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FORMATS FOR DABS DATA LINK APPLICATIONS.(U)
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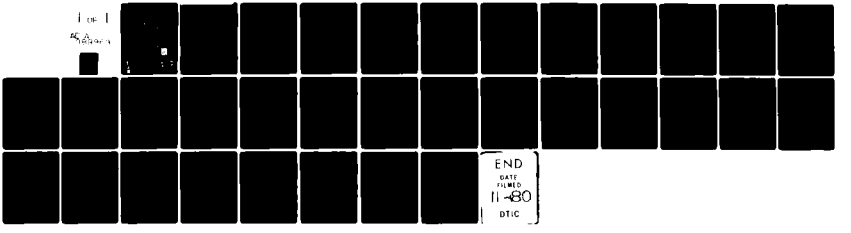

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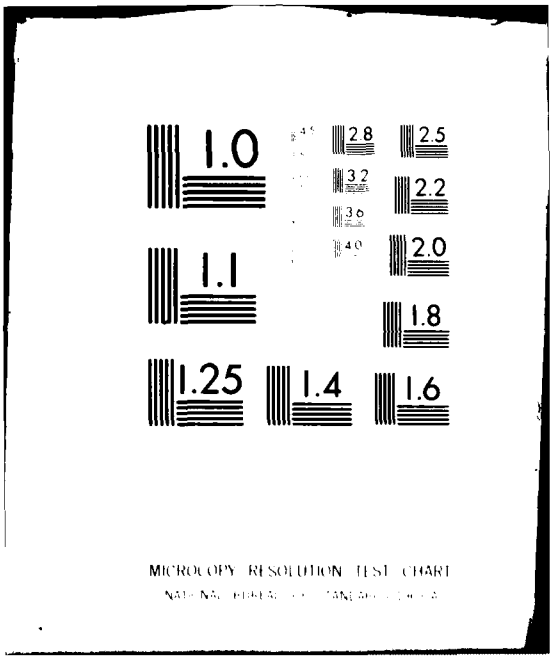
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16. Abstract

The purpose of this paper is to describe formats developed for transmitting aviation-related messages over the Discrete Address Beacon System (DABS) data link. Initial data link applications include:

(1) Minimum Safe Altitude Warning (MSAW) alerts (Terminal Area)
(2) Takeoff Clearance Confirmation
(3) Altitude Assignment Clearance Confirmation (Enroute)
(4) Weather Reports
  (a) Surface Observations
  (b) Terminal Forcasts
  (c) Pilot Reports
  (d) Winds Aloft
  (e) Hazardous Weather Advisories
  (f) Digitized Weather Radar Maps
(5) Enhanced Terminal Information Service (ETIS)
(6) Downlink of Airborne Measurements

The formats described in this paper cover the DABS communications formats for uplink messages from the DABS sensor to the airborne data link system, and the downlink messages from the aircraft. Downlink messages include pilot requests for routine weather information and ETIS service, pilot acknowledgements for uplink tactical messages, and airborne measurements.

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1.0 INTRODUCTION

The objective of the DABS data link applications development program is to develop, evaluate, and demonstrate the benefits and methods of using the DABS digital data link for transmitting aviation-related messages. The program is directed toward the development of an initial Technical Data Package for the implementation of a first level of DABS data link services to be enhanced and augmented later. The purpose of this paper is to outline the DABS data link formats developed for the initial applications.

The initial data link applications were developed using the DABS Experimental Facility (DABSEF) at M. I. T. Lincoln Laboratory in the summer and fall of 1979. The resultant system will be incorporated in the NAFEC ATC test facility for demonstration and evaluation. The applications to be demonstrated in the NAFEC tests are:

(1) Minimum Safe Altitude Warning (MSAW) alerts (Terminal Area)
(2) Takeoff Clearance Confirmation
(3) Altitude Assignment Clearance Confirmation (Enroute)
(4) Weather Reports
    (a) Surface Observations
    (b) Terminal Forecasts
    (c) Pilot Reports
    (d) Winds Aloft
    (e) Hazardous Weather Advisories
    (f) Digitized Weather Radar Maps
(5) Enhanced Terminal Information Services (ETIS)
(6) Downlink of Airborne Measurements

Figure 1.1 is a block diagram of the basic message flow for the NAFEC data link system. The formats outlined in this paper cover the DABS communications formats for uplink messages from the DABS sensor to the airborne data link system, and the downlink messages from the aircraft. Downlink messages include pilot requests for routine weather information and ETIS service, pilot acknowledgements of uplink tactical messages, and airborne measurements. The formats for the downlink airborne measurements are not included in this paper.

The formats for communications between the DABS sensor and external message sources and sinks are contained in Reference 1. External message interfaces in the NAFEC DABS sensors are the Terminal Automation Test Facility (TATF), the System Support Facility (SSF) and the data link Applications Processor (AP). The Minimum Safe Altitude Warning (MSAW) messages are generated in the TATF and the Altitude Assignment Clearance

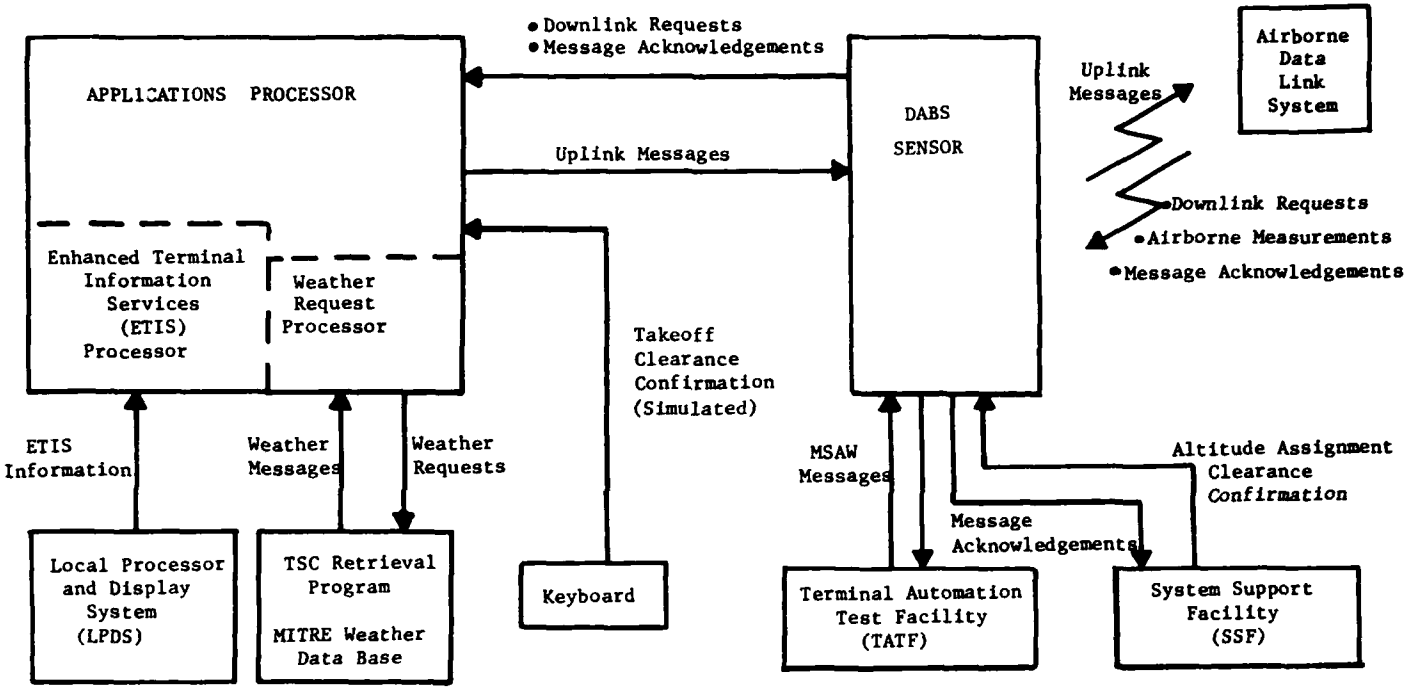


Fig. 1.1. DABS Data Link Communications Flow Diagram for NAFEC Tests and Evaluations.

Confirmation messages are generated in the SSF. The remaining uplink messages (Takeoff Clearance Confirmation, weather messages and ETIS messages) are delivered to the DABS sensors by the Applications Processor (AP).

Communications between the AP and its information sources are not included in this paper. The AP information sources are the Local Processor and Display System (LPDS) which provides ETIS information to the AP ETIS processor, the Transportation Systems Center (TSC) retrieval program which provides weather messages in response to pilot requests, and the keyboard input of simulated Takeoff Clearance Confirmation messages. In the field implementation, it is expected that the Terminal Information Processing System (TIPS) will be used to input the Takeoff Clearance Confirmation message.

Downlink messages are delivered to all message sinks by the DABS sensor, and it is the task of each message sink to recognize messages intended for that processor and disregard other downlink messages. Downlink requests for weather data and ETIS information are recognized by the AP processing routines. Downlink acknowledgments of uplink tactical messages are also recognized by the appropriate processors.

Section 2 outlines the general DABS communications formats which are used for the data link communications between the NAFEC DABS sensors and the DABS data link equipped aircraft. The formats for the ATC coordination messages and downlink acknowledgments are given in Section 3. The formats for the downlink weather requests and the resultant uplink weather messages are given in Section 4. The ETIS message formats are given in Section 5.

2.0 DABS COMMUNICATIONS FORMATS

The general structure of the DABS communications formats are illustrated in Figure 2.1. DABS data link information is transferred from the ground sensor to DABS data link aircraft in Comm-A and Comm-C interrogations, and air-to-ground data link information is delivered in Comm-B and Comm-D replies. The following discussion of the data link formats focuses on the content of the message fields in the interrogations and replies. Definitions of the contents of the Link Control Fields, Special Designator Field and Address/Parity Fields are available in reference 2.

Comm-A interrogations include a 56-bit field (MA field) for the transmission of ground-to-air information. Comm-B replies contain 56-bits of air-to-ground information in the MB field. The Comm-A and Comm-B messages are designed to handle tactical message applications, and other applications where the message content can be encoded in the 56-bit field.

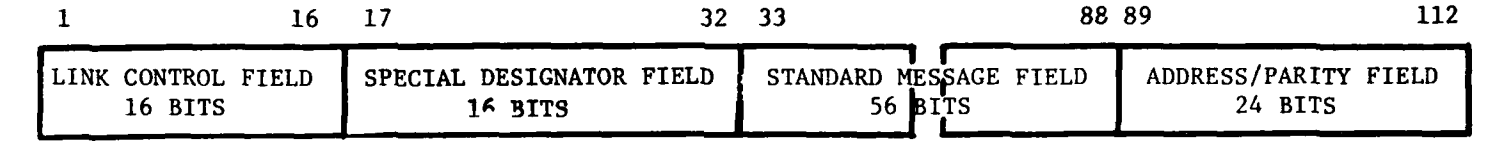
The Comm-C interrogations and Comm-D replies are used for the more efficient transmission of long data link messages. Each Comm-C uplink transmission includes an 80-bit message field (MC field), and up to 16 Comm-C interrogations may be acknowledged by a single transponder reply. Each Comm-D reply includes an 80-bit message field (MD field), and up to 16 Comm-D replies may be transmitted as a single long response. The delivery of multiple message fields in a single interrogation or reply cycle provides an Extended Length Message (ELM) capability. The Comm-C format is used in the initial data link applications for long ground-to-air data link messages. The Comm-D format is not required for any of the initial applications.

2.1 Comm-A Message Structure

Comm-A interrogations are used to deliver uplink messages which are tactical in nature, or messages that are easily encoded in a single Comm-A interrogation. The limited size of the MA field precludes the delivery of long text messages.

The MA field of a Comm-A interrogation consists of an 8-bit Comm-A definition subfield (ADS) followed by a 48-bit data subfield. The ADS code defines the message type and the interpretation of the remaining 48-bit data subfield. The use of the ADS code allows the data subfield coding to change from application to application, increasing the flexibility of the Comm-A message structure.

A set of sixteen ADS codes are assigned for Comm-A data link messages. These messages are simple text messages consisting of an alphabetic letter field followed in most cases by a numeric field. Letters are encoded using a 5-bit character code and number characters are encoded using a 4-bit character code (Table 2.1). The data link ADS codes and the corresponding content of the data subfields are given in Table 2.2.



NORMAL (COMM-A, COMM-B)

EXTENDED LENGTH (COMM-C, COMM-D)

Fig. 2.1. DABS Communications Formats.

TABLE 2.1 COMM-A DATA LINK CHARACTER SETS

	5-Bit Letter Code				4-Bit Number Code		
	b5	0	0	1	1	b4	0	1
	b4	0	1	0	1			
b3 b2 b1								
0 0 0	Space		H	P	X		0	8
0 0 1	A		I	Q	Y		1	9
0 1 0	B		J	R	Z		2	L
0 1 1	C		K	S	/		3	R
1 0 0	D		L	T	*		4	Space
1 0 1	E		M	U	?		5	/
1 1 0	F		N	V	-		6	C
1 1 1	G		O	W	&		7	.

TABLE 2.2 COMM-A DATA LINK MESSAGE TYPES

Priority ADS	Non-Priority ADS	Data Subfield Content
01000001	01000000	2 Letters, 9 Numbers
01000011	01000010	3 Letters, 8 Numbers
01000101	01000100	4 Letters, 7 Numbers
01000111	01000110	5 Letters, 5 Numbers
01001001	01001000	6 Letters, 4 Numbers
01001011	01001010	7 Letters, 3 Numbers
01001101	01001100	8 Letters, 2 Numbers
01001111	01001110	9 Letters

The sixteen ADS codes define eight basic message types which can be designated as priority messages or non-priority messages. The data subfield coding is identical for each priority ADS code and the corresponding non-priority ADS code in Table 2.2. The priority ADS code alerts the airborne display equipment that the message is a priority messsage, and is independent of the priority bit associated with the DABS ground communications of Comm-A messages (reference 1).

The letter field of these formats is used to define the message type, and the number field is used to deliver any corresponding numeric quantities. Standard contractions (reference 3) are used in the letter field to designate the message type. If the message is displayed as transmitted, a space is assumed between the letter field and the number field. "Maintain Flight Level 190" would be delivered as "MNTN FL 190", using an ADS code of 01001010. This message could be displayed as transmitted, or expanded to provide a full text presentation.

The Comm-A data link formats defined by Table 2.2 are designed to provide a flexible message structure for data link Comm-A applications. The message structure defined by the formats exceeds the requirements of the initial applications, and it is anticipated that it will be utilized for additional data link applications as they are implemented.

The Comm-A data link formats are used for ATC coordination messages and ETIS messages in the initial applications. The message coding for the individual messages is discussed in Sections 3 and 5.

2.2 Comm-B Message Structure

Comm-B replies include a 56-bit field for the transmission of air-to-ground messages. Comm-B replies are used in the initial data link applications to downlink pilot requests for weather data, and to downlink pilot acknowledgements of uplink tactical messages.

The Comm-B message structure is identical to the Comm-A message structure. The Comm-B message field consists of an 8-bit Comm-B definition subfield (BDS) followed by a 48-bit data subfield. The BDS code defines the interpretation of the data subfield.

The BDS codes assigned to initial data link applications are given in Table 2.3. The sixteen BDS codes reserved for pilot acknowledgement of uplink messages correspond to the ADS codes given in Table 2.2.

TABLE 2.3 COMM-B DATA LINK MESSAGE TYPES

BDS CODE	MESSAGE TYPE
01000000- 01001111	Pilot Acknowledgement of Uplink Comm-A Messages
01010000	Pilot Requests for Weather Data

Pilot acknowledgement of uplink messages is covered in Section 3. Pilot requests for weather data is covered in Section 4.

2.3 Comm-C Message Structure

Comm-C interrogations are used for transmitting long ground-to-air messages. Each Comm-C interrogation includes 80-bits for communications, and up to 16 Comm-C interrogations can be delivered to the aircraft as an Extended Length Message (ELM). Comm-C interrogations are used in the initial data link applications to deliver weather messages and several of the ETIS messages.

The first 8-bits of the 80-bit MC field of the first Comm-C segment contain the Comm-C definition subfield (CDS) code. The CDS code defines the interpretation of the remainder of the Comm-C message. The two CDS codes assigned to the initial data link applications are given in Table 2.4.

TABLE 2.4. COMM-C DATA LINK MESSAGE TYPES

CDS CODE	MESSAGE TYPE
01000001	Free-text Messages
01000010	Digitized Weather Radar Maps

Most Comm-C data link applications utilize the CDS code of 01000001, which indicates a free-text message using 6-bit character coding. The 2 bits following the CDS code are reserved for ELM message extension. The text message is contained in the remaining 70 bits of the first Comm-C segment and the 80-bit MC-fields of the subsequent Comm-C segments. A 16-segment Comm-C message contains up to 211 characters.

The 6-bit character coding used in the Comm-C free text messages is a modified 6-bit ASCII code (Table 2.6), with b6 transmitted first. Four changes to the standard character definitions are included in this character set. The changes preclude the use of "[", "]", "^" and "@" in the uplink message texts, and replaces them with control characters to indicate start/stop of priority color, carriage return/line feed and end-of-message. The combined carriage return/line feed character is used for logical breaks in the free text message. It is the responsibility of the airborne data link equipment to produce normal carriage return/line feeds based on the characters/line of the output device.

If the uplink message exceeds the 211 character capacity of a 16-segment ELM, the 2 bits following the CDS code in the first segment are used to indicate linked ELM messages. The two message extension bits (ME-field) are defined in Table 2.5. The initial segment of intermediate and final ELMs contain the appropriate CDS field and ME field, and the remainder of the

MC fields contain sequential text information. In the case of linked ELMs, each ELM contains up to 211 characters. Zero padding is used to fill all unused areas of the data field.

TABLE 2.5. ME-FIELD DEFINITIONS

ME-FIELD	MEANING
00	Text Message is contained in a single ELM
01	Initial ELM of multiple-ELM text message
10	Intermediate ELM of multiple-ELM text message
11	Final ELM of multiple-ELM text message

TABLE 2.6. 6-BIT CHARACTER SET

BIT NUMBERS	b6	0	0	1	1
	b5	0	1	0	1
b4 b3 b2 b1					
0 0 0 0		ETX	P	SP	0
0 0 0 1		A	Q	!	1
0 0 1 0		B	R	"	2
0 0 1 1		C	S	#	3
0 1 0 0		D	T	$	4
0 1 0 1		E	U	%	5
0 1 1 0		F	V	&	6
0 1 1 1		G	W	'	7
1 0 0 0		H	X	(	8
1 0 0 1		I	Y	)	9
1 0 1 0		J	Z	*	:
1 0 1 1		K	PS	+	;
1 1 0 0		L	\	,	<
1 1 0 1		M	PE	-	=
1 1 1 0		N	CR	.	>
1 1 1 1		O	_	/	?

Special Character Meanings:

SP = Space
ETX = End of Message Text
PS = Start Priority Color
PE = Stop Priority Color
CR = Carriage Return/Line Feed

3.0 ATC COORDINATION MESSAGES

ATC messages identified to date, both the initial applications and potential follow-on applications, are highly structured messages which often require rapid delivery to the airborne display system. This type of data link application lends itself to Comm-A message delivery since the message can be delivered on a priority basis, and the information content of the message can be encoded within the available message field.

The Comm-A text formats outlined in Section 2.1 are utilized for the ATC coordination messages. Sections 3.1 to 3.3 detail the messages used for the initial ATC applications. Section 3.4 covers the Comm-B format associated with the pilot acknowledgement of ATC messages.

3.1 Minimum Safe Altitude Warning (MSAW) Alerts

The ARTS III processors include MSAW algorithms which provide the controller with a visual warning and an aural alarm when tracked Mode-C equipped aircraft are projected to violate altitude criteria programmed into the ARTS III computer. The DABS data link MSAW message extends the MSAW algorithm by automatically providing the same alert to DABS data link equipped aircraft.

Data link MSAW messages consist of two messages types. One is used to provide the MSAW alert and the second to clear the alert. The MSAW alert message contains the contraction "MSAW" and includes the minimum safe altitude value, in feet, in the number field. This message is delivered to the aircraft each scan as long as the MSAW alert is active. When the MSAW alert is dropped, a clear-MSAW message is delivered to the aircraft to clear the alert from the cockpit display. In the event that the clear-MSAW message is not received by the aircraft, the airborne display system clears the MSAW message if it has not been updated in the last 15 seconds.

MSAW ALERT

01000101	01101	10011	00001	10111	1100	1100	1100	0001	0101	0000	0000
ADS	M	S	A	W	← spaces		→	1	5	0	0

Clear-MSAW

01001110	01101	10011	00001	10111	00000	00011	01100	10010	00000	000
ADS	M	S	A	W	space	C	L	R	space	

Fig. 3.1. Comm-A MA Field for MSAW Alert and Clear-MSAW Examples Messages.

Examples of an MSAW alert for 1500 feet and a clear-MSAW message are given in Fig. 3.1. The ADS code of the MSAW alert, 01000101, identifies the message as a priority Comm-A containing 4 letters and 7 numbers. The letter field contains the contraction "MSAW" and the number field contains the minimum safe altitude value. The Clear-MSAW message uses an ADS code of 01001110 which indicates a non-priority message containing 9 letters. The Clear-MSAW message contains the message "MSAW CLR ".

3.2 Altitude Assignment Clearance Confirmation

The Altitude Assignment Clearance Confirmation message is an uplink message to the cockpit of the altitude to which the enroute controller has cleared the aircraft. The message provides the pilot with a visual confirmation of the standard voice clearance. The message is triggered by the controller keyboard input of the assigned altitude. The keyboard entry is used as standard procedure to enter the assigned altitude into the aircraft data block on the controller's display. If the aircraft is a DABS data link equipped aircraft, the assigned altitude value can be uplinked to the aircraft as a confirmation of the voice clearance.

There are three basic message types associated with the Altitude Assignment Clearance Confirmation. These are "Maintain", "Climb to and Maintain" and "Descend to and Maintain". The ADS code 01001010 is used for these messages. This defines a non-priority message composed of 7 letters and 3 numbers.

For the "Maintain" message, the contraction "MNTN" is used. For the "Climb to and Maintain" message, the contraction "CTAM" is used. For the "Descend to and Maintain" message, the contraction "DTAM" is used. The number field for all three messages contains the assigned altitude in hundreds of feet. If the altitude is to be provided as a flight level, the letter field includes the contraction "FL" as part of the message.

Examples of Altitude Assignment Clearance Confirmation messages are given below.

MAINTAIN 5000 FEET

01001010	01101	01110	10100	01110	00000	00000	00000	0	1100	0101	0000
ADS	M	N	T	N	space	space	space		space	5	0

CLIMB TO AND MAINTAIN FLIGHT LEVEL 230

01001010	00011	10100	00001	01101	00000	00110	01100	0	0010	0011	0000
ADS	C	T	A	M	space	F	L		2	3	0

DESCEND TO AND MAINTAIN 12000 FEET

01001010	00100	10100	00001	01101	00000	00000	00000	0	0001	0010	0000
ADS	D	T	A	M	space	space	space		1	2	0

Fig. 3.2. Comm-A MA Field for Altitude Assignment Clearance Confirmation Examples.

3.3 Takeoff Clearance Confirmation

The Takeoff Clearance Confirmation message is an uplink message to the cockpit which confirms the takeoff clearance issued verbally by the controller. The ADS code 01001010 is used for this application, and indicates a non-priority message made up of 7 letters and 3 numbers. The letter portion of the Comm-A contains the word "TAKEOFF", and the number portion is used to identify the Runway number. The "L", "R" and "C" characters in the 4-bit number code of Table 2.1 are included for runway designations. Figure 3.3 illustrates a Comm-A message for a takeoff clearance confirmation for runway 27 right (27R).

01001010	10100	00001	01011	00101	01111	00110	00110	0	0010	0111	1011
ADS	T	A	K	E	O	F	F		2	7	R

Fig. 3.3. Comm-A MA Field for Takeoff Clearance Confirmation Example.

3.4 ATC Message Acknowledgement

The initial ATC data link messages are designed to provide the pilot with a visual confirmation of the corresponding ATC voice messages. The messages are not intended to replace the existing voice communications in the initial stages of the DABS data link implementation, but simply provide a verification of the voice messages.

In anticipation of a time when data link could be used for actual delivery of the ATC message, a "WILCO" function is provided in the Comm-B formats. The downlink acknowledgement of ATC messages is a Comm-B reply in which the 56-bit MB field contains the 56-bit MA field corresponding to the message on the cockpit display at the time of the pilot acknowledgement. The downlink "echo" of the Comm-A message field resolves ambiguities in the event that tactical uplink messages are revised.

4.0 WEATHER MESSAGES

Weather information is currently available on the ground, but must be provided to pilots by voice communications. With the introduction of DABS this information can be delivered to the cockpit over the DABS data link. Included in the initial data link applications are downlink pilot requests for selected weather products. The resultant weather messages obtained from a National Weather Service data base are displayed to the pilot on a cockpit display device. The DABS message formats associated with weather messages are outlined in this section.

4.1 Downlink Weather Requests

Pilot requests for weather data are transmitted from the aircraft to the DABS sensor as Comm-B messages. The general format for the Comm-B message field of the weather request messages is given below.

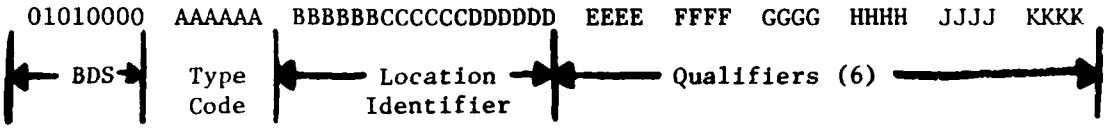


Fig. 4.1. Comm-B Message Field for Pilot Weather Requests.

The BDS code of 01010000 identifies the Comm-B message as a pilot request message. The type code (AAAAAA) identifies the particular weather product. The three character location identifier (LOCID) is required for all weather products and is coded in the modified 6-bit ASCII coding given in Table 2.6. The six qualifiers are used to define numerical quantities, such as time, associated with the requests. The interpretation of the weather product type codes and the qualifiers are summarized in Table 4.1 for the initial data link weather products. The ETIS request message is also included in the table for completeness, and is covered in Section 5.1.

Surface observation requests and hazardous weather advisory requests are fully defined by the appropriate type code and the LOCID. The qualifier field is not used for these requests. Terminal forecast requests and pilot report requests are defined by the appropriate type code, the LOCID, and the GMT time in hours. The first eight bits of the qualifier subfield (EEEE FFFF) are interpreted as a two digit time quantity using the 4-bit number code of Table 2.1. Winds aloft forecast requests are defined by the type code, the LOCID, the GMT time and the altitude. GMT time is encoded the same as the terminal forecast and pilot report requests. Altitude in thousands of feet is encoded as a two digit quanitity using the 4-bit number code of Table 2.1. To illustrate the Comm-B request format, an example of a winds aloft request for Boston (LOCID of BOS) for 1300Z at 26,000 feet is illustrated in Fig. 4.2.

TABLE 4.1. FIELD DEFINITIONS OF COMM-B PILOT WEATHER REQUESTS

Weather Product	Type Code AAAAAA	Qualifiers EEEE	FFFF	GGGG	HHHH	JJJJ	KKKK
Surface Observation	000001						
Terminal Forecast	000010	Time (GMT Hours)		NOT USED			
Pilot Reports	000011	Time (GMT Hours)					
Winds Aloft Forecast	000100	Time (GMT Hours)		Altitude			
Digitized Weather Radar Map	000101	Offset	NOT USED	X-Dimension		Y-Dimension	
ETIS	000110	ETIS Request Items - see Section 5.1					
Hazardous Weather Advisories	000111	NOT USED					

NOTES:

1. Time in GMT hours is encoded as a two digit quantity using the 4-bit number code of Table 2.1.

2. Altitude in thousands of feet is encoded as a two digit quantity using the 4-bit number code of Table 2.1.

3. The 4-bit field of the Weather Radar Map offset (EEEE) represent north, east, south and west respectively.

4. The 6 request qualifiers in the ETIS request correspond to the particular data items desired (see Section 5.1).

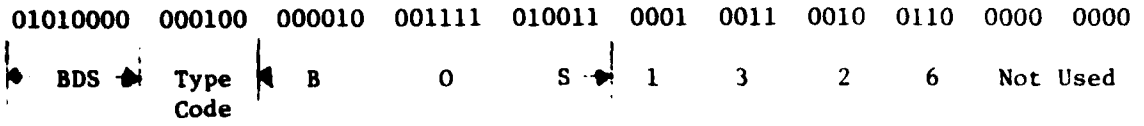


Fig. 4.2. Example Comm-B Message Field for Winds Aloft Request.

The digitized weather map is a semi-graphical presentation of precipitation intensity near a specified location. Pilot requests for the digitized maps include the X and Y dimensions of the desired weather map. The dimensions correspond to the number of characters per line (X) and the total number of lines (Y) available for the actual weather map presentation. This allows the weather map request to be tailored to the device which will be used to display the map. The dimensions are encoded as two two-digit numbers using the 4-bit number code of Table 2.1. The offset field of the request (EEEE) is used to indicate the North, East, South, West offset relative to the LOCID. An offset field value of 0110 corresponds to Southeast and will result in the LOCID being located in the upper lefthand corner of the map.

If a digitized weather radar summary were desired for the area west of Oklahoma City (LOCID OKC), and the map were to be displayed on a display area of 10 lines of 26 characters, the pilot request would be as shown in Fig. 4.3. The Y dimension is given as 9 since one line would be required for the map title. An example of a uplink response to this request is given in the following section.

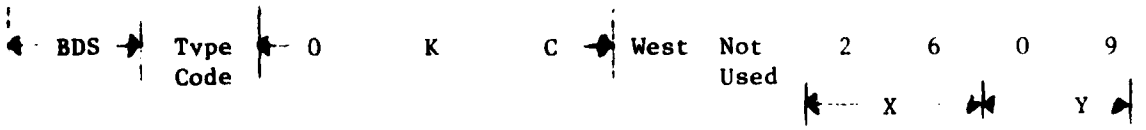


Fig. 4.3. Example of Comm-B Message Field for Digitized Weather Radar Summary Request.

4.2 Weather Product Messages

With the exception of digitized weather radar summaries, weather product messages are alphanumeric text messages delivered as Comm-C messages. The

format for such messages is outlined in Section 2.3. The Comm-C format for the digitized weather radar maps is given in this section.

The digitized weather radar summary is a semigraphical description of precipitation intensities about a specified LOCID, and are delivered to the aircraft in one or more Comm-C ELM messages. The weather map information is encoded in a four bit character set which allows a combination of character coding and run length coding. The choice between the available coding strategies is made on the ground so as to minimize the number of bits required to encode each map for transmission.

An example of a digitized weather radar map presentation for an alpha-numeric display device is given in Figure 4.4. The first line contains the location identifier (LOCID), the precipitation intensity in the area of the LOCID, GMT time and dimensions associated with the map. The digitized weather radar map is represented by a rectangular display of characters, each character representing a 22 x 22 nautical miles area. Precipitation levels range from 1 to 6, 1 being the lowest measurable intensity and 6 the highest. A "?" indicates that the precipitation level is missing. Blanks indicate no precipitation, and dots delineate state boundaries where blanks appear. The corners of the map are denoted by the "+" character, and the "*" locates the reference point (LOCID) of the map. The precipitation level for the area corresponding to the LOCID character follows the LOCID name on the first line.

```
OKC  (2)  1510Z 572x198 NM
+           .........1111+
............          11 2
            ........     3
     ??     .      .    112
   11111    .      .    21*
  122221    .      .    121
 11223221   1      .     11
11122322111111     ..
+ 12211212  .         ....+
```

Fig. 4.4. Example of Digitized Weather Radar Summary.

The initial segment of a Comm-C digitized weather radar map message contains the header information at the top of the map. The format for the initial segment is given in Figure 4.5. The CDS code, 01000010, identifies the Comm-C message as a digitized weather radar summary. The ME-field is the message extension field which is used to link multiple ELM messages when the weather map exceeds the coding space of a 16-segment Comm-C message. The message extension field is identical to the ME-field given in section 2.3 for Comm-C text messages. The three character LOCID is encoded with the six bit character set of Table 2.6. The precipitation intensity at the LOCID is

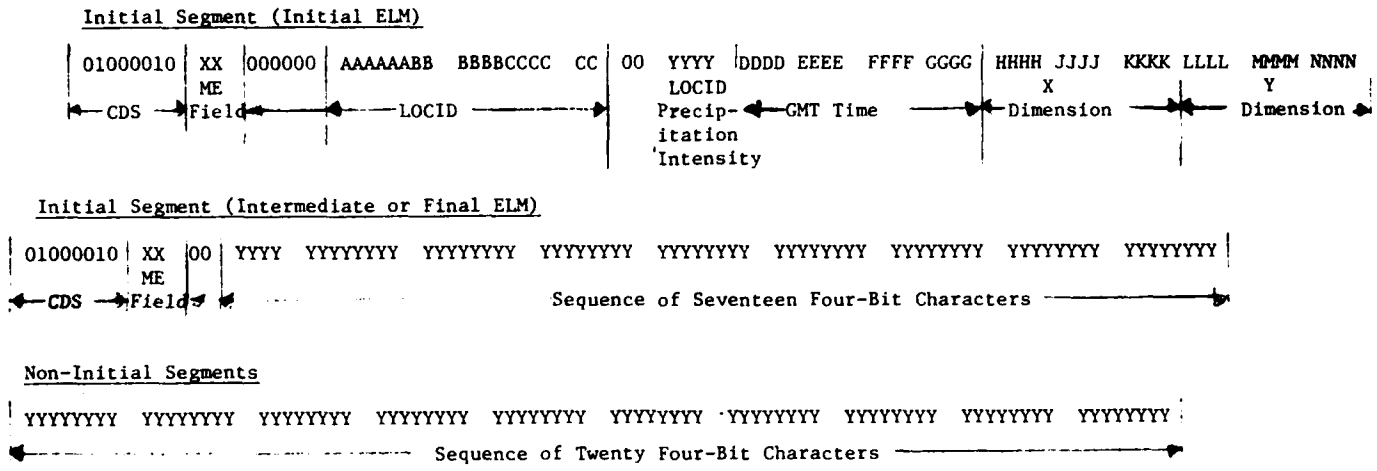


Fig. 4.5. Comm-C MC-Field for Digitized Weather Radar Map.

encoded with the four bit character set of Table 4.2 discussed below. The remaining data quantities are encoded in the 4-bit numeric code of Table 2.1, and include the four digit valid time and two three-digit dimensions of the map. The map dimensions correspond to the horizontal (X) and vertical (Y) extent of the map in nautical miles.

With the exception of the initial segment, the 80-bit message fields of each ELM segment contain weather map information. The 80-bit fields are divided into a sequence of twenty characters each represented by four bits. A total of 300 characters can be encoded in the initial ELM, although the information content can exceed 300 characters by the use of run length coding. If more than 300 characters are required to encode the weather map, additional ELM messages can be linked to the initial ELM by the ME-field. The initial segment of subsequent ELM messages contain the CDS code for the weather radar map, 01000010, the appropriate ME-field and 17 map characters. The two bits following the ME field are padded with zeros in the initial segment of the subsequent ELM messages. The remaining segments of subsequent ELM messages contain twenty characters, as in the initial ELM.

The character set used for the digitized weather radar maps is given in Table 4.2. The first eleven characters are the output characters used for the weather map, and the last five are control characters that do not appear explicitly as outputs. The two carriage return/line feed characters provided are used to identify the primary encoding strategy utilized on the next line of the map. CR_1 indicates character coding will be used until the next carriage return. The "TAB" and "REPEAT" control characters are used to signal the use of limited run length coding when full run length coding between carriage returns is not warranted.

TABLE 4.2. CHARACTER SET FOR DIGITIZED WEATHER RADAR MAPS

Four-Bit Field	Hexidecimal Value	Character Set	
0000	0	SPACE	
0001	1	1	
0010	2	2	Weather
0011	3	3	Map
0100	4	4	Characters
0101	5	5	
0110	6	6	
0111	7	?	
1000	8	*	
1001	9	+	
1010	A	.	
1011	B	CR_1	
1100	C	CR_2	Control
1101	D	TAB	Characters
1110	E	REPEAT	
1111	F	END-OF-DATA	

CR_1: Carriage Return/Line Feed - Use Character Coding for Next Line

CR_2: Carriage Return/Line Feed - Use Run Length Coding for Next Line

TAB: Output N + 3 blanks where N is the next four bit character

REPEAT: Output the preceeding character N + 4 times were
N is the next four bit character

In the character coding, the weather map information is encoded directly using the first eleven characters of Table 4.2. For run length coding, two character sets (eight bits per set) are used to define the character and its run length. The first character of the set must be a weather map character and the second four bit character defines the run length. Since a run length of zero has no meaning, the run length is N + 1 where N is the numeric value of the run length character. A run length character of 1100 (Hex C) has a numeric value of 12 and defines a run length of 13.

If character coding were used, the first line of the weather map in Figure 4.4 would be encoded as:

"+ .....1111+"

following a CR_1. If run length coding were employed the same line would be encoded:

"+0 A.813+0"

following a CR_2. The run length encoding uses two character sets to define the character and its run length, so "+0" defines a "+", " A" defines 11 blanks, ".8" defines a run of 9 "." characters, "13" defines "1111", and "+0" decodes as a "+".

When character coding is used, the "TAB" and "REPEAT" control characters provide a limited run length encoding capability within the character encoded string. Specifically, the tab character indicates that the next four bit word is to interpreted as a run length indicator for blanks. Since no gain is achieved for cases of one or two blanks, the number of blanks is N + 3 where N is the numeric value of the word following the tab. In a similar vein, the repeat character is used to indicate limited run lengths for other map characters. The four bit word following the repeat character indicates the number of times the output character preceding the repeat character is to be output. Since there is no benefit in using the repeat character unless the output sequence is four or more characters long, the actual run length is N + 4. Thus following a CR_1, the five character sequence "3 2 TAB 4 5" yields a ten character output of "32 5". The five character sequence "3 4 REPEAT 2 3" following a CR_1 yields an eight character output of "34444443". The final line of Figure 4.4 would be character coded as:

"+ 12211212 . ....+"

following a CR_1. Limited run length encoding could be used to encode the sequence of eight blanks and four periods at the end of the line. The 12 character sequence could be replaced by the five character sequence "TAB 5 . REPEAT 0".

5.0 ENHANCED TERMINAL INFORMATION SERVICE (ETIS) MESSAGES

The Enhanced Terminal Information Service (ETIS) is a flight advisory service which provides information to the pilot to assist him in conducting a safe approach to or departure from an airport. It includes all information currently provided by the Automated Terminal Information Service (ATIS), plus other data such as weather alerts which pertain to the airport of interest. (Reference 4).

The ETIS system to be demonstrated at NAFEC includes downlink pilot requests associated with the ETIS service and a variety of uplink response messages. The uplink ETIS messages include the basic ETIS message, updates to the basic ETIS message, Wind Shear Alerts and Final Approach data messages.

5.1 Downlink ETIS Requests

Pilot initiated ETIS requests utilize the same Comm-B format as weather request messages discussed in Section 4.1. The Comm-B message field of the ETIS request message is given in Fig. 5.1.

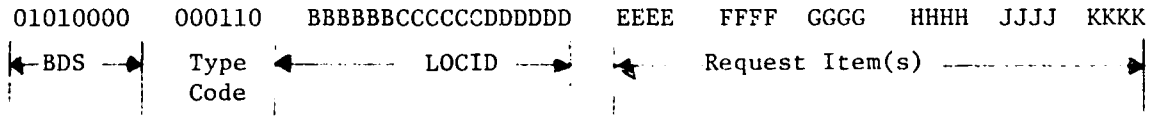


Fig. 5.1. Comm-B Message Field for ETIS Requests.

The BDS code identifies the Comm-B as a pilot request message, and the type code (000110) identifies the request as an ETIS request. The 3-character location identifier (LOCID) is coded in the modified 6-bit ASCII coding given in Table 2.6. The 6 Request Item codes identify the specific type of ETIS service desired.

When the pilot wishes to request or change ETIS service, an ETIS menu is displayed on the cockpit display. An example of one possible ETIS menu is shown in Fig. 5.2.

```
ETIS REPORT REQUEST LOC ID __
             UPDATES? Y/N __
REPORT TYPES:

1-FULL ETIS     2-SKY CONDITIONS
3-VISIBILITY    4-WINDS
5-ALTIMETER     6-RVR
7-TEMP/DEW PT   8-RWY/APR IN USE
9-ADVISORIES    0-DISCONTINUE
```

Fig. 5.2. Example ETIS Request Menu.

The report types selected by the pilot are delivered to the ground in the request items field of the Comm-B ETIS request. Table 5.1 defines the interpretation of the request items.

TABLE 5.1. ETIS REQUEST ITEMS

Request Item	ETIS Service/Item Desired
0000	No meaning
0001	Full ETIS
0010	Sky conditions
0011	Visibility/Precipitation
0100	Winds
0101	Altimeter
0110	RVR
0111	Temperature/Dewpoint
1000	Runway(s)/Approach(es) in use
1001	General Text Messages
1010	Discontinue ETIS service
1011	Updates requested
1100-1111	Not used

Six request items can be delivered in a single ETIS request from the aircraft. If more than six request items are required to handle the particular ETIS request, the request is delivered in two Comm-B replies.

5.2 Basic ETIS Message

The basic ETIS message is similar to the current ATIS message, and is delivered to DABS data link equipped aircraft as they approach the terminal area. Departing aircraft can also request the information in a downlink ETIS request. The basic ETIS message includes the following items of information.

(1) Location Identifier (LOCID) of the airport
(2) Time of Day
(3) Sky condition
(4) Prevailing visibility and Precipitation
(5) Centerfield Wind
(6) Temperature and Dewpoint
(7) Altimeter Setting
(8) Runway(s) in use (Approach and Departure)
(9) Runway Visual Range (RVR) if conditions warrant
(10) Advisories

The basic ETIS message is delivered to the cockpit in the Comm-C free-text format outlined in section 2.3.

If a pilot requests ETIS service for a location from which ETIS information is not available, an uplink Comm-C free text message is used to alert the pilot that the service is not available. If the weather sensors providing data to the ETIS ground processor fail, uplink Comm-C free text messages are delivered to all affected aircraft.

5.3 Final Approach Messages

Pilots requesting ETIS service receive wind and visibility measurements during the final approach to the airport served by the ETIS processor. The final approach ETIS messages are tactical uplink messages and are delivered to the aircraft using the Comm-A data link structure outlined in Section 2.1. The final approach information is updated as often as once each scan if changing conditions warrant.

Final approach wind information uses an ADS code of 01000010 or 01000011, depending on the prevailing conditions. These formats identify a message containing three letters and eight numbers. The letter field contains the contraction "WND" and the number field contains the wind information. The eight characters of the number field include two characters for wind direction in tens of degrees, two characters for wind speed in knots and two characters for wind gust values in knots. The three numeric fields are separated by "/" characters. An example of a final approach wind message is given in Fig. 5.3. The message indicates winds from 310 degrees at 12 knots with gusts to 20 knots.

01000010	10111	01110	00100	0 0011	0001	1101	0001	0010	1101	0010	0000
ADS	W	N	D	3	1	/	1	2	/	2	0

Fig. 5.3. Comm-A MA Field for Final Approach Wind Measurement Example Message.

Final approach visibility information is the prevailing visibility or the runway visual range (RVR), whichever is appropriate for the approach in use and the conditions. For RVR messages, an ADS code of 01000010 or 01000011 is used as in the final approach wind messages. The three letter field contains the contraction "RVR" and the number field contains the RVR measurements for touchdown, mid-point and rollout in hundreds of feet. Slashes are used to separate the three values. If RVR measurements are not available for the approach being used, the centerfield RVR is delivered as the mid-point value and the touchdown and rollout values are left blank.

If prevailing visibility is used for the final approach visibility message, the ADS code 01000010 is used. The three letter field contains "VIS" and the number field contains the prevailing visibility in miles.

Figure 5.4 contains examples of the Comm-A message fields for final approach visibility messages. The first message indicates a touchdown RVR of 2600 feet, a mid-point RVR of 2700 feet and a rollout RVR of 1900 feet. The second message indicates a prevailing visibility of 2 1/2 miles.

01000010	10010	10110	10010	0	0010	0110	1101	0010	0111	1101	0001	1001
ADS	R	V	R		2	6	/	2	7	/	1	9
01000010	10110	01001	10011	0	1100	0010	1100	0001	1101	0010	1100	1100
ADS	V	I	S			2		1	/	2		

Fig. 5.4. Comm-A MA Field for Final Approach Visibility Example Messages.

5.4 ETIS Alert Messages

The ETIS concept includes alert messages for wind shear, inordinate pressure or temperature changes, and thunderstorm warnings. Wind shear alerts are included in the initial NAFEC ETIS system. Formats for other ETIS alert functions will be added as they are implemented. Wind shear alerts are based on the comparison of centerfield winds with wind sensors located on the airport boundary. A wind shear alert is triggered if the vector difference between the centerfield wind and any boundary sensor exceeds 15 knots.

Two types of wind shear alert message are possible. The single sensor wind shear message includes the centerfield wind, the boundary sensor wind, and an identifier designating the boundary sensor triggering the alert. If several sensors indicate wind shear conditions, the wind shear message simply indicates the existence of wind shear conditions but does not include specific wind information.

Wind shear messages are delivered as priority Comm-A messages using the Comm-A message structure outlined in Section 2.1. The general wind shear message uses an ADS code of 01001111 which indicates a priority message containing nine letters. The letter field contains the message "WND SHEAR". The single sensor wind shear message uses an ADS code of 01000001 which indicates a priority message containing 2 letters and 9 numbers. The two letters of the single sensor wind shear message contain the direction identifier of the boundary sensor triggering the alert. Valid identifiers are " N", " E", " S",

" W", "NE", "NW", "SE", and "SW". The nine character number field contains two characters for the wind direction of the boundary sensor in tens of degrees, two characters for wind speed at the boundary sensor in knots, and the corresponding values for the centerfield sensor. The four characters of the boundary sensor wind measurement are separated from the four characters of the centerfield measurement by a "/" character.

The Comm-A MA fields for the wind shear alert messages are illustrated in Fig. 5.5. The single sensor wind shear measurement indicates a wind shear between the northeast boundary sensor and the centerfield sensor. The wind at the northeast sensor is from 220 degrees at 37 knots, and the centerfield wind is from 150 degrees at 19 knots.

Single Sensor Wind Shear Measurement

01000001	01110	00101	00	0010	0010	0011	0111	1101	0001	0101	0001	1001
ADS	N	E		2	2	3	7	/	1	5	1	9

General Wind Shear Alert

01001111	10111	01110	00100	00000	10011	01000	00101	00001	10010	000
ADS	W	N	D	space	S	H	E	A	R	

Fig. 5.5. Comm-A MA Field for ETIS Wind Shear Alert Messages.

5.5 ETIS Change Notices

As local conditions change, change notices are delivered to aircraft receiving ETIS service. The change notices utilize the Comm-C free text format. To minimize the impact of delivering an excessive number of messages to the DABS sensor, the Applications Processor ETIS routine delivers the change notices to the DABS sensor over a series of scans based on a range criterion.

6.0 SUMMARY

The data link formats described in this paper utilize Comm-A and Comm-C interrogations for uplink message delivery and Comm-B replies for downlink messages. The Comm-A formats are used to deliver uplink tactical messages, and messages that can be encoded in a single Comm-A message. Comm-C formats are used for long ground-to-air messages. The Comm-B replies are used for air-to-ground requests of weather information and for pilot acknowledgement of uplink tactical messages.

The Comm-A message field consists of an 8-bit Comm-A definition subfield (ADS) followed by a 48-bit data subfield. The sixteen data link ADS codes define eight basic message types which can be designated as priority or non-priority messages. The eight message types are text oriented consisting of a letter field followed in most cases by a number field. The letter field is encoded in a 5-bit letter code and the number field is encoded in a 4-bit number code. Table 2.1 details the 5-bit and 4-bit codes used for the Comm-A data link messages, and Table 2.2 summarizes the sixteen message types and the corresponding data subfield content. These tables are reproduced from Section 2 on page 26 for convenience.

The Comm-A messages are used for ATC coordination messages and ETIS alert messages. The text messages used for the initial data link Comm-A applications are given in Sections 3 and 5.

Comm-B messages are used for air-to-ground pilot requests for weather information and for pilot acknowledgement of uplink tactical messages. The Comm-B pilot acknowledgements contain the same information in the Comm-B message field as was contained in the Comm-A message field of the uplink tactical message. The general format of the Comm-B pilot weather requests is covered in Section 4.1. Figure 4.1 on page 13 illustrates the format, and the encoding formats are summarized in Table 4.1 on page 14.

Comm-C messages are used for long air-to-ground messages. The initial segment of an ELM contains an 8-bit Comm-C definition subfield (CDS) which defines the coding used for that ELM. Free text ELM messages use a CDS code of 01000001 and contain up to 211 characters in a 16-segment Comm-C message. The free text Comm-C messages use a modified 6-bit ASCII code given in Table 2.6. This table is reproduced on page 27.

Digitized weather radar summaries use the Comm-C format with a CDS code of 01000010. The digitized weather map information is encoded in a four bit character set which allows a combination of character coding and run length coding. The weather map encoding is discussed in Section 4.2 and the 4-bit character set is given in Table 4.2. This table is reproduced on page 27.

TABLE 2.1 COMM-A DATA LINK CHARACTER SETS

	5-Bit Letter Code				4-Bit Number Code		
	b5	0	0	1	1	b4	0	1
	b4	0	1	0	1			
b3 b2 b1								
0 0 0	Space		H	P	X		0	8
0 0 1	A		I	Q	Y		1	9
0 1 0	B		J	R	Z		2	L
0 1 1	C		K	S	/		3	R
1 0 0	D		L	T	*		4	Space
1 0 1	E		M	U	?		5	/
1 1 0	F		N	V	-		6	C
1 1 1	G		O	W	&		7	.

TABLE 2.2 COMM-A DATA LINK MESSAGE TYPES

Priority ADS	Non-Priority ADS	Data Subfield Content
01000001	01000000	2 Letters, 9 Numbers
01000011	01000010	3 Letters, 8 Numbers
01000101	01000100	4 Letters, 7 Numbers
01000111	01000110	5 Letters, 5 Numbers
01001001	01001000	6 Letters, 4 Numbers
01001011	01001010	7 Letters, 3 Numbers
01001101	01001100	8 Letters, 2 Numbers
01001111	01001110	9 Letters

TABLE 2.6. 6-BIT CHARACTER SET

BIT NUMBERS				b6	0	0	1	1
				b5	0	1	0	1
b4	b3	b2	b1					
0	0	0	0		ETX	P	SP	0
0	0	0	1		A	Q	!	1
0	0	1	0		B	R	"	2
0	0	1	1		C	S	#	3
0	1	0	0		D	T	$	4
0	1	0	1		E	U	%	5
0	1	1	0		F	V	&	6
0	1	1	1		G	W	'	7
1	0	0	0		H	X	(	8
1	0	0	1		I	Y	)	9
1	0	1	0		J	Z	*	:
1	0	1	1		K	PS	+	;
1	1	0	0		L	/	,	<
1	1	0	1		M	PE	-	=
1	1	1	0		N	CR	.	>
1	1	1	1		O	_	/	?

Special Character Meanings:

SP = Space
ETX = End of Message Text
PS = Start Priority Color
PE = Stop Priority Color
CR = Carriage Return/Line Feed

TABLE 4.2. CHARACTER SET FOR DIGITIZED WEATHER RADAR MAPS

Four-Bit Field	Hexidecimal Value	Character Set	
0000	0	SPACE	
0001	1	1	
0010	2	2	Weather Map Characters
0011	3	3	
0100	4	4	
0101	5	5	
0110	6	6	
0111	7	?	
1000	8	*	
1001	9	+	
1010	A	.	
1011	B	CR_1	
1100	C	CR_2	Control Characters
1101	D	TAB	
1110	E	REPEAT	
1111	F	END-OF-DATA	

CR_1: Carriage Return/Line Feed - Use Character Coding for Next Line

CR_2: Carriage Return/Line Feed - Use Run Length Coding for Next Line

TAB: Output N + 3 blanks where N is the next four bit character

REPEAT: Output the preceeding character N + 4 times were N is the next four bit character

References

1. "DABS/ATC Facility Surveillance and Communication Message Formats," FAA-RD-80-14 (April 1980).

2. DABS National Standard (June 1979).

3. "Contractions," Air Traffic Service Handbook 7340.IF (1 February 1978).

4. R.W. Wisleder, "Enhanced Terminal Information Service (ETIS) Utilizing the Discrete Address Beacon System (DABS) Data Link - Concept Definition," Final Report, Transportation Systems Center, (May 1979).