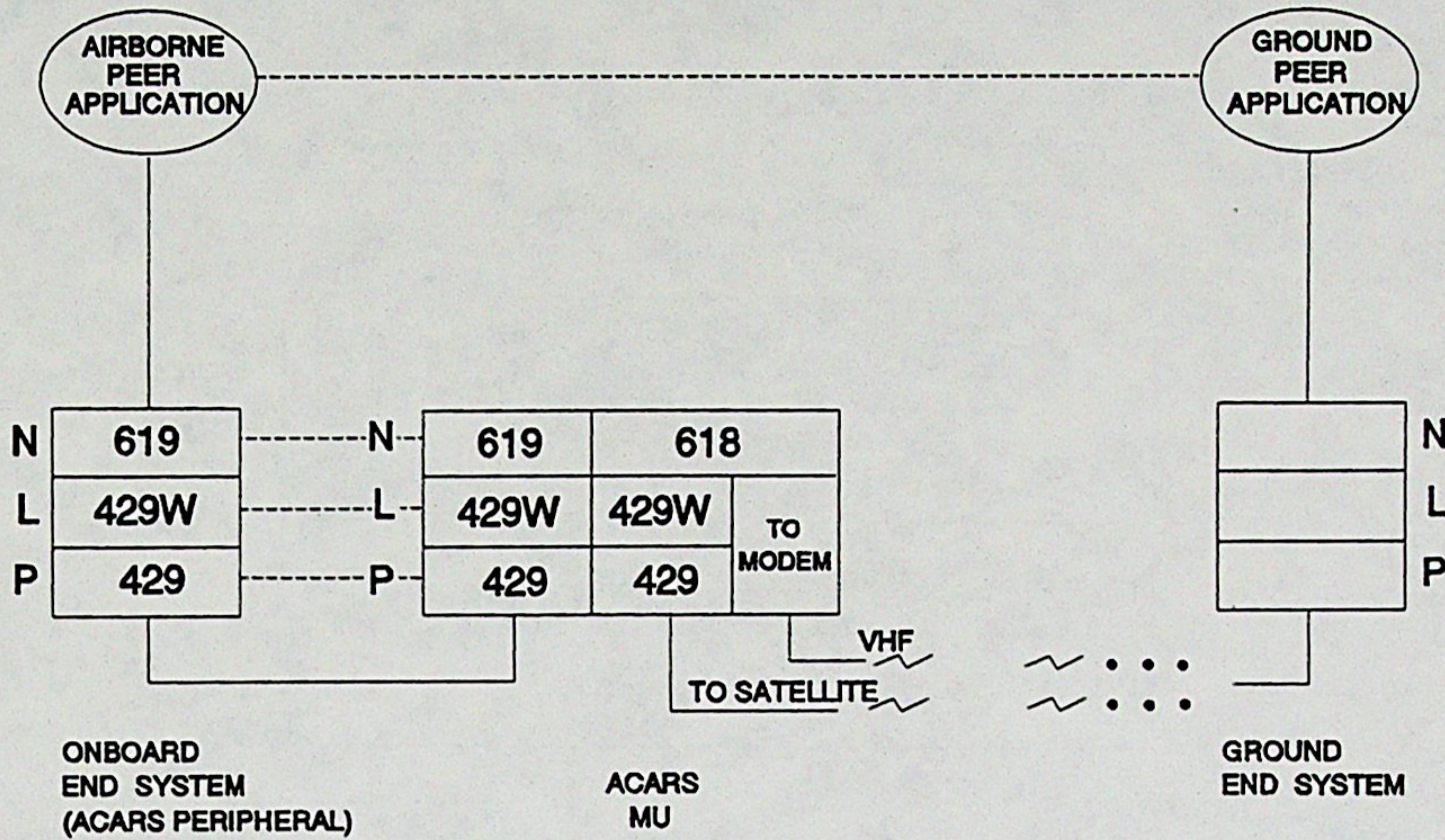


Figure 9-1 Interaction of End Systems through an MU - OSI Presentation

ATTACHMENT 10
CHARACTER FILE TRANSFER PROTOCOL TIMING

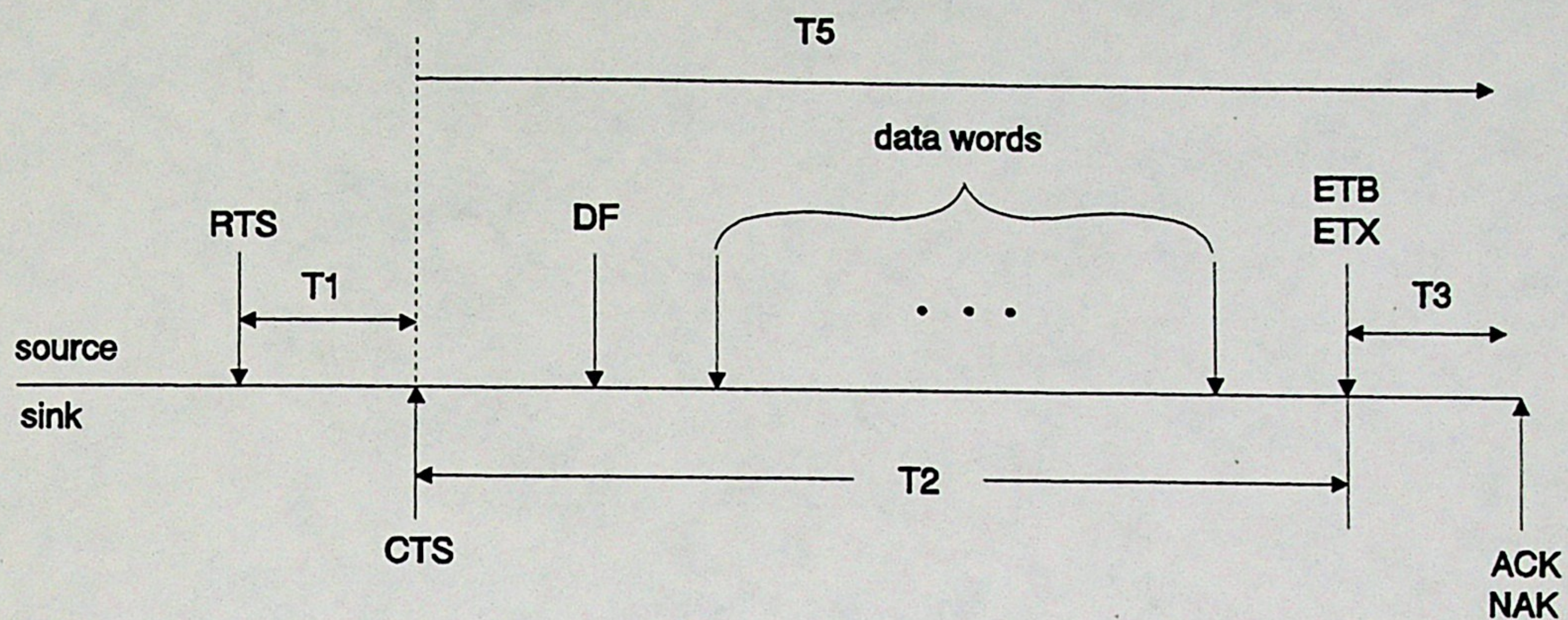


Figure 10-1 Typical Block Transfer Timing

ATTACHMENT 10 (cont'd)
CHARACTER FILE TRANSFER PROTOCOL TIMING

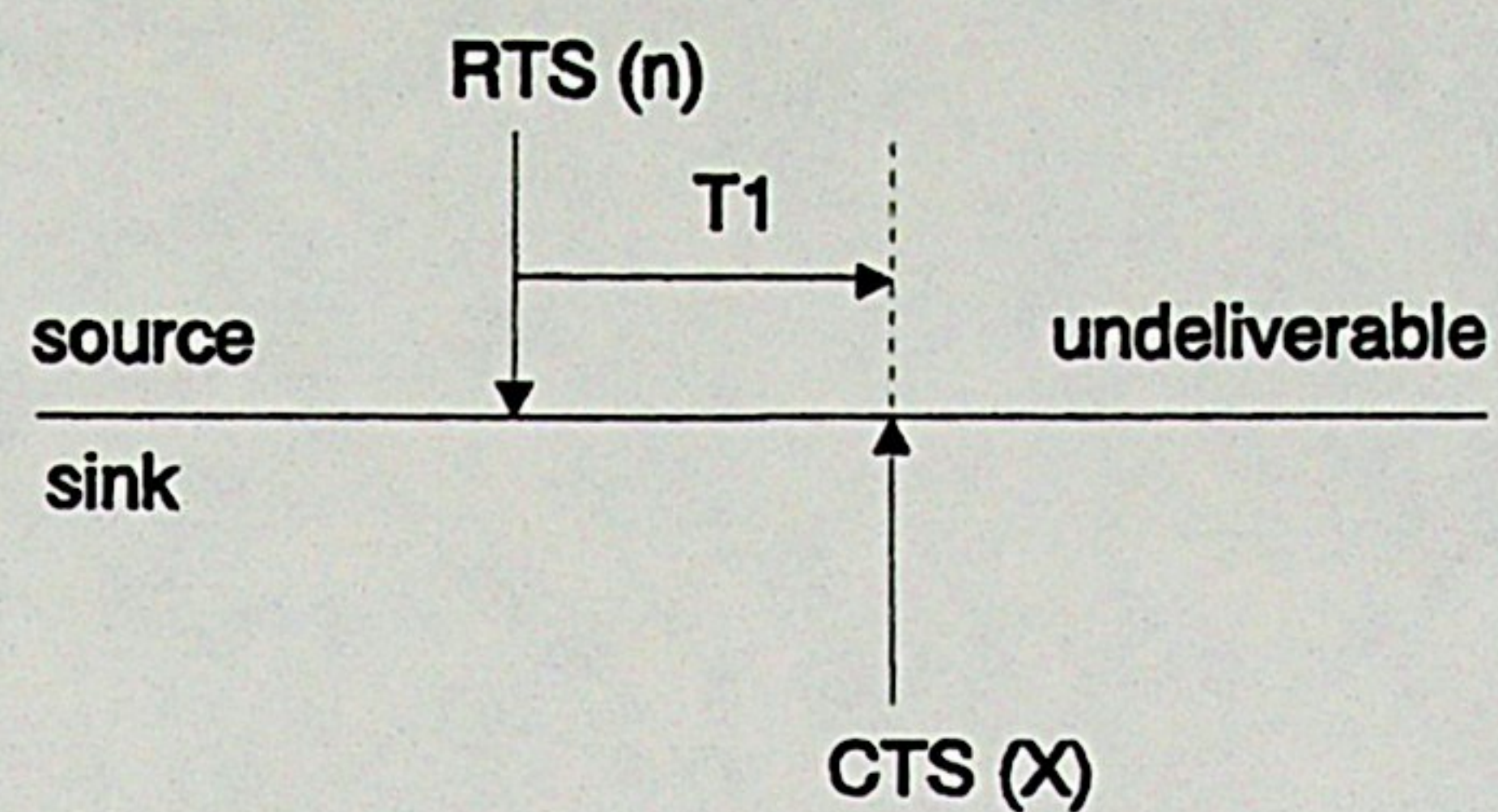


Figure 10-2 CTS Response

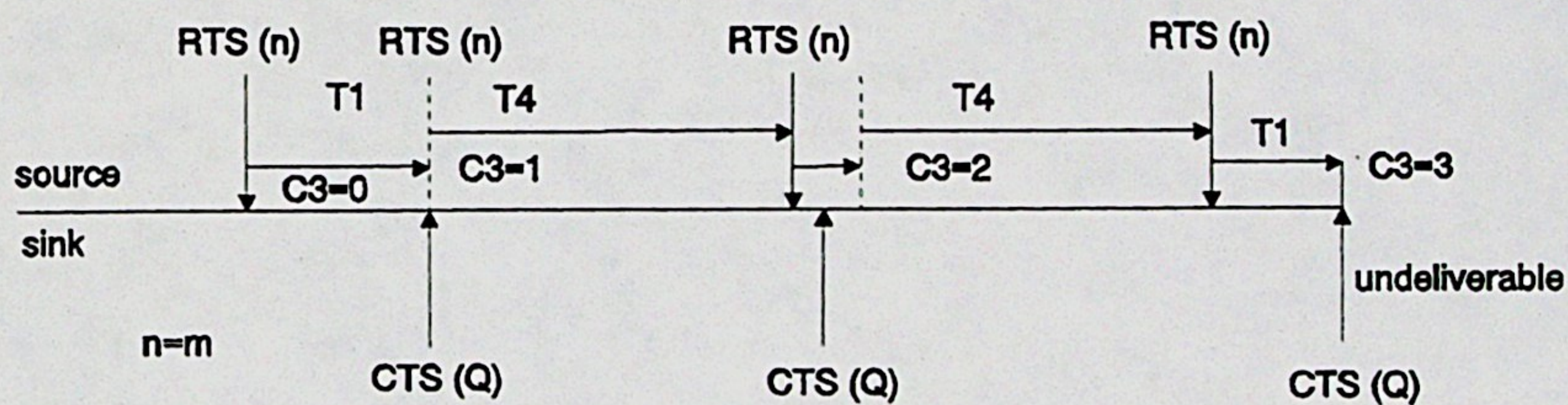


Figure 10-3 Busy (Q) Response

ATTACHMENT 10 (cont'd)
CHARACTER FILE TRANSFER PROTOCOL TIMING

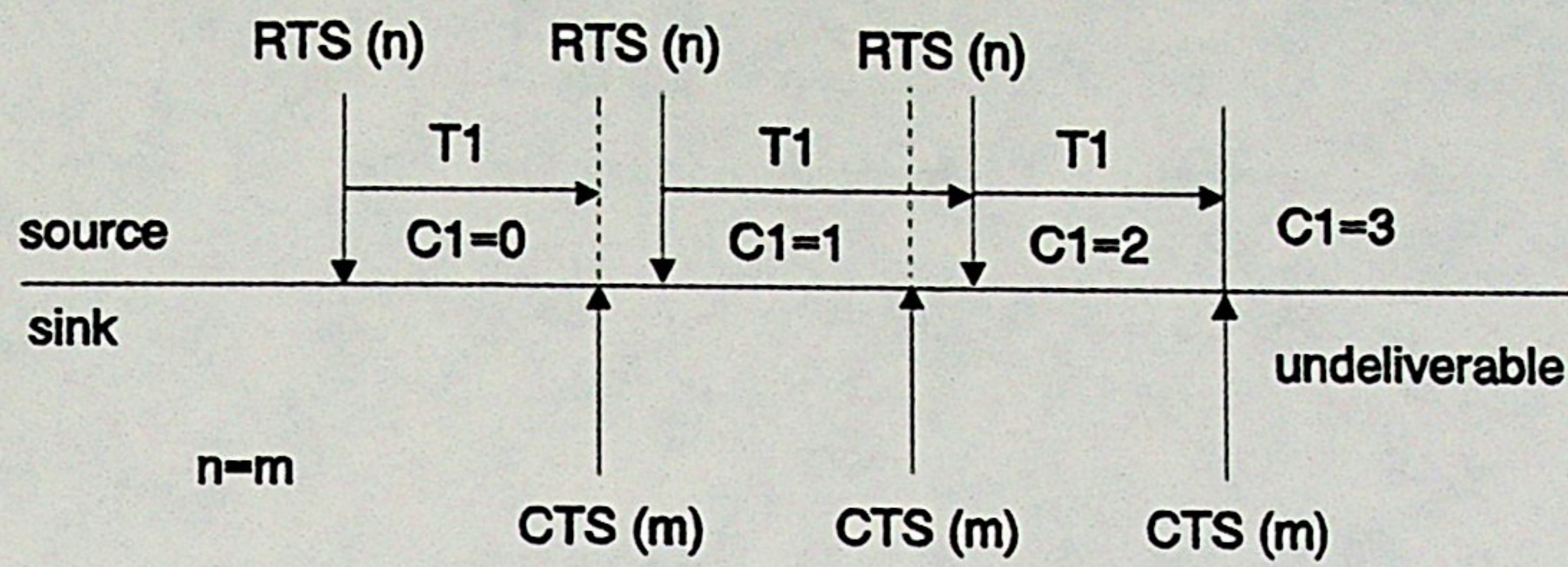


Figure 10-4 CTS Not Matching and No Busy (Q) Response

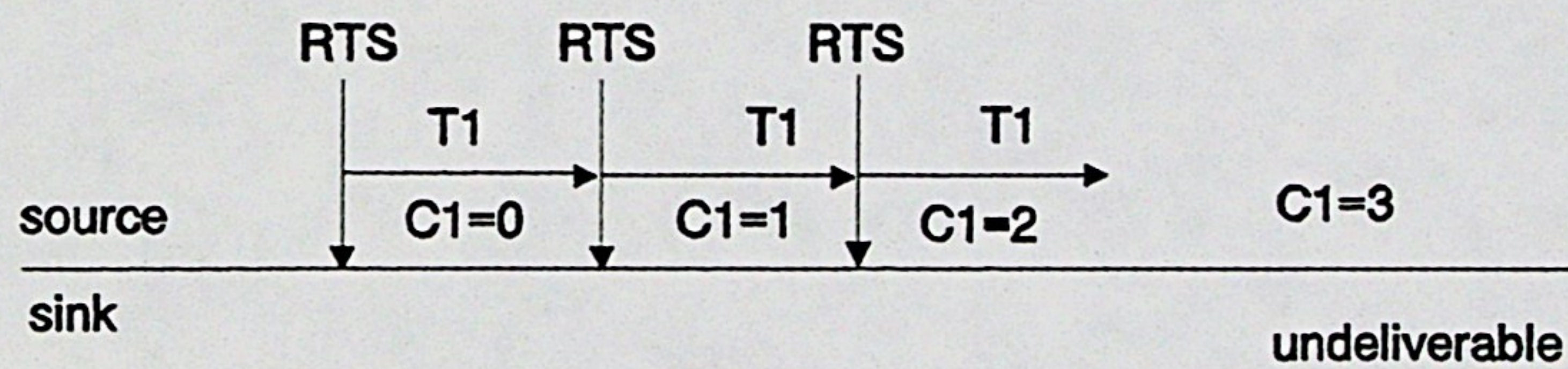


Figure 10-5 No Response

ATTACHMENT X
OPEN ISSUES LIST

Supplement 1 Issues:

1. Purge the command for Character Protocol
2. Dynamically changing print font using escape sequence in uplink or similar.
3. Link layer protocol determination and negotiation/reselection.
4. Message Deletion Status
5. Store and Forward Printer
6. Cabin Terminal All Call (T0)
7. Limitation of Onboard End System to End System Message Length
8. Message Prioritization
9. Limitations to ASCII character set
10. Should peripherals be required to transmit Label 172 data words?
11. Master/Slave SDU configuration.
12. Queue management - Establish the choice for downlink when multiple air/ground links are available.
13. The MU should provide the header in downlink messages. This feature will preclude conflicting flight number identification.
14. Master/Slave swap for "store and forward" operation when the Williamsburg protocol is in use. Refer to Section 4.5.1.3.1.