STANDARD INTERFACE FOR DATA TRANSFER EQUIPMENT

ENFZ-TM-83-803

DECEMBER 1983

FINAL REPORT FOR 1 SEPTEMBER 1983 - 7 DECEMBER 1983

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

F-22 SPO PROGRAM
AERONAUTICAL SYSTEMS CENTER
AIR FORCE MATERIEL COMMAND
WRIGHT-PATTERSON AFB OH 45433-7126
NOTICE

USING GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA INCLUDED IN THIS DOCUMENT FOR ANY PURPOSE OTHER THAN GOVERNMENT PROCUREMENT DOES NOT IN ANY WAY OBLIGATE THE US GOVERNMENT. THE FACT THAT THE GOVERNMENT FORMULATED OR SUPPLIED THE DRAWINGS, SPECIFICATIONS, OR OTHER DATA DOES NOT LICENSE THE HOLDER OR ANY OTHER PERSON OR CORPORATION; OR CONVEY ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATANTED INVENTION THAT MAY RELATE TO THEM.

THIS REPORT IS RELEASABLE TO THE NATIONAL TECHNICAL INFORMATION SERVICE (NTIS). AT NTIS, IT WILL BE AVAILABLE TO THE GENERAL PUBLIC, INCLUDING FOREIGN NATIONS.

THIS TECHNICAL REPORT HAS BEEN REVIEWED AND IS APPROVED FOR PUBLICATION.
### 4. TITLE AND SUBTITLE
Standard Interface for Data Transfer Equipment
ENFZ-TM-83-803

### 5. FUNDING NUMBERS

### 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
F-22 SPO Program
Aeronautical Systems Center
Air Force Materiel Command
Wright-Patterson AFB OH 45433-7126

### 8. PERFORMING ORGANIZATION REPORT NUMBER

### 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
F-22 SPO Program
Aeronautical Systems Center
Air Force Materiel Command
Wright-Patterson AFB OH 45433-7126
POC: Dana Springer, ASC/YF, 937-255-1415 x2498

### 10. SPONSORING/MONITORING AGENCY REPORT NUMBER
ASC-TR-1998-5001

### 11. SUPPLEMENTARY NOTES

### 12a. DISTRIBUTION AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

### 12b. DISTRIBUTION CODE

### 13. ABSTRACT (Maximum 200 words)

### 14. SUBJECT TERMS
Data Transfer Equipment Communication Protocol

### 15. NUMBER OF PAGES
47

### 16. PRICE CODE

### 17. SECURITY CLASSIFICATION OF REPORT
UNCLASSIFIED

### 18. SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

### 19. SECURITY CLASSIFICATION OF ABSTRACT
UNCLASSIFIED

### 20. LIMITATION OF ABSTRACT
SAR
STANDARD INTERFACE
FOR
DATA TRANSFER EQUIPMENT
(SIDTE)

ENFZ-TM-83-03
DECEMBER 7, 1983
OUTLINE

1.0 SCOPE

2.0 APPLICABLE DOCUMENTS

3.0 REQUIREMENTS

3.1 HARDWARE INTERFACE REQUIREMENTS

3.1.1 PHYSICAL CHARACTERISTICS

3.1.1.1 CONNECTORS

3.1.1.2 DCU CONTROLS AND DISPLAYS

3.1.1.2.1 DISPLAY

3.1.1.2.2 DATA TRANSFER INITIATION

3.1.1.2.3 BIT INITIATION

3.1.1.2.4 FAULT INDICATION

3.1.1.3 CABLES

3.1.1.4 ADR/DCU POWER REQUIREMENTS

3.1.2 ELECTRICAL CHARACTERISTICS

3.1.2.1 EIA STANDARD INTERFACES

3.1.2.1.1 RS-232C INTERFACE

3.1.2.1.2 RS-422A INTERFACE

3.1.2.1.3 DCU POLLING FOR ACTIVE INTERFACE

3.1.2.2 DATA RATES

3.1.2.3 SIGNAL QUALITY

3.1.2.3.1 TRANSMITTING EQUIPMENT

3.1.2.3.1.1 DISTORTION

3.1.2.3.1.2 CHARACTER INTERVAL

3.1.2.3.2 RECEIVING EQUIPMENT

3.1.2.3.2.1 RECEIVING MARGIN

3.1.2.3.2.2 CHARACTER INTERVAL

3.1.2.3.2.3 MIN. DURATION START ELEMENT

3.1.3 DCU CONNECTOR PIN ASSIGNMENTS

3.2 SOFTWARE AND PROTOCOL INTERFACE REQUIREMENTS

3.2.1 CHARACTER SET

3.2.2 PROTOCOL FORMAT

3.2.2.1 HEADER FORMAT

3.2.2.1.1 START OF HEADER (SOH)

3.2.2.1.2 ADR DEVICE IDENTIFIER

3.2.2.1.3 BLOCK COUNT FIELD

3.2.2.1.4 AIRCRAFT TAIL NUMBER

3.2.2.1.5 AIRCRAFT TYPE IDENTIFIER

3.2.2.1.6 ENGINE IDENTIFIERS

3.2.2.1.7 FAULT INDICATION BYTE

3.2.2.1.8 FAULT CODE DISPLAY FIELD

3.2.2.1.9 ADDITIONAL DATA DISPLAY FIELD

3.2.2.1.10 END OF TEXT (ETX)

3.2.2.1.11 BLOCK CHECK CHARACTER (BCC)

3.2.2.2 DATA TRANSFER FORMAT

3.2.2.2.1 START OF TEXT (STX)

3.2.2.2.2 DATA BYTE COUNT

3.2.2.2.3 TRANSPARENT DATA FIELD

3.2.2.2.4 END OF BLOCK (ETB)

3.2.2.2.5 END OF TEXT (ETX)
3.2.3 PROTOCOL CONSIDERATIONS
3.2.3.1 FRAMING CONTROL
3.2.3.2 ERROR CONTROL
   3.2.3.2.1 BYTE PARITY ERROR
   3.2.3.2.2 LRC ERROR
3.2.3.3 SEQUENCE CONTROL
3.2.3.4 TRANSPARENCY
3.2.3.5 LINE CONTROL
3.2.3.6 SPECIAL CASES
   3.2.3.6.1 NO DATA
3.2.3.7 TIME-OUT CONTROL
3.2.3.8 START-UP CONTROL

3.2.4 COMMUNICATIONS BETWEEN DEVICES
3.2.4.1 ADR/DCU COMMUNICATIONS
   3.2.4.1.1 ADR TO DCU DOWNLOAD
      3.2.4.1.1.1 COMMUNICATIONS SETUP
      3.2.4.1.1.2 DCU DETERMINATION
      3.2.4.1.1.3 DATA TRANSFER
   3.2.4.1.2 DCU TO ADR UPLOAD
   3.2.4.1.3 APPLICATION UNIQUE FUNCTION REQUESTS
3.2.4.2 DCU TO GSC COMMUNICATIONS
   3.2.4.2.1 DCU TO GSC DOWNLOAD
   3.2.4.2.2 GSC TO DCU UPLOAD
   3.2.4.2.3 SPECIAL FUNCTION REQUEST INITIALIZATION

3.2.5 CONTROL CHARACTER DEFINITIONS
3.2.5.1 START OF HEADER (SOH)
3.2.5.2 START DATA TRANSMISSION (STX)
3.2.5.3 END BLOCK TRANSMISSION (ETB)
3.2.5.4 END DATA TRANSMISSION (ETX)
3.2.5.5 NEGATIVE ACKNOWLEDGEMENT (NAK)
3.2.5.6 ENQUIRY (ENQ)
3.2.5.7 AFFIRMATIVE ACKNOWLEDGEMENT (ACK)
3.2.5.8 AFFIRMATIVE ACKNOWLEDGEMENT WAIT (WACK)
3.2.5.9 REVERSE INTERRUPT (RVI)
3.2.5.10 TEMPORARY TEXT DELAY (TTD)
3.2.5.11 DATA DELIMITERS (DC1, DC2, DC3, DC4, FS)
TABLES

1.0 CONTROL CHARACTER CODE ASSIGNMENTS
2.0 DISPLAY CHARACTERS
3.0 ASCII CODE ASSIGNMENTS

FIGURES

1.0 HEADER BLOCK FORMAT
2.0 TEXT BLOCK FORMAT
3.0 DEVICE IDENTIFIER FIELD
4.0 EQUIPMENT INTERFACE

FUNCTIONAL FLOWCHARTS

A1.0 ADR TO DCU COMMUNICATIONS
A1.1 ADR TO DCU DOWNLOAD MODE
A1.2 ADR TO DCU FUNCTION MODE
A1.3 ADR TO DCU ILLEGAL OPERATION MODE
D1.0 DCU TO ADR COMMUNICATIONS
D1.1 DCU TO ADR FUNCTION MODE
DG1.0 DCU TO GSC COMMUNICATIONS
DG1.1 DCU TO GSC INITIALIZATION MODE
G1.0 GSC TO DCU COMMUNICATIONS
S1.0 WAIT STATE HANDSHAKE
S2.0 RETRANSMIT BLOCK HANDSHAKE
S3.0 HOLD LINE HANDSHAKE
S4.0 TRANSMIT TEXT MODE
S5.0 RECEIVE TEXT MODE
S6.0 RECEIVE HEADER MODE
S7.0 TRANSMIT HEADER MODE

vi
1.0 SCOPE
This document establishes techniques to be used in the development or
modification of airborne data recorders (ADR) (i.e., turbine engine moni-
toring system recorders, aircraft structural recorders, etc.) and their
associated electronic data transfer units -- called data collection units
(DCU). It has been developed to ensure compatibility of data transfer devi-
ces with a wide variety of flight recorders and should be used to reduce the
number of unique DCUs developed to support recording devices. This document
describes data communications between DCUs and the associated flight recor-
ders and ground station computers (GSC) or other flight line support equip-
ment.

2.0 APPLICABLE DOCUMENTS
The following documents, of the exact issue shown, form a part of this
standard to the extent specified herein. In the event of conflict between
the documents referenced herein and the contents of this standard, the con-
tents of this standard shall be the superseding requirement.

GOVERNMENT STANDARDS
MIL-STD-7040 Aircraft Electrical Power Characteristics
MIL-STD-810C Environmental Test Methods
MIL-STD-1560A Insert Arrangements for MIL-C-38999 and MIL-C-27599
        Electrical, Circular Connectors

GOVERNMENT SPECIFICATIONS
MIL-C-38999H Connectors, Electrical...

INDUSTRY STANDARDS
EIA STANDARD RS-232C Interface between Data Terminal Equipment
        and Data Communication Equipment Employing
        Serial Binary Data Interchange
EIA STANDARD RS-363 Standard for Specifying Signal Quality for
        Transmitting and Receiving Data Processing
        Terminal Equipments Using Serial Data
        Transmission at the Interface with
        Non-Synchronous Data Communication Equipment
EIA STANDARD RS-422A Electrical Characteristics of Balanced
        Voltage Digital Interface Circuits

3.0 REQUIREMENTS
This section defines the requirements for interfacing airborne data
recorders, data transfer devices, and ground computers (or other flight line
support equipment). It details both the hardware interface (physical and
electrical characteristics) and the data communication protocol (software/ 
firmware programmed) necessary for physical and functional compatibility of
all the units mentioned above.
3.1 Hardware Interface Requirements

3.1.1 Physical Characteristics
This section details the physical interface characteristics of the DCU, airborne data recorder, and the ground computer. It addresses control devices located on each piece of equipment, as applicable, and displays since these are part of the equipment interface. Control of the flight and ground equipment using switches or displays will be discussed in detail in the following hardware and software requirements sections.

3.1.1.1 Connectors
All connectors applicable to this interface shall comply with the requirements outlined in MIL-C-38999H, Connectors, Electrical, Circular..., with the following additions/revisions to the requirements:

a) All connectors that can be mated/unmated in a Class 1, Division 1 hazardous location, as defined in the National Fire Protection Association (NFPA) National Electrical Code 70-1983, shall be explosionproof with arc suppression. The explosive atmosphere test shall be in accordance with MIL-STD-810C, Method 511, procedure I.

b) The durability of the connector shall be 1000 mate/unmate cycles when tested per paragraph 4.7.7 of MIL-C-38999H.

c) The connector shall be of a scoop-proof design, have a size 15 shell and use the type B recommended panel mounting dimensions per MIL-C-38999H. The connector shall use the standard 19 pin insert arrangement for the corresponding shell size, per MIL-STD-1560A.

3.1.1.2 DCU Controls and Displays

3.1.1.2.1 Display
The DCU shall have an electro-optical display of at least eight characters. The display may be capable of displaying more ASCII encoded characters than the alphanumericics, but the allowable display characters shall be limited to those listed in Table 2.0. The display shall be capable of displaying a line of 20 characters -- if scrolling is employed to achieve the line display, the character scrolling shall be manually controlled. Each logical line of display information shall be ended with an ASCII encoded carriage return (CR). The memory locations associated with the display shall be transparent to the unit sending the data to the DCU.

3.1.1.2.2 Data Transfer Initiation
The DCU shall have means for switching the battery power to the interface on and initiating communications and data transfer.

3.1.1.2.3 BIT Initiation
The DCU shall have a means for initiating DCU built-in-test as required by the DCU specification or statement of work.

3.1.1.2.4 Fault Indication
The DCU shall have an electro-optical display that automatically
indicates whether or not a fault indicator code has been transmitted to the DCU. The indicator shall be activated as soon as data transfer is completed if a fault code has been transmitted. This function shall be transparent to the transmitting unit as discussed in section 3.2.2.1.7, Fault Indication Byte.

3.1.1.3 Cable(s)
One cable shall be used for connecting a DCU to either an airborne data recorder or a ground computer. The cable shall be designed to meet the requirements specified in section 3.1.2.3 for signal quality and in section 3.1.2.2 for data transfer rates.

3.1.1.4 ADR/DCU Power Requirements
The DCU shall be self-powered and capable of supplying +28VDC to ADRs (when aircraft power is unavailable to the ADR) within the tolerances specified in MIL-STD-704D. The DCU shall sense whether or not power is present on the interface connector before switching its battery power to the interface "on". The DCU may use GSC provided power to power itself. The assumed external load to be serviced by the DCU power shall be 2.0 Amperes for a period of at least 1 hour before recharging shall be required. Any ADRs using the standard interface must also be compatible with MIL-STD-704D power and shall have a rated load of no greater than 2.0 Amperes at +28VDC within the tolerances of MIL-STD-704D.

3.1.2 Electrical Characteristics
This section describes the electrical interface requirements for data communication among DCUs, ADRs, and ground computers.

3.1.2.1 EIA Standard Interfaces
This standard describes 2 Electronics Industries Association (EIA) standard interfaces for data communications -- RS-232C and RS-422A. The airborne data recorders and ground computers shall communicate with the DCU using either interface. The DCU shall incorporate both an RS-232C half-duplex and an RS-422A dual-simplex interface. Details of the interfaces and DCU selection of the active interface are discussed in the following sub paragraphs.

3.1.2.1.1 RS-232C Interface
Reference EIA Standard RS-232C. Related cross-reference standards are:

   a) CCITT V.24
   b) CCITT V.28
   c) ISO 2110

Only the "primary data" and "ground" circuits (as defined in the standard) shall be implemented. Control and timing shall be implemented in software as described in Section 3.2, Software and Protocol Interface Requirements.

3.1.2.1.2 RS-422A Interface
Reference EIA Standard RS-422. Related cross-reference standards are:

-3-
a) CCITT V.11 (X.27)
b) FED-STD-1020

The RS-422 shall be implemented as described in the EIA Standard except for the required circuit driving capability. The implemented interface shall be capable of driving at least two (2) RS-422A receiver circuits. The RS-422A interface shall be capable of satisfactory operation at two (2) discrete Baud rates as specified in paragraph 3.1.2.2, Data Rates.

3.1.2.1.3 DCU Polling to Determine Active Interface

The DCU shall initiate communications on both interfaces as specified in paragraph 3.2.3.8 at the low rate, initially. If no response is received on either low rate interface, the DCU then assumes the active interface is the high-rate RS-422. If no response is received on the high-rate RS-422 interface, the DCU shall declare a communications fault. Timeout and start-up control are discussed further in paragraphs 3.2.3.7 and 3.2.3.8, respectively. After identifying the active interface, the DCU shall communicate only on that interface. The "off" states for the RS-232 and RS-422 interfaces shall be "spacing" and logic high, respectively.

3.1.2.2 Data Rates

The data rate for the RS-232C interface shall be 9.6K Baud (on all equipments). The DCU RS-422 interface shall have a high and a low data rate. The nominal low data rate shall be 9.6K Baud, and the nominal high rate shall be 19.2K Baud.

3.1.2.3 Signal Quality

The following subparagraphs outline the signal quality requirements for the data transmission and reception circuits addressed in this document.

3.1.2.3.1 Transmitters

3.1.2.3.1.1 Distortion
In the communications transmitter circuits, the signal provided shall have a synchronous start-stop distortion not greater than 1.0%, and a gross start-stop distortion of not greater than 2.1%, assuming no signal element shall have a duration of less than 97.9% of a unit interval.

3.1.2.3.1.2 Character Interval
Under continuous start-stop operation, the signals provided on the communications interface may have a minimum average character interval shorter than the nominal character interval and an occasional character with a still shorter duration (called the minimum character interval) according to the following definitions (from EIA Standard RS-363):

a) Minimum Average Character Interval - In continuous start-stop operation, the interval between successive start transitions on the transmitted data circuit averaged over 2 consecutive characters shall be no less than the nominal character interval reduced by 3% of a unit interval.

b) Minimum Character Interval - In continuous start-stop operation, the interval between successive start transitions on the
transmitted data circuit shall not be less than the nominal character interval reduced by 5% of a unit interval.

3.1.2.3.2 Receivers

3.1.2.3.2.1 Receiving Margin

In the start-stop communications system, the receiver(s) shall have a synchronous margin of 2.5% and a practical margin of 35%, and shall not be expected to respond to any signal element having a duration of less than 51.5% of a unit interval.

3.1.2.3.2.2 Character Interval

The receivers shall respond to signals that have a minimum average character interval shorter than the nominal character interval and an occasional character having a still shorter duration (called the minimum character interval) according to the following definitions (from EIA Standard RS-363):

a) Minimum Average Character Interval - In continuous start-stop operation, the implemented receiver(s) shall be prepared to respond to successive start transitions on the received data circuit which follow their previous start transitions by a character interval averaged over 2 consecutive characters which is no less than the nominal character interval reduced by 25% of a unit interval.

b) Minimum Character Interval - In continuous start-stop operation when the above average is met, the receiver(s) shall be prepared to respond to a start transition which follows the start transition of the preceding character by an interval no less than the nominal character interval reduced by 48.5% of a unit interval.

3.1.2.3.2.3 Minimum Duration Start Element

In the communication system, when the receiver is in the stop (or waiting) condition, it shall not be required to respond to a character on a spacing signal element with a duration of less than 51.5% of a unit interval.

3.1.3 DCU Connector Pin Assignments

Electrical signals are assigned to the connector pins as follows:

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>RESERVED (no connection)</td>
</tr>
<tr>
<td>B</td>
<td>RESERVED (no connection)</td>
</tr>
<tr>
<td>C</td>
<td>RS-422A Data High (Received Data, relative to DCU)</td>
</tr>
<tr>
<td>D</td>
<td>RS-422A Data Low (Received Data, relative to DCU)</td>
</tr>
<tr>
<td>E</td>
<td>+28 VDC</td>
</tr>
<tr>
<td>F</td>
<td>+28 VDC Return</td>
</tr>
<tr>
<td>G</td>
<td>RS-422A Data High (Transmit Data, relative to DCU)</td>
</tr>
<tr>
<td>H</td>
<td>RS-422A Data Low (Transmit Data, relative to DCU)</td>
</tr>
<tr>
<td>J</td>
<td>Discrete Test Return</td>
</tr>
<tr>
<td>*K</td>
<td>Closure to pin J for data transfer (less than 100 ohms)</td>
</tr>
</tbody>
</table>
RS-232C Transmitted Data (circuit BA) (relative to DCU)
RS-232C Received Data (circuit BB) (relative to DCU)
Signal Ground (circuit AB)
*Signal Shields
Protective Ground
MIL-STD-1553B Data High (optional)
MIL-STD-1553B Data Low (optional)
RESERVED (no connection)
RESERVED (no connection)

*NOTE: Pin K must be connected to Pin J before communications are attempted and must remain connected until communications are complete. This is necessary for data transfer from ADR to DCU only. The pins may be permanently connected within the DCU. ADR circuits shall supply a maximum of 20 milliamperes through the DCU switching circuit.

**NOTE: Protective ground shall double as the power shield and shall be grounded at both ends of the DCU cable. Signal shields shall be grounded at the ADR/GSC mating end of the cable.

3.2 Software/Protocol Requirements
The SIDTE data transfer protocol defines the allowable ASCII character set, control characters, control concepts, and machine states. The control characters recognized by the protocol shall be limited to those defined in Table 1.0. All display characters and control characters shall be transmitted as defined in Tables 1.0 and 2.0.

3.2.1 Character Set
The character set recognized by this protocol shall be limited to those characters listed in the complete set of codes referred to as the American Standard Code for Information Interchange (ASCII), 1968 (Table 3.0). The characters that may be transmitted in fields that are supplied to the display on the DCU shall be limited to those listed in Table 2.0.

3.2.2 Protocol Format
The protocol defined herein is a character oriented protocol. For this application, asynchronous communications shall be implemented.

3.2.2.1 Header Format
After communications have been established, a header message shall be transmitted once for the entire data package. The header shall be used to preface mass data transfer and request special functions. Its format and field identification shall be as shown in Figure 1.0. Individual fields shall be encoded as specified in the following subparagraphs.

3.2.2.1.1 Start of Header (SOH)
See paragraph 3.2.5.1 and Table 1.0.

3.2.2.1.2 ADR Device Identifier
The device identifier field immediately follows the SOH and is followed by delimiter #1 (DC1). It is a variable length field to accommodate varying device serial numbers. The device identifier shall designate the
intended airborne device for data upload and identify the source of
downloaded data. This identifier shall also be used for data segregation on
the ground station computer. The device identification shall consist of two
parts -- a generic identifier and a specific identifier. The first three
bytes shall represent the generic identifier to be used when an upload of
numerous devices is desired. A contractor selected 3-byte code shall allow
upload of data to any device that recognizes this code thus allowing control
of data configuration. When upload to one specific unit is desired, the
generic identifier shall contain three nulls. The specific identifier shall
occupy the remainder of the field and shall contain the exact serial number
of the device for which an upload or request is intended, if required by the
particular ADR. The generic identifier shall have priority in deciding
whether to allow or disallow an upload. This field shall never contain DCU
or GSC identifier numbers.

3.2.2.1.3 Block Count Field
The block count field shall contain a 16-bit numerical value to
reflect the number of blocks to be transmitted (65,535 blocks of 256 bytes
each, maximum). Least significant byte shall be transmitted first. This
count will enable the receiving device to predetermine that sufficient
storage capacity exists before the text mode is entered for data transfer.
The receiving device shall assume 256 bytes will be contained in all blocks
for the capacity calculation.

3.2.2.1.4 Aircraft Tail Number
The aircraft tail number shall be fixed 8-byte field. If the
tail number is less than 8 alphanumeric characters, it shall be filled with
leading nulls. This field shall always be filled with nulls if the aircraft
tail number is not available.

3.2.2.1.5 Aircraft Type Identifier
This shall be a variable length field that designates the
aircraft type (i.e., T46A, B18, etc.). The end of this field shall be identifed by delimiter #2 (DC2). If aircraft type is unavailable or unknown to
the ADR, this field shall be absent.

3.2.2.1.6 Engine Identifiers
Due to varying aircraft configurations, the engine identifier
field shall be variable. The field shall follow DC2 and precede delimiter
#3 (DC3). Each engine identifier shall be 8 bytes in length with leading
nulls if the number is less than 8 alphanumeric characters. If engine num-
bers are unavailable or not applicable, this field shall be absent.

3.2.2.1.7 Fault Indication Byte
The presence of any ASCII (Table 2.0) byte within the fault code
field shall indicate to the DCU that fault codes have been transmitted from
the ADR. The GSC shall place an ASCII coded "!" in this field when ini-
tializing the DCU with upload or function request data. This "!" is used
only by the DCU to recognize that it has been initialized by a GSC. The
character shall be removed by the DCU prior to initiation of communications
with an ADR.
3.2.2.1.8 Fault Code Display Field
This shall be of variable length. It shall follow the fault indication byte and precede DC4. Any information transmitted in this field shall be available for DCU display and shall also be transmitted in the transparent data field. If no fault codes were logged by the ADR, this field shall be absent.

3.2.2.1.9 Additional Data Field
The additional data field shall be used for different purposes depending upon the equipment connected and direction of data transfer. For data download (i.e. ADR to DCU to GSC) this field shall contain data that needs to be accessed at the flight line or in the absence of a GSC. Any data transmitted within this field (during a download) shall be available for display by the DCU and shall also be transmitted in the transparent text data blocks as required by each application.

The absence of this field during a DCU to ADR header transmission shall convey to the ADR that a data upload (i.e. GSC to DCU to ADR, or DCU to ADR) is commanded.

The presence of this field during a DCU to ADR header transmission shall convey to the ADR that an application unique function is commanded.

The additional data field shall be followed by delimiter # 5 (FS).

3.2.2.1.10 End of Text (ETX)
See paragraph 3.2.5.4 and Table 1.0.

3.2.2.1.11 Block Check Character (BCC)
The BCC is the result of a Longitudinal Redundancy Check (LRC) and shall be appended to the end of the transmission. This calculation shall be bounded by the start of block (SOH/STX) and end of block (ETB/ETX) exclusively. The BCC functions as a message content error detection scheme. An LRC is defined as a parity on columns. Column parity shall be odd. For example, an odd column parity generates the following BCC.

\[
\begin{array}{c}
\text{BYTE} \\
10110010 \\
01101001 \\
11011001
\end{array}
\]

\[
\text{BCC}=11111101
\]

An "exclusive OR" (XOR) of the current BCC with the next byte will maintain a BCC of even parity. Complementing the final BCC will provide an odd parity BCC. This calculated BCC shall be appended to the transmission or used for comparison with the received BCC. This approach is illustrated below.

\[
\begin{array}{c}
\text{Byte 1} \\
\oplus \text{Byte 2}
\end{array}
\]

\[
\begin{array}{c}
11001101 \\
10011101 \\
01010110
\end{array}
\]
3.2.2.2 Data Transfer Format

After communications have been established and documentary (header) data has been received, the transfer of data shall be accomplished using the data format as shown in Figure 2.0.

3.2.2.2.1 Start of Text (STX)
See paragraph 3.2.5.2 and Table 1.0.

3.2.2.2.2 Data Byte Count
An 8-bit numerical value defining the data block size (256 bytes or less). This technique shall facilitate data transparency and assist detection of transmission errors. Zero shall represent 256. If there is no data to send, the block count (see 3.2.2.1.3) will be equal to zero (0).

3.2.2.2.3 Transparent Data Field
This field shall contain data which is peculiar to the application itself. The interpretation and/or processing of this information shall be a function of the particular device for which it is intended (i.e., acquisition device or ground computer).

3.2.2.2.4 End of Block (ETB)
See paragraph 3.2.5.3 and Table 1.0.

3.2.2.2.5 End of Text (ETX)
See paragraph 3.2.5.4 and Table 1.0.

3.2.2.2.6 Block Check Character (BCC)
See paragraph 3.2.2.1.11.

3.2.3 Protocol Considerations
Protocol implementation considerations are discussed in the following subparagraphs.

3.2.3.1 Framing Control
Framing is defined as the determination of which eight bit groups constitute characters and what groups of characters constitute messages. Each 8-bit data byte transmitted shall be preceded by 1 start bit and followed by an odd parity bit and 1 stop bit. The byte shall be transmitted least significant bit first. The transparent data field (see 3.2.2.2.3) encoding shall be defined by the contractor for each peculiar ADR application. The following information shall be transmitted ASCII encoded:

a) All control characters (per Table 1.0)
b) ADR identifier number
c) Aircraft tail number
d) Aircraft type
e) Engine identifier(s)
f) Fault and additional data display information
The following information shall be transmitted non-ASCII encoded:

a) Block count (two bytes)
b) Block check character
c) Data byte count

3.2.3.2 Error Control
Error detection shall consist of hardware detected parity error on all bytes, erroneous LRC value, and transmission related problems (i.e., loss of communications, etc.).

3.2.3.2.1 Byte Parity Error
A byte parity error detected during the reception of a header or text block shall result in a receiver request for retransmission (NAK) after the block transmission has terminated. Such an error detected during the reception of single control characters (for handshaking) shall generate a negative acknowledgement (NAK) resulting in the retransmission of the control character. Five (5) retransmission attempts shall be made before declaring a communications fault.

3.2.3.2.2 LRC Error
An erroneous LRC value in the BCC shall generate a negative acknowledgement (NAK) response by the receiver. The transmitter shall make five (5) attempts to retransmit the same block before declaring a communications fault.

3.2.3.3 Sequence Control
Since communications used in this interface are half-duplex, message numbering is not required. A positive acknowledgement control character shall be sent in response to correctly received control characters and data blocks as illustrated in the functional flowcharts. The affirmative acknowledgement control character shall be transmitted as the ASCII code for ACK. The reverse interrupt control character is an affirmative acknowledgement transmitted as the ASCII code for RVI. The ACK and RVI characters maintain transmission sequence and establish the line direction.

3.2.3.4 Transparency
Transparency of application unique data is imperative to avoid interpretation of data as control characters. Transparency shall be achieved by the data byte count technique.

3.2.3.5 Line Control
Communication initiation shall be as defined in 3.2.3.8. Determination as to which device has control of the line at any particular instant is a function of the control character handshaking process and DCU initialized state. (Reference functional flowcharts.)

3.2.3.6 Special Cases
3.2.3.6.1 No Data to Send
If an ADR has no data to send to the DCU, it simply responds to the DCU's ENQ with the normal RVI to turn the communication line around and
sends a header with a zero block count. If a DCU is empty it responds to a GSC acknowledgement with a header containing a zero block count and a fault code reflecting no data to send.

3.2.3.7 Timeout Control
If communications are lost for a period of 500 milliseconds, at any time, a timeout condition shall be declared; communication lines shall be returned to logic high or spacing conditions and startup shall be attempted as described in paragraphs 3.1.2.1.3 and 3.2.3.8 before declaring a communications fault.

3.2.3.8 Startup Control
The DCU shall initiate communications by delaying at least 1 second after application of power to the interface, followed by repeated transmission of the ENQ control character for 2 seconds at 50 millisecond intervals, or until an affirmative acknowledgement is received by the DCU. The equipment receiving the ENQ shall respond with an affirmative acknowledgement control character depending on the desired line direction and function.

3.2.4 Communications Between Devices
The flowcharts referenced by the following paragraphs are intended to depict information flow, state transitions, and line control in a normal mode of operation. These are functional flowcharts and are not intended to depict the software structure to achieve implementation.

3.2.4.1 ADR/DCU Communications
The communications between these devices shall be limited to three major functions. They are: 1) downloading of ADR accumulated data, 2) uploading of data to the ADR, and 3) function requests.

3.2.4.1.1 ADR to DCU Download
This function is estimated to constitute the major operational usage of this interface. Once the physical connection has been made and communications initiated the data transfer shall progress as illustrated in figures A1.0, A1.1 and D1.0. These figures are referenced in the following discussion.

3.2.4.1.1.1 Communications Setup
Once the ADR interface has been enabled it awaits the reception of an ENQ control character. If the ADR needs to perform BIT or other internal housekeeping prior to initiating communications it enters a wait handshaking process denoted by A1.0 (1). When ready to proceed the recorder responds with a reverse interrupt control character (RVI) to attempt an automatic download.

3.2.4.1.1.2 DCU Determination
Once communications have been established and the DCU has received the expected RVI it shall respond according to its initialized state. The DCU shall be initialized by either the GSC or its own keyboard to perform a specific function.
3.2.4.1.3 Data Transfer

The DCU responds with an ACK to allow automatic download if it has not been initialized to perform a different task. When the ADR recognizes this ACK, A1.0 (2), it enters the download mode. The header is then transmitted and the response is received from the DCU. This response could be one of 4 acknowledgements. A NAK would request retransmission, a WACK would hold the communications and either an RVI or ACK would transition control from the transmit header mode back to the download mode. If the response is an RVI at this point the DCU has aborted transfer. The ADR acknowledges (ACK) this and awaits the reestablishment of communications. If the DCU response was an ACK the ADR enters a transmit text mode. Once all data has been transferred the DCU acknowledges the last block with an RVI, thus returning control to the DCU. The ADR then acknowledges the request and awaits reestablishment of communications.

3.2.4.1.2 DCU to ADR Upload

DCU to ADR upload procedures are depicted in Figures A1.0, D1.0, and D1.1.

3.2.4.1.3 Application Unique Function Requests

Reference figures A1.0, A1.3, DA1.0, and DA1.3.

3.2.4.2 DCU to GSC Communications

The functions performed on this interface shall be limited to: 1) acceptance of ADR accumulated data via the DCU, 2) initialization of the DCU to perform an ADR upload, and 3) initialization of the DCU to perform a function request of the ADR.

3.2.4.2.1 DCU to GSC Download

Reference Figures G1.0 and DG1.0.

3.2.4.2.2 GSC to DCU Upload

Reference Figures G1.0 and DG1.1.

3.2.4.2.3 Function Request Initialization

Reference Figures G1.0 and DG1.1.

3.2.4.3 ADR - Subsystem Communications

To be supplied (TBS) when applicable

3.2.5 Control Character Definitions

The control characters are defined in the paragraphs that follow. All control characters are transmitted ASCII encoded as defined in Table 1.0.

3.2.5.1 Start of Header (SOH)

As the name implies, this control character identifies the data that follows as header information.

3.2.5.2 Start of Text (STX)

This character identifies the beginning of text data.
3.2.5.3 End of Transmission Block (ETB)
ETB identifies the end of a transmitted block which began with STX and indicates that the block check character (BCC) follows.

3.2.5.4 End of Text (ETX)
ETX marks the end of a block which started with either SOH or STX. Its function is the same as ETB except that it indicates no more data blocks to send in the case of STX.

3.2.5.5 Negative Acknowledgement (NAK)
This is the response to the transmitting device that the last block or control character was received in error and shall be retransmitted.

3.2.5.6 Enquiry (ENQ)
ENQ is used to establish communications.

3.2.5.7 Affirmative Acknowledgement (ACK)
This control character verifies to the sender that the previous block was received without errors, or is used (when applicable) as an affirmative acknowledgement of a correctly received control character.

3.2.5.8 Wait Before Transmit Positive Acknowledgement (WACK)
A WACK response from the receiving device is an affirmative acknowledgement of a block, and indicates the receiver is not ready to receive the next block. The transmitting device sends ACK and the receiver responds with WACK at least once every 450 milliseconds (to prevent a time-out condition as described in paragraph 3.2.3.7) until ready to receive the next block. When the receiver is ready, it responds with an ACK.

3.2.5.9 Reverse Interrupt (RVI)
An RVI is an affirmative acknowledgement. It requests the transmitting device to assume the role of receiver and thus turn the communication line around.

3.2.5.10 Temporary Text Delay (TTD)
This control character is sent by the transmitting device when it is not ready but wants to retain the line. The receiver responds with ACK to each TTD sent until the transmitter is ready. The transmitter shall send a TTD control character at least once every 450 milliseconds to retain the line.

3.2.5.11 Data Delimiters (DC1, DC2, DC3, DC4, FS)
The codes for the 5 data delimiters are defined in Table 1.0.
<table>
<thead>
<tr>
<th>CONTROL CHARACTER</th>
<th>OCTAL</th>
<th>HEXADECIMAL</th>
<th>DECIMAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOH</td>
<td>001</td>
<td>01</td>
<td>1</td>
</tr>
<tr>
<td>STX</td>
<td>002</td>
<td>02</td>
<td>2</td>
</tr>
<tr>
<td>ETX</td>
<td>003</td>
<td>03</td>
<td>3</td>
</tr>
<tr>
<td>ENQ</td>
<td>005</td>
<td>05</td>
<td>5</td>
</tr>
<tr>
<td>ACK</td>
<td>006</td>
<td>06</td>
<td>6</td>
</tr>
<tr>
<td>DC1</td>
<td>021</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>DC2</td>
<td>022</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>DC3</td>
<td>023</td>
<td>13</td>
<td>19</td>
</tr>
<tr>
<td>DC4</td>
<td>024</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>NAK</td>
<td>025</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>ETB</td>
<td>027</td>
<td>17</td>
<td>23</td>
</tr>
<tr>
<td>FS</td>
<td>034</td>
<td>1C</td>
<td>28</td>
</tr>
<tr>
<td>WACK</td>
<td>035</td>
<td>1D</td>
<td>29</td>
</tr>
<tr>
<td>RVI</td>
<td>036</td>
<td>1E</td>
<td>30</td>
</tr>
<tr>
<td>TTD</td>
<td>037</td>
<td>1F</td>
<td>31</td>
</tr>
</tbody>
</table>

**TABLE 1.0**
<table>
<thead>
<tr>
<th>CHARACTER</th>
<th>OCTAL</th>
<th>HEXDECIMAL</th>
<th>DECIMAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>null</td>
<td>000</td>
<td>00</td>
<td>0</td>
</tr>
<tr>
<td>CR</td>
<td>015</td>
<td>0C</td>
<td>12</td>
</tr>
<tr>
<td>space</td>
<td>040</td>
<td>20</td>
<td>32</td>
</tr>
<tr>
<td>&quot;</td>
<td>042</td>
<td>22</td>
<td>34</td>
</tr>
<tr>
<td>$</td>
<td>044</td>
<td>24</td>
<td>36</td>
</tr>
<tr>
<td>%</td>
<td>045</td>
<td>25</td>
<td>37</td>
</tr>
<tr>
<td>&amp;</td>
<td>046</td>
<td>26</td>
<td>38</td>
</tr>
<tr>
<td>;</td>
<td>047</td>
<td>27</td>
<td>39</td>
</tr>
<tr>
<td>(</td>
<td>050</td>
<td>28</td>
<td>40</td>
</tr>
<tr>
<td>)</td>
<td>051</td>
<td>29</td>
<td>41</td>
</tr>
<tr>
<td>*</td>
<td>052</td>
<td>2A</td>
<td>42</td>
</tr>
<tr>
<td>+</td>
<td>053</td>
<td>2B</td>
<td>43</td>
</tr>
<tr>
<td>,</td>
<td>054</td>
<td>2C</td>
<td>44</td>
</tr>
<tr>
<td>-</td>
<td>055</td>
<td>2D</td>
<td>45</td>
</tr>
<tr>
<td>&quot;</td>
<td>056</td>
<td>2E</td>
<td>46</td>
</tr>
<tr>
<td>/</td>
<td>057</td>
<td>2F</td>
<td>47</td>
</tr>
<tr>
<td>0</td>
<td>060</td>
<td>30</td>
<td>48</td>
</tr>
<tr>
<td>1</td>
<td>061</td>
<td>31</td>
<td>49</td>
</tr>
<tr>
<td>2</td>
<td>062</td>
<td>32</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>063</td>
<td>33</td>
<td>51</td>
</tr>
<tr>
<td>4</td>
<td>064</td>
<td>34</td>
<td>52</td>
</tr>
<tr>
<td>5</td>
<td>065</td>
<td>35</td>
<td>53</td>
</tr>
<tr>
<td>6</td>
<td>066</td>
<td>36</td>
<td>54</td>
</tr>
<tr>
<td>7</td>
<td>067</td>
<td>37</td>
<td>55</td>
</tr>
<tr>
<td>8</td>
<td>070</td>
<td>38</td>
<td>56</td>
</tr>
<tr>
<td>9</td>
<td>071</td>
<td>39</td>
<td>57</td>
</tr>
<tr>
<td>&lt;</td>
<td>074</td>
<td>3C</td>
<td>58</td>
</tr>
<tr>
<td>=</td>
<td>075</td>
<td>3D</td>
<td>59</td>
</tr>
<tr>
<td>&gt;</td>
<td>076</td>
<td>3E</td>
<td>60</td>
</tr>
<tr>
<td>?</td>
<td>077</td>
<td>3F</td>
<td>61</td>
</tr>
<tr>
<td>@</td>
<td>100</td>
<td>40</td>
<td>62</td>
</tr>
<tr>
<td>A</td>
<td>101</td>
<td>41</td>
<td>63</td>
</tr>
<tr>
<td>B</td>
<td>102</td>
<td>42</td>
<td>64</td>
</tr>
<tr>
<td>C</td>
<td>103</td>
<td>43</td>
<td>65</td>
</tr>
<tr>
<td>D</td>
<td>104</td>
<td>44</td>
<td>66</td>
</tr>
<tr>
<td>E</td>
<td>105</td>
<td>45</td>
<td>67</td>
</tr>
<tr>
<td>F</td>
<td>106</td>
<td>46</td>
<td>68</td>
</tr>
<tr>
<td>G</td>
<td>107</td>
<td>47</td>
<td>69</td>
</tr>
<tr>
<td>H</td>
<td>110</td>
<td>48</td>
<td>70</td>
</tr>
<tr>
<td>I</td>
<td>111</td>
<td>49</td>
<td>71</td>
</tr>
<tr>
<td>J</td>
<td>112</td>
<td>4A</td>
<td>72</td>
</tr>
<tr>
<td>K</td>
<td>113</td>
<td>4B</td>
<td>73</td>
</tr>
<tr>
<td>L</td>
<td>114</td>
<td>4C</td>
<td>74</td>
</tr>
<tr>
<td>M</td>
<td>115</td>
<td>4D</td>
<td>75</td>
</tr>
<tr>
<td>N</td>
<td>116</td>
<td>4E</td>
<td>76</td>
</tr>
<tr>
<td>O</td>
<td>117</td>
<td>4F</td>
<td>77</td>
</tr>
</tbody>
</table>

-15-
<table>
<thead>
<tr>
<th>P</th>
<th>120</th>
<th>50</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
<td>121</td>
<td>51</td>
<td>81</td>
</tr>
<tr>
<td>R</td>
<td>122</td>
<td>52</td>
<td>82</td>
</tr>
<tr>
<td>S</td>
<td>123</td>
<td>53</td>
<td>83</td>
</tr>
<tr>
<td>T</td>
<td>124</td>
<td>54</td>
<td>84</td>
</tr>
<tr>
<td>U</td>
<td>125</td>
<td>55</td>
<td>85</td>
</tr>
<tr>
<td>V</td>
<td>126</td>
<td>56</td>
<td>86</td>
</tr>
<tr>
<td>W</td>
<td>127</td>
<td>57</td>
<td>87</td>
</tr>
<tr>
<td>X</td>
<td>130</td>
<td>58</td>
<td>88</td>
</tr>
<tr>
<td>Y</td>
<td>131</td>
<td>59</td>
<td>89</td>
</tr>
<tr>
<td>Z</td>
<td>132</td>
<td>5A</td>
<td>90</td>
</tr>
</tbody>
</table>

**TABLE 2.0**
<table>
<thead>
<tr>
<th>DEFINITION</th>
<th>OCTAL</th>
<th>HEX DECIMAL</th>
<th>DECIMAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUL</td>
<td>000</td>
<td>00</td>
<td>0</td>
</tr>
<tr>
<td>SOH</td>
<td>001</td>
<td>01</td>
<td>1</td>
</tr>
<tr>
<td>STX</td>
<td>002</td>
<td>02</td>
<td>2</td>
</tr>
<tr>
<td>ETX</td>
<td>003</td>
<td>03</td>
<td>3</td>
</tr>
<tr>
<td>EOT</td>
<td>004</td>
<td>04</td>
<td>4</td>
</tr>
<tr>
<td>ENQ</td>
<td>005</td>
<td>05</td>
<td>5</td>
</tr>
<tr>
<td>ACK</td>
<td>006</td>
<td>06</td>
<td>6</td>
</tr>
<tr>
<td>BEL</td>
<td>007</td>
<td>07</td>
<td>7</td>
</tr>
<tr>
<td>BS</td>
<td>010</td>
<td>0A</td>
<td>10</td>
</tr>
<tr>
<td>HT</td>
<td>011</td>
<td>0B</td>
<td>11</td>
</tr>
<tr>
<td>LF</td>
<td>012</td>
<td>0C</td>
<td>12</td>
</tr>
<tr>
<td>VT</td>
<td>013</td>
<td>0D</td>
<td>13</td>
</tr>
<tr>
<td>FF</td>
<td>014</td>
<td>0E</td>
<td>14</td>
</tr>
<tr>
<td>CR</td>
<td>015</td>
<td>0F</td>
<td>15</td>
</tr>
<tr>
<td>SO</td>
<td>016</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>SI</td>
<td>017</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>DLE</td>
<td>020</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>DC1</td>
<td>021</td>
<td>13</td>
<td>19</td>
</tr>
<tr>
<td>DC2</td>
<td>022</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>DC3</td>
<td>023</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>DC4</td>
<td>024</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>NAK</td>
<td>025</td>
<td>17</td>
<td>23</td>
</tr>
<tr>
<td>SYN</td>
<td>026</td>
<td>18</td>
<td>24</td>
</tr>
<tr>
<td>ETB</td>
<td>027</td>
<td>19</td>
<td>25</td>
</tr>
<tr>
<td>CAN</td>
<td>030</td>
<td>1A</td>
<td>26</td>
</tr>
<tr>
<td>EM</td>
<td>031</td>
<td>1B</td>
<td>27</td>
</tr>
<tr>
<td>SUB</td>
<td>032</td>
<td>1C</td>
<td>28</td>
</tr>
<tr>
<td>ESC</td>
<td>033</td>
<td>1D</td>
<td>29</td>
</tr>
<tr>
<td>FS</td>
<td>034</td>
<td>1E</td>
<td>30</td>
</tr>
<tr>
<td>GS</td>
<td>035</td>
<td>1F</td>
<td>31</td>
</tr>
<tr>
<td>RS</td>
<td>036</td>
<td>20</td>
<td>32</td>
</tr>
<tr>
<td>US</td>
<td>037</td>
<td>21</td>
<td>33</td>
</tr>
<tr>
<td>SP</td>
<td>040</td>
<td>22</td>
<td>34</td>
</tr>
<tr>
<td>!</td>
<td>041</td>
<td>23</td>
<td>35</td>
</tr>
<tr>
<td>#</td>
<td>042</td>
<td>24</td>
<td>36</td>
</tr>
<tr>
<td>$</td>
<td>043</td>
<td>25</td>
<td>37</td>
</tr>
<tr>
<td>%</td>
<td>044</td>
<td>26</td>
<td>38</td>
</tr>
<tr>
<td>&amp;</td>
<td>045</td>
<td>27</td>
<td>39</td>
</tr>
<tr>
<td>(</td>
<td>046</td>
<td>28</td>
<td>40</td>
</tr>
<tr>
<td>)</td>
<td>047</td>
<td>29</td>
<td>41</td>
</tr>
<tr>
<td>+</td>
<td>050</td>
<td>2A</td>
<td>42</td>
</tr>
<tr>
<td>,</td>
<td>051</td>
<td>2B</td>
<td>43</td>
</tr>
<tr>
<td>-</td>
<td>052</td>
<td>2C</td>
<td>44</td>
</tr>
<tr>
<td>.</td>
<td>053</td>
<td>2D</td>
<td>45</td>
</tr>
<tr>
<td>/</td>
<td>054</td>
<td>2E</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>055</td>
<td>2F</td>
<td>47</td>
</tr>
<tr>
<td>a</td>
<td>144</td>
<td>64</td>
<td>100</td>
</tr>
<tr>
<td>---</td>
<td>-----</td>
<td>----</td>
<td>-----</td>
</tr>
<tr>
<td>b</td>
<td>145</td>
<td>65</td>
<td>101</td>
</tr>
<tr>
<td>c</td>
<td>146</td>
<td>66</td>
<td>102</td>
</tr>
<tr>
<td>d</td>
<td>147</td>
<td>67</td>
<td>103</td>
</tr>
<tr>
<td>e</td>
<td>150</td>
<td>68</td>
<td>104</td>
</tr>
<tr>
<td>f</td>
<td>151</td>
<td>69</td>
<td>105</td>
</tr>
<tr>
<td>g</td>
<td>152</td>
<td>6A</td>
<td>106</td>
</tr>
<tr>
<td>h</td>
<td>153</td>
<td>6B</td>
<td>107</td>
</tr>
<tr>
<td>i</td>
<td>154</td>
<td>6C</td>
<td>108</td>
</tr>
<tr>
<td>j</td>
<td>155</td>
<td>6D</td>
<td>109</td>
</tr>
<tr>
<td>k</td>
<td>156</td>
<td>6E</td>
<td>110</td>
</tr>
<tr>
<td>l</td>
<td>157</td>
<td>6F</td>
<td>111</td>
</tr>
<tr>
<td>m</td>
<td>160</td>
<td>70</td>
<td>112</td>
</tr>
<tr>
<td>n</td>
<td>161</td>
<td>71</td>
<td>113</td>
</tr>
<tr>
<td>o</td>
<td>162</td>
<td>72</td>
<td>114</td>
</tr>
<tr>
<td>p</td>
<td>163</td>
<td>73</td>
<td>115</td>
</tr>
<tr>
<td>q</td>
<td>164</td>
<td>74</td>
<td>116</td>
</tr>
<tr>
<td>r</td>
<td>165</td>
<td>75</td>
<td>117</td>
</tr>
<tr>
<td>s</td>
<td>166</td>
<td>76</td>
<td>118</td>
</tr>
<tr>
<td>t</td>
<td>167</td>
<td>77</td>
<td>119</td>
</tr>
<tr>
<td>u</td>
<td>170</td>
<td>78</td>
<td>120</td>
</tr>
<tr>
<td>v</td>
<td>171</td>
<td>79</td>
<td>121</td>
</tr>
<tr>
<td>w</td>
<td>172</td>
<td>7A</td>
<td>122</td>
</tr>
<tr>
<td>x</td>
<td>173</td>
<td>7B</td>
<td>123</td>
</tr>
<tr>
<td>y</td>
<td>174</td>
<td>7C</td>
<td>124</td>
</tr>
<tr>
<td>z</td>
<td>175</td>
<td>7D</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>176</td>
<td>7E</td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>177</td>
<td>7F</td>
<td>127</td>
</tr>
</tbody>
</table>

**TABLE 3.0**
**Figure 1.0, "Header Block Format"**

```
| SOH | DEVICE IDENTIFIER | DC1 | BLOCK COUNT | TAIL NUMBER | AIRCRAFT TYPE | DC2 | ENGINE IDENTIFIERS | DC3 | FAULT CODES | DC4 | ADDITIONAL DATA | FS | ETX | BCC |
```

**Figure 2.0, "Text Block Format"**

```
| STX | BYTE COUNT | TRANSPARENT DATA | ETB OR ETX | BCC |
```

**Figure 3.0, "Device Identifier Field"**

```
| SOH | ..... | DC1 | BLOCK COUNT |
```

**Generic Identifier Field**

**Specific Identifier Field**
FIGURE 4.0, "EQUIPMENT INTERFACES"
INTERFACE ENABLED

A

RECEIVE ENQ?

YES

NO

ADR READY?

YES

NO

WAIT STATE

Fig. 5.10

TRANSMIT AVI

TRANSMIT NAK

INVALID

RECEIVE RESPONSE

NAK

ACK AVI

ACK RESPONSE?

RAVI

DOWNLOAD MODE

Fig. A1.1

FUNCTION MODE

Fig. A1.2

A

FIGURE A1.0, "ADR TO DCU COMMUNICATIONS"
Figure A1.2, "Function Mode"
FIGURE A1.3, "ILLEGAL OPERATION MODE"
FIGURE D1.0, "DCU TO ADR COMMUNICATIONS" (CONTINUED)
FIGURE D.1 "SPECIAL FUNCTION MODE"
FIGURE D1.1, (CONTINUED)
INITIATE

TRANSMIT END

NOTE 3

RECEIVE RESPONSE

WACK
TRANSMIT ACK

ACK

RECV

DCU EMPTY?

NO

YES

CONSTRUCT A HEADER WITH ZERO BLOCK COUNT + EMPTY DCU FAULT CODE

TRANSMIT HEADER MODE

FIG. 57.1 (ACK)

TRANSMIT TEXT MODE

FIG. 54.0 (ACK)

END

INITIALIZE MODE

FIG. 61.1

ALL DATA SENT?

NO

YES

FIGURE D91.0, "DCU TO GSC COMMUNICATIONS"
FIGURE G10, "GSC TO DCU COMMUNICATIONS"
FIGURE G1.1, "GSC TO DCH LOAD MODE"
Figure G1.2, "GSC to DLU Empty Mode"
**Figure S10, "Wait State Handshake"**

- **ENTER**
- **TRANSMIT NAK**
- **INVALID**
- **RECEIVE RESPONSE**
- **NAK**
- **ACK**
- **RETURN**

**Figure S20, "Retransmit Block Handshake"**

- **ENTER**
- **TRANSMIT NAK**
- **INVALID**
- **RECEIVE RESPONSE**
- **NAK**
- **SND STX**
- **RETURN**

-36-
**Figure S3.0, "Hold Line Handshake"**

**Figure S6.0, "Receive Header Mode"**
FIGURE 54.0, "TRANSMIT TEXT MODE"
Figure 55.0, "Receive Text Mode"
Figure 5.7.0, "Transmit Header Mode"
NOTES

(1) Device must be capable of distinguishing between an invalid control character (CC) and invalid start of block to know when to "NAK".

(2) The DCU transmits "ENG" per paragraph 3.2.3.8 until a valid response is received.

(3) Same as (2)

(4) The header loaded into the DCU from the GSC shall contain an ASCII encoded "!" per paragraph 3.2.2.1.7