APPENDIX TO CHAPTER 11. HF DATA LINK

TABLE OF CONTENTS

1. INTRODUCTION

1.1 The purpose of this appendix is to provide detailed technical specifications for the HF data link (HFDL) system.

2. PHYSICAL LAYER

2.1 Physical layer RF characteristics

Note.— Both ITU Appendix S27 and Annex 10, Part 2 contain obsolete emission designators. Under current ITU Radio Regulations Appendix S1, the designator for the HFDL emission is 2K80J2DEN.

2.2 Physical layer functions

2.2.1 Transmitter and receiver control

Note.— All details related to transmitter and receiver control are contained in Chapter 11.

2.2.2 Transmission of data

2.2.2.1 Physical layer protocol data unit (PPDU) structure

The encoding of the PPDU shall consist of the prekey, preamble and data segments, in that order (see Figures A.1 and A.4).

2.2.2.1.1 Prekey segment

During the prekey segment, the modulator shall output on the assigned frequency 448 2-PSK symbols with a constant phase modulation of 180 degrees, and the duration of the prekey segment shall be 249 ms.

2.2.2.1.2 Preamble segment

The preamble segment shall consist of 531 2-PSK symbols. The preamble sequence is defined in Figure A.1

2.2.2.1.3 **Data segment**

a) The data segment shall consist of seventy-two data segment frames (1.8 s interleaver) or 168 data segment frames (4.2 s interleaver) of forty-five M-PSK symbols, thirty of which are information-carrying (user data) symbols and fifteen are known 2-PSK probe symbols defined in Figure A.1, that are multiplexed with the data to assist with the adaptive equalization processing at the receiving side.

b) The M-PSK modulation employed to encode the user data symbols shall be data-rate dependent, as defined in Table 2-1.

Table 2-1. Modulation employed to encode user data symbols

Data rate	Data PSK modulation	# coded chips per PSK symbol	PSK symbol phase mapping
1 800	8-PSK	3	Gray code
1 200	4-PSK	2	Gray code
600	2-PSK	1	
300	2-PSK	1	

The Gray coding for 4-PSK and 8-PSK is defined in Section 2.2.2.1.6.

2.2.2.1.4 **Data symbol formation**

a) The steps involved in the encoding of the information-carrying data symbols shall be as shown in Figure A.2. Prior to encoding, the data segment of the transmitted burst shall consist of user data bits followed by the flush field and fill bits, if necessary. The number of bits for each data rate is shown in Table 2-2.

b) Fill bits consisting of four bits, all zeros, shall be added if necessary, to make the actual number of bits equal to the product of the data rate times 1.8 or 4.2 seconds.

c) The user data, flush and fill bits shall then be encoded, interleaved, mapped into PSK symbols, and scrambled, in that order, as defined in the following paragraphs.

Table 2-2. Number of bits for each data rate

Data rate (bits/s)	User + flush bits + fill bits	
	1.8 s Interleaver	4.2 s Interleaver
1 800	3 240 bits	7 560 bits
1 200	2 160 bits	5 040 bits
600	1 080 bits	2 520 bits
300	540 bits	1 260 bits

Note.— The physical layer user bits are the media access control protocol data unit (MPDU) and the squitter protocol data unit (SPDU) packets that include the flush field.

Forward Error Correction Encoding

a) The Forward Error Correction (FEC) encoding of user, flush and fill bits for each data rate shall be as defined in Table 2-3 and Table 2-4.

Table 2-3. FEC of user bits for 1.8 second interleaver

Data rate	Maximum # user + flush + fill bits	Maximum # coded chips	Code rate	Implementation of code rate
1 800	3 240	6 480	1/2	½
1 200	2 160	4 320	1/2	½
600	1 080	2 160	1/2	½
300	540	2 160	1/4	1/2, 2 repeats

Table 2-4. FEC of user bits for 4.2 second interleaver

Data rate	Maximum # user + flush + fill bits	Maximum # coded chips	Code rate	Implementation of code rate
1 800	7 560	15 120	1/2	½
1 200	5 040	10 080	1/2	½
600	2 520	5 040	1/2	½
300	1 260	5 040	1/4	1/2, 2 repeats

a) The rate 1/2 encoder shall be a 64-state (constraint length 7) convolutional encoder with octal generator coefficients G1 = 133 and G2 = 171. The rate 1/2 encoder shall be as defined in Figure A.3.

b) The rate 1/4 encoding shall be accomplished using the rate 1/2 encoder and repeating each output chip two times so that for every input bit to the encoder, four output chips are transmitted. The implementation of the rate 1/4 encoder shall be as defined in Table 2.5, where c(n) are the encoder chip outputs per Figure A.3.

Table 2-5. Rate 1/2 and 1/4 encoder chip outputs

Code rate	**Chip index**										
	1	2	3	4	5	6	7	8	9	10	etc.
½	c(1)	c(2)	c(3)	c(4)	c(5)	c(6)	c(7)	c(8)	c(9)	c(10)	etc.
¼	c(1)	c(1)	c(2)	c(2)	c(3)	c(3)	c(4)	c(4)	c(5)	c(5)	etc.

2.2.2.1.5 **Interleaving**

a) Data interleaving shall be accomplished by writing the coded chips into the columns of a 40 row x N column block buffer one column at a time, starting at column zero as follows: the first chip is loaded into row 0, the next chip is loaded into row 9, the third chip is loaded into row 18, etc. Thus, the row location for the chips increases by 9 modulo 40. This process shall continue until all 40 rows are loaded. The loading process shall then advance to column 1 and the process repeated until the matrix block is filled. The number of columns in the block interleaver for each data rate and interleaver size shall be as shown in Table 2-6.

Table 2-6. Number of interleaver Columns N

Data rate	**# Interleaver Columns N**	
	1.8 s INTLV	4.2 s INTLV
1800	162	378
1200	108	252
600	54	126
300	54	126

b) Once the interleaver buffer is full, the chips shall be read out starting with the first chip being taken from row 0, column 0. The location of each successive fetched chip shall be determined by incrementing the row by one and decrementing the column number by 17 modulo N (the number of columns in the interleaver matrix), if the 1.8 second interleaver is being used, or decrementing the column number by 23 modulo N if the 4.2 second interleaver is being used. Thus, if the 1.8 second interleaver with N = 108 is being used, the second chip comes from row 1, column 91, and the third chip from row 2, column 74. This process shall continue until the row number reaches 39. At this point, the row number shall be reset to 0, the column number increased by 1 and then decreased by 17 modulo N or 23 modulo N. The process shall be continued until the entire matrix data block is unloaded.

2.2.2.1.6 **Coded chip to M-PSK symbol mapping**

a) The symbol phase of the modulated signal shall be determined based on the number of phase shifts, M, of the M-PSK waveform in Table 2-7.

Table 2-7. Coded chip to M-PSK symbol mapping

2-PSK		**4-PSK**		**8-PSK**	
Phase	coded chips	phase	coded chips	phase	coded chips
0°	0	0°	00	0°	000
180°	1	90°	01	45°	001
		180°	11	90°	011
		270°	10	135°	010
				180°	110
				225°	111
				270°	101
				315°	100

b) The right-most chip shall be the first chip, and the left-most chip shall be the last chip out of the interleaver.

2.2.2.1.7 **M-PSK symbol scrambling**

Only the information-carrying symbols shall be scrambled. The phase of each PSK symbol shall be scrambled by adding 0 or 180 degrees to it depending on the state of a periodically repeating binary scrambling pattern of 120 symbols. A binary "1" in the scrambling pattern shall cause a 180 degree phase reversal of the PSK symbol. The 120-bit scrambling pattern in hexadecimal notation shall be as follows:

131BC4250F8C15EFCD6AEC996E2368 hexadecimal

where the most significant bit of the left-most hexadecimal number is the first bit of the scrambling pattern. The first bit of the interleaver output block is scrambled first and continues on in order to the last scrambled bit transmitted.

Note.— This binary scrambling pattern can be derived by taking the first 120 bits of a 15 stage shift register with coefficient generator polynomial $1 + X + X^{15}$. *The initial state of the shift register should be 6959 hexadecimal where the least significant bit (LSB) is coincident with element* X^{15}.

2.2.3 **Reception of data**

All specifications related to reception of data are contained in Chapter 11.

3. LINK LAYER

Note.— Further details on link layer protocols and services are contained in the Manual on HF Data Link (HFDL) Technical Details.

3.1 Data encapsulation

a) The link layer shall perform three levels of encapsulation for Reliable Link Service (RLS). User data (HF Network Protocol Data Units [HFNPDUs]), shall be segmented into Basic Data Units (BDUs) when the HFNPDU is to be delivered using the RLS. Each segment of the HFNPDU shall be encapsulated into a Link Protocol Data Unit (LPDU) and then one or more LPDUs shall be encapsulated into a single Medium Access Control (MAC) Protocol Data Unit (MPDU). For Direct Link Service (DLS), the HFNPDU shall be directly encapsulated into an LPDU. HFNPDU, BDU, LPDU, and MPDU formats and types shall be as defined in Attachments 1 and 2.

b) Each MPDU shall consist of a variable length MPDU header, 0 to 15 LPDUs for downlinks and 0 to 64 LPDUs for uplinks, and a one octet flush field. The HFDL aircraft ground station sub-systems shall select the interleaver size based on the slot duration, and data rate based on the minimum and maximum MPDU size as shown in Table 3-1.

Table 3-1. Data rate and interleaver size selection

MPDU size (min/max octets)	Date rate	Interleaver duration	Single/ double slot
13-67 octets	300 bits/s	1.8 s	single
68-135 octets	600 bits/s	1.8 s	single
136-270 octets	1200 bits/s	1.8 s	single
271-405 octets	1800 bits/s	1.8 s	single
68-157 octets	300 bits/s	4.2 s	double
158-315 octets	600 bits/s	4.2 s	double
271-630 octets	1200 bits/s	4.2 s	double
631-945 octets	1800 bits/s	4.2 s	double

3.2 LPDU prioritization

a) HF Data Link shall support up to 16 levels of prioritization of user packets. Each LPDU shall be assigned a priority level between 15 and 0 with the highest priority level being 15 and the lowest 0. The LPDU priority level assignment shall be based on the type of LPDU. The priority level of Numbered Data and Unnumbered Data LPDUs shall also depend on the type of HFNPDUs encapsulated within the LPDU.

b) The priority level of an LPDU encapsulating a whole or a segment of an HF Subnetwork layer HFNPDU shall be determined from the priority level of the logical virtual circuit connection.

c) The priority to be given to LPDUs shall be as described in Table 3-2. For a Data LPDU, the priority shall be determined from the priority indicator of the HFNPDU from which the LPDU is derived. If the priority indicator of the HFNPDU cannot be determined, the priority of LPDUs derived from the HFNPDU shall be set at Q = 7.

Table 3-2. PDU priorities

LPDU Type	Payload	Priority Q
Log-On Request	Unsegmented HFNPDU (Optional)	13
Log-Off Request		13
Log-On Resume		13
Log-On Confirm	None	13
Log-On Resume Confirm		13
Log-On Denied		13
Numbered Data	HF Subnetwork layer HFNPDU	Priority of Virtual Circuit
	Enveloped Data HFNPDU	7
Unnumbered Data	HFDL System Table uplink	6*
	Performance Data downlink	6*
	HFDL System Table Request downlink	13
Unnumbered Acknowledged Data	Enveloped Data HFNPDU	7

* The priorities indicated in Table 3-2 shall apply to HFNPDUs whether they are transmitted in unnumbered or numbered LPDUs.

3.3 Link management

The channel access protocol to be used in the HF data link system shall be a combination of frequency division multiple access (FDMA) and time division multiple access (TDMA).

HFDL ground station sub-systems shall assign uplink slots, reserved downlink slots, and random access downlink slots taking into account message priority and maintenance of communications.

If the HFDL ground station sub-system has not assigned the HFDL aircraft station sub-system a slot, the HFDL aircraft station sub-system shall select and use a random access slot.

With each downlink transmission, the HFDL aircraft station sub-system shall request slot assignments, if necessary, for future transmissions.

Log-on procedures shall be performed between the HFDL ground-station sub-system and the HFDL aircraft station sub-system using the signal unit field descriptions as defined in Attachments 1 and 2.

Each HFDL ground station sub-system shall maintain a table of HFDL aircraft station sub-systems logged on each of its operating frequencies.

The HFDL ground station sub-system and the HFDL aircraft station sub-system shall report the maximum usable data rate.

The HFDL ground station sub-system shall maintain a current HFDL System Table as defined in Attachments 1 and 2. When the HFDL System Table version number, stored within the HFDL aircraft station sub-system, is less than the HFDL System Table version number broadcast in an SPDU, the link layer shall update the HFDL System Table with the newer broadcast HFDL System Table.

For the purpose of monitoring operating frequencies, an HFDL aircraft station sub-system shall establish its master TDMA frame reference using only an SPDU that indicates HFDL ground station sub-system synchronization to within ±25 ms of UTC.

4. SUBNETWORK LAYER PROTOCOLS AND SERVICES

Note.— Further details on sub-network layer protocols and services are contained in the Manual on HF Data Link (HFDL) Technical Details.

4.1 Architecture

Figure 4-1 shows the HFDL subnetwork dependent (HFSND), interworking (IW) and subnetwork access (SNAc) functions and the ATN HFDL subnetwork protocol architecture. The HFDL subnetwork layer (HFSNL) shall interface with the link layer and the HFDL aircraft station sub-system/HFDL ground station sub-system management.

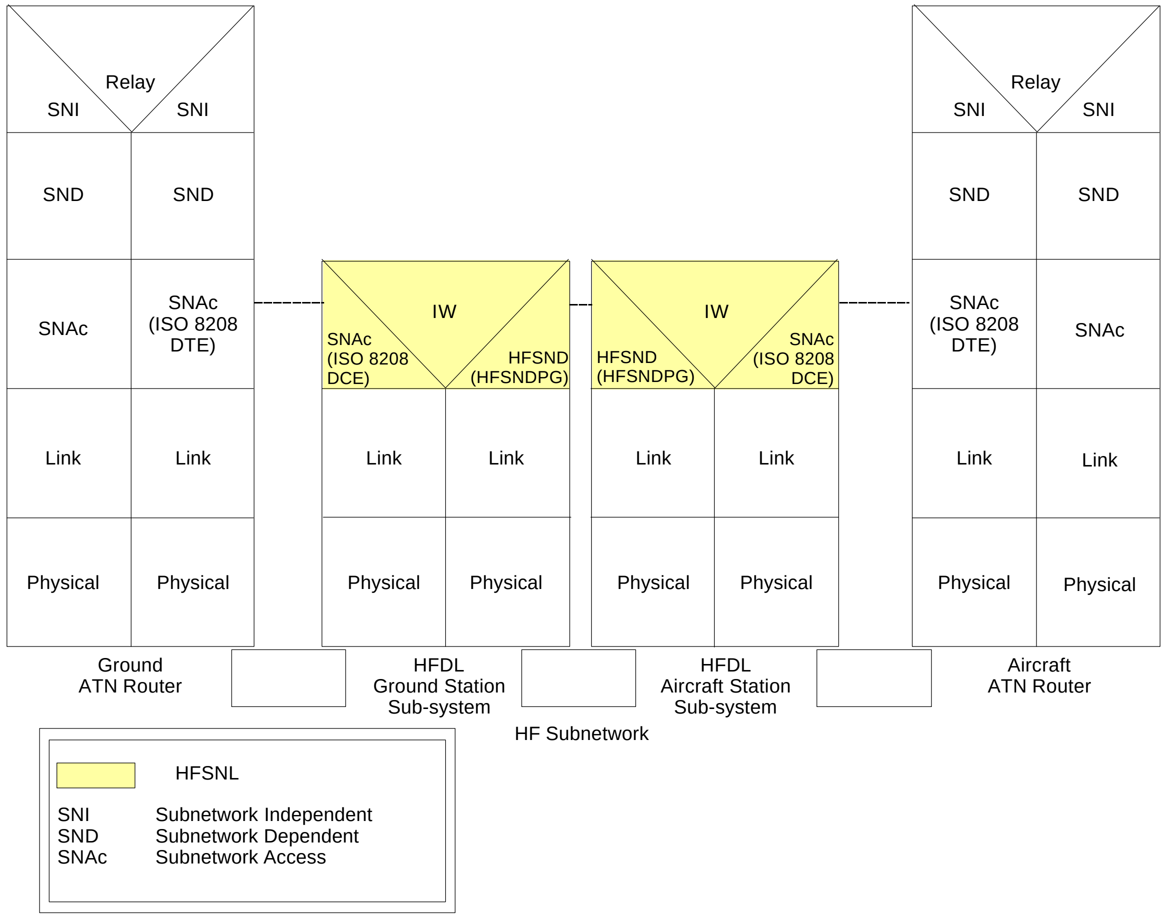


Figure 4-1. HFSNL function and the ATN subnetwork

4.2 General HFNDPU format

An HFNDPU shall consist of at least two octets. Octet 1 shall contain the D- and M-bits and the HFNPDU type identifier field. Octet 2 shall contain the logical channel number field; depending on the particular HFNPDU type, additional octets may be required. The general HFNPDU format shall be as defined in Figure 4-2.

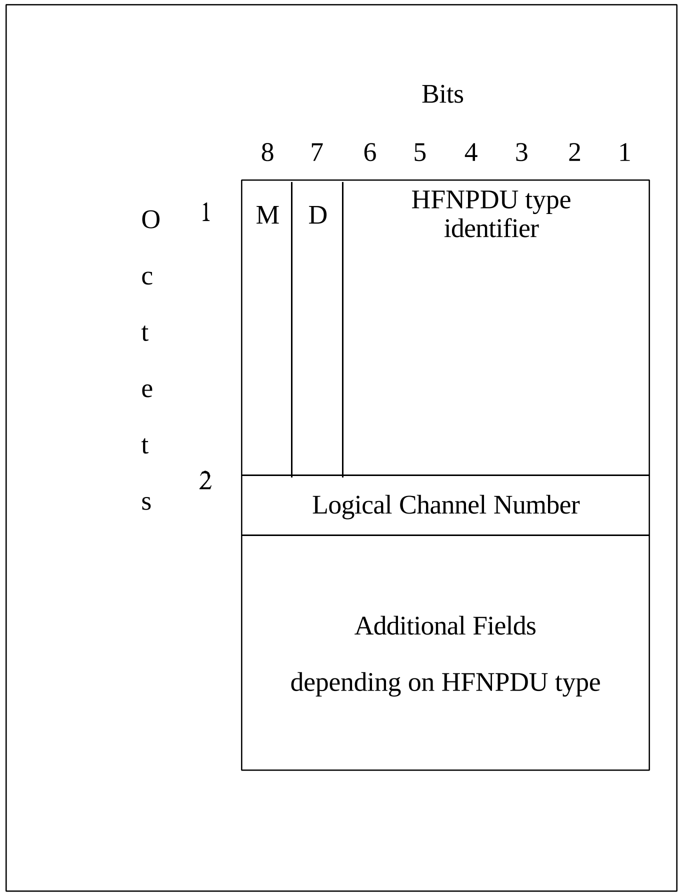


Figure 4-2. General format of a HFNPDU

5. HFDL GROUND MANAGEMENT SUB-SYSTEM

5.1 Management functions

The HFDL management sub-system shall carry out the following functions:

5.1.1 HFDL table management

The HFDL Management sub-system shall maintain the following tables for the HFDL system:

a) HFDL system table;

b) HFDL log-on status table; and

c) HFDL operating frequency management table.

5.1.1.1 HFDL system table

The HFDL system table shall include the following information for each HFDL ground station:

a) HFDL ground station identification;

b) HFDL ground station assigned frequencies;

c) HFDL ground station latitude and longitude;

d) SPDU version;

e) HFDL system table version; and

f) Master TDMA frame slot offset by assigned frequency.

5.1.1.2 HFDL log-on status table

The HFDL log-on status table shall include the following information for each HFDL aircraft station logged-on to each HFDL ground station:

a) HFDL ground station identification; and

b) HFDL aircraft station identification.

5.1.1.2.1 **HFDL log-on status table update**

The HFDL management sub-system shall update the HFDL log-on status table when an HFDL aircraft station is logged-on (initial or resume) or logged-off from any HFDL ground station.

5.1.1.2.2 **HFDL operating frequency management table**

The HFDL management sub-system shall maintain a frequency table to control the operating frequencies for the HFDL ground station sub-system or sub-systems under its control.

a) The frequency table shall contain the following data:

1) HFDL ground station identification;

2) Service availability times for each operating frequency; and

3) SPDU Master TDMA frame offset for each operating frequency; and

b) The operating frequencies for each HFDL ground station shall be selected from the frequencies identified in the HFDL System Table.

Recommendation.— *The HFDL management sub-system should employ automatic and adaptive schemes to facilitate the dynamic selection of optimum operating frequencies, the sharing of frequencies, and adaptive selection of alternate frequencies within the HFDL networks. Use of such schemes will maximize HFDL signal availability under time-varying ionoshperic conditions within the respective HFDL service volumes.*

5.2 **Management/control information exchange**

The following management/control information shall be exchanged between the HFDL ground management sub-system and the HFDL ground station sub-system(s):

a) to the HFDL ground station sub-system:

1) log status information:

i) HFDL aircraft station log-on/log-off;

ii) HFDL aircraft station identification;

iii) HFDL ground station identification;

2) HFDL system table;

3) frequency management data; and

b) to the HFDL ground management sub-system

1) log status information:

i) HFDL aircraft station log-on/log-off;

ii) HFDL aircraft station identification;

iii) HFDL ground station identification; and

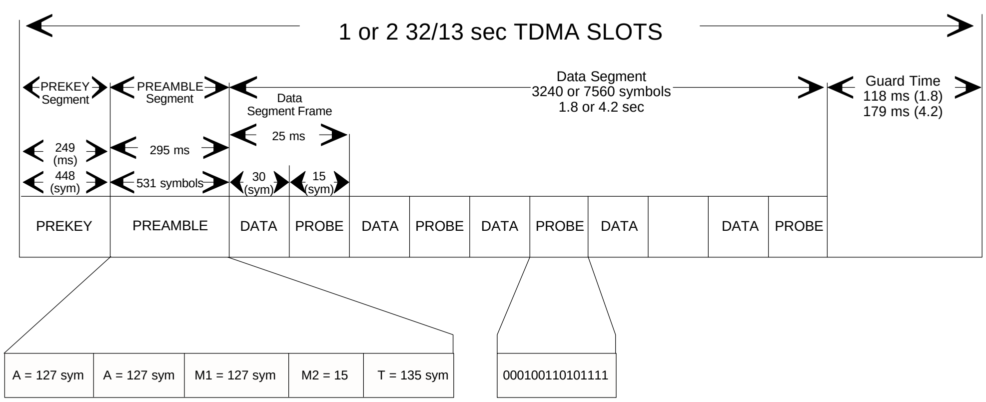
2) frequency utilization flag status.

Recommendation.— *The following management/control should be passed from the HFDL ground station sub-system to the HFDL ground management sub-system:*

a) HFDL aircraft station performance data;

b) HFDL aircraft station frequency data; and

c) HFDL aircraft station position data.



A = 010 1101 1101 1110 0011 1010 0010 1011 1000 0001 1110 1100 1100 0100 1001 1100
1111 1001 0000 0100 0110 1010 1001 1011 0100 1010 0001 0110 0001 1001 0111 1111

M1 = 1 OF 10 SHIFTS OF FOLLOWING SEQUENCE: 011 1011 0111 1010 0010 1100 1011 1110
0010 0000 0110 0110 1100 0111 0011 1010 1110 0001 0011 0000 0101 0101 1010 0111
1001 00001 1010 1000 0111 1111

M2 = first 15 symbols of shifted M1 sequence

T = 000 100 110 101 111 repeated 9 times

NOTE = Left most bit of each sequence is transmitted first

DATA RATE	INTERLEAVER	M1 SHIFT
300 bits/s	1.8 s	72 sym
600 bits/s	1.8 s	82 sym
1 200 bits/s	1.8 s	113 sym
1 800 bits/s	1.8 s	123 sym
300 bits/s	4.2 s	61 sym
600 bits/s	4.2 s	103 sym
1 200 bits/s	4.2 s	93 sym
1 800 bits/s	4.2 s	9 sym

Figure A.1 TDMA slot definition

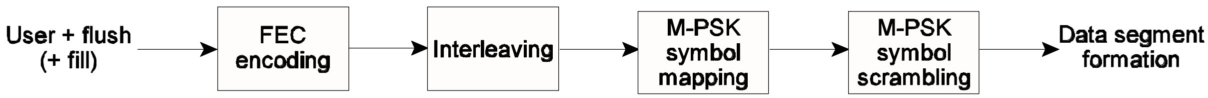


Figure A-2. Data symbol formation

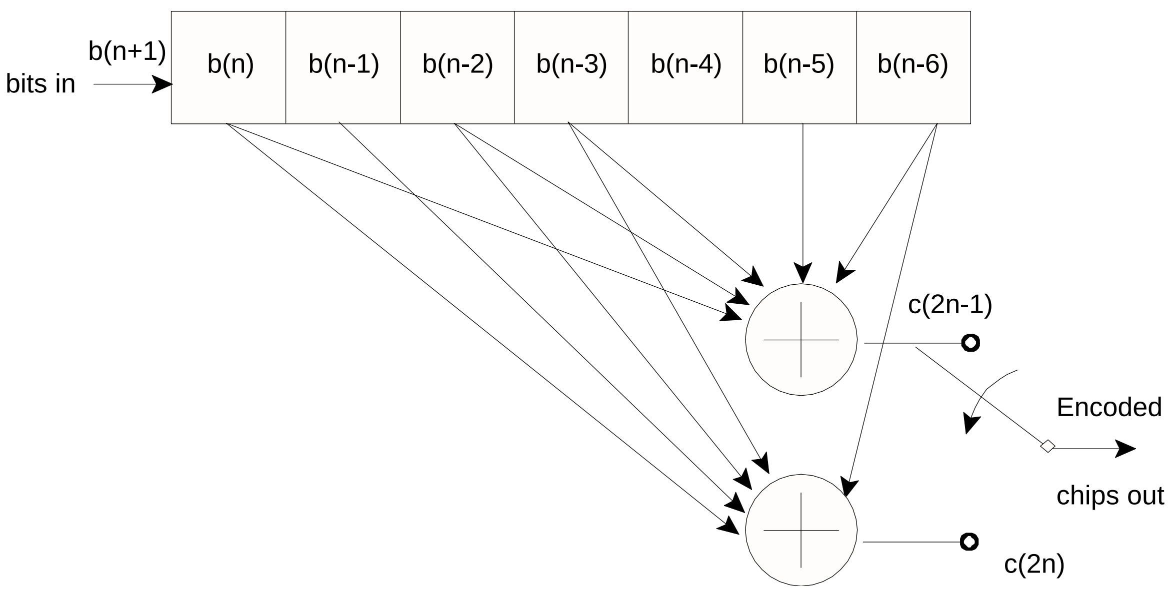


Figure A-3. Rate ½ convolutional encoder

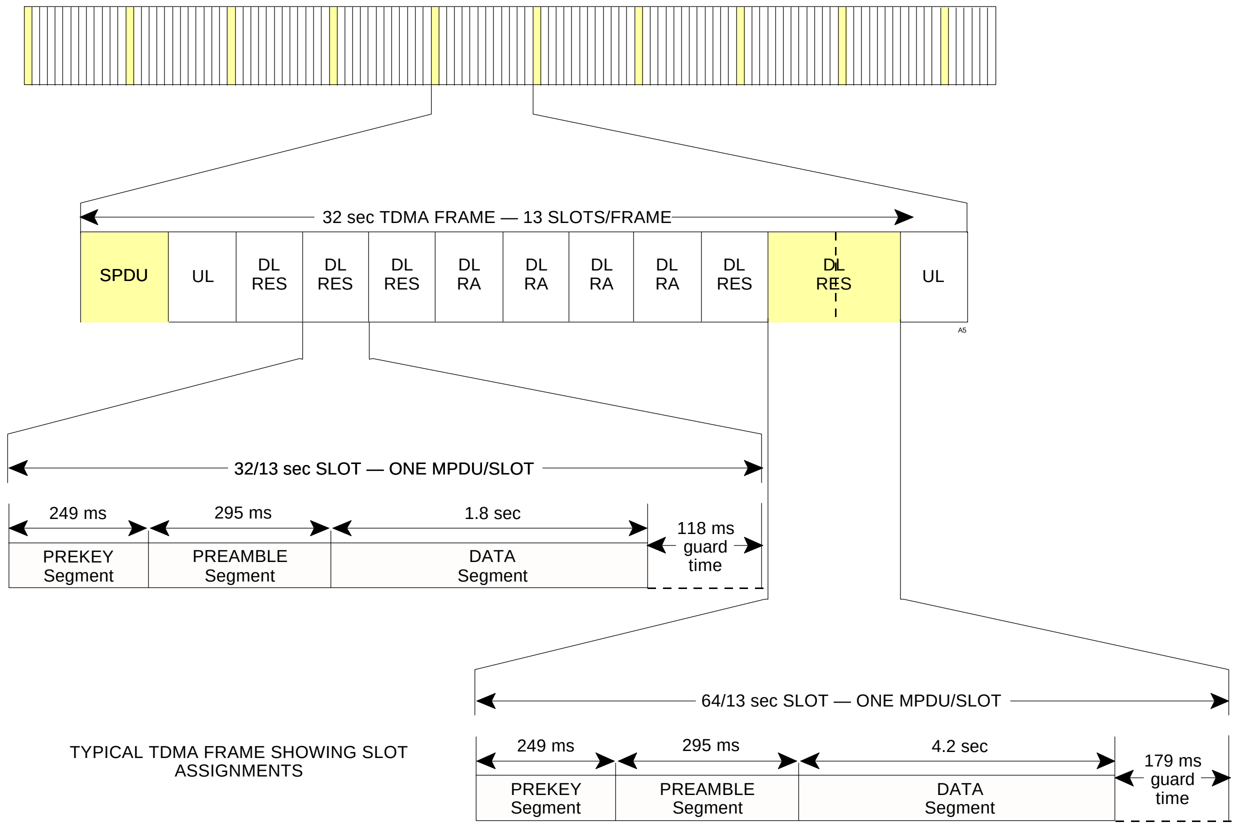


Figure A-4. Slotted TDMA frame

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ATTACHMENT 1

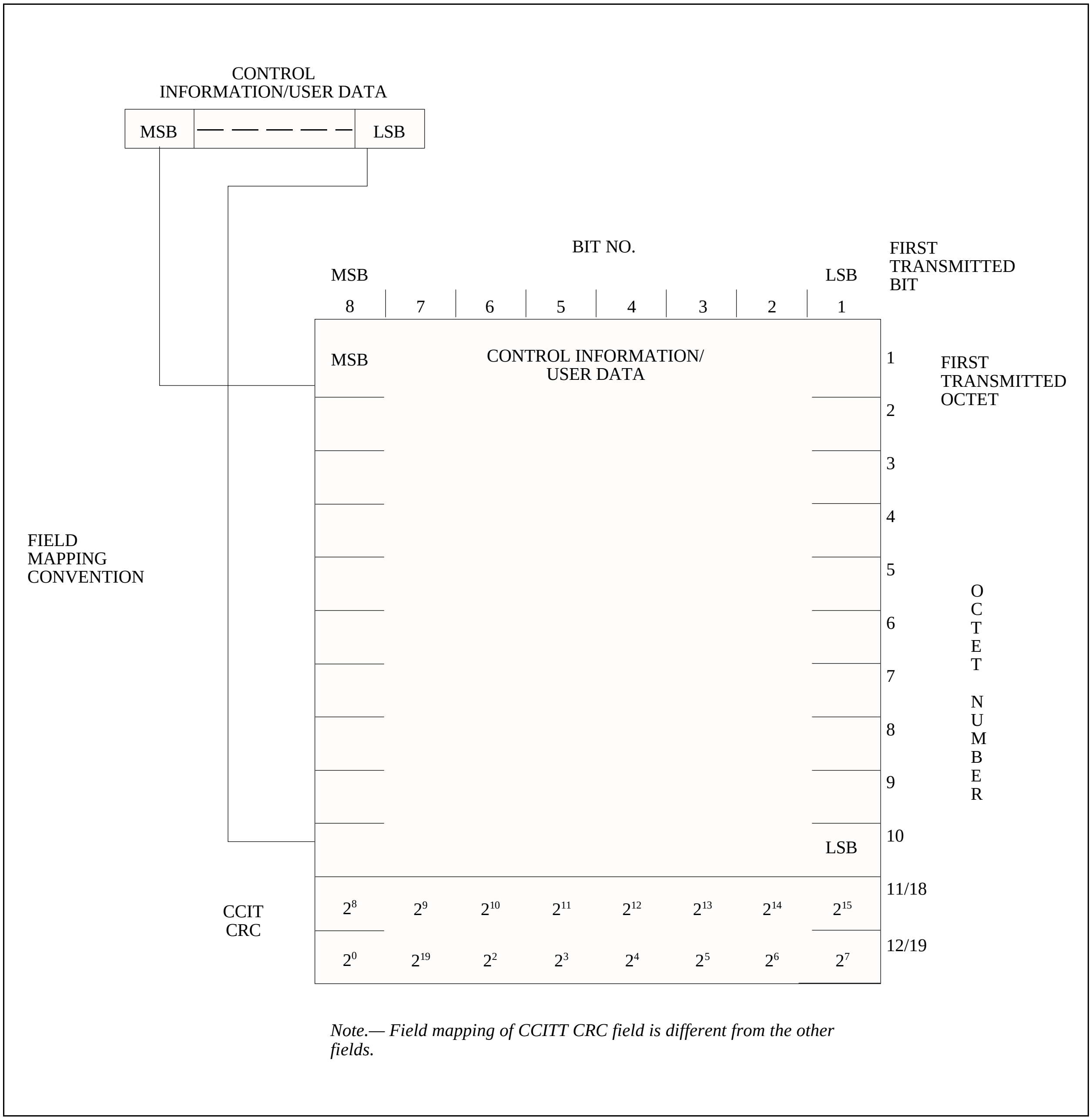

Figure 1. Data unit field mapping and bit transmission order

BIT NO.

<table>
<tr><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>OCTET NUMBER</th></tr>
<tr><td>P</td><td>0</td><td colspan="4">NLP (1 in this example)</td><td>T</td><td>1</td><td>1</td></tr>
<tr><td>UTC SYNC</td><td colspan="7">GROUND STATION ID</td><td>2</td></tr>
<tr><td colspan="8">AIRCRAFT ID</td><td>3</td></tr>
<tr><td rowspan="2">SLOT SEL</td><td>H</td><td colspan="3">N2</td><td colspan="3">N1</td><td rowspan="2">4</td></tr>
<tr><td colspan="7">NF</td></tr>
<tr><td colspan="5">U(R)</td><td colspan="3">UDR</td><td>5</td></tr>
<tr><td colspan="8">U(R) vect</td><td>6</td></tr>
<tr><td colspan="8">LPDU SIZE (one octet per LPDU)</td><td>7</td></tr>
<tr><td colspan="8">MPDU HEADER FCS</td><td>.
.
.</td></tr>
<tr><td colspan="8">. .</td><td>.
.
.</td></tr>
<tr><td colspan="8">FLUSH FIELD</td><td rowspan="2">N</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>

Figure 2. Downlink MPDU

BIT NO.

8	7	6	5	4	3	2	1	OCTET NUMBER
P	NAC (1 in this example)			0	0	T	1	1
UTC SYNC	GROUND STATION ID							2
AIRCRAFT ID								3
NLP (1 in this example)				DDR			P	4
LPDU SIZE (one octet per PLDU)								5
MPDU HEADER FCS								.
. .								.
. .								.
FLUSH FIELD								
0	0	0	0	0	0	0	0	N

Figure 3. Uplink MPDU

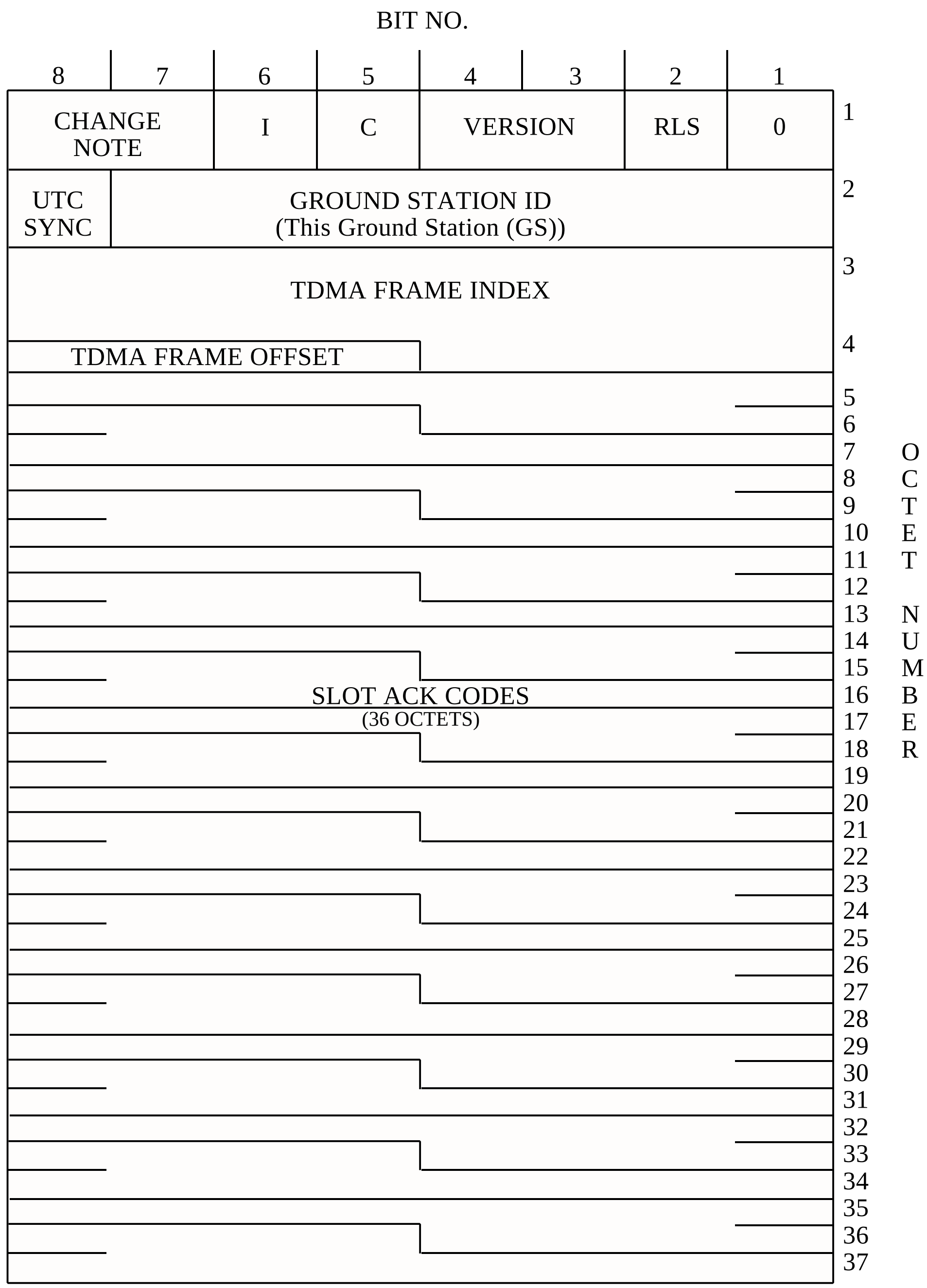

Figure 4. SPDU (Page 1 of 2)

BIT NO.

8	7	6	5	4	3	2	1	OCTET NUMBER
SLOT ACK CODES (CONTINUED)								38
								39
								40
FRAME N SLOT 03 ASSIGNMENT CODE								41
FRAME N SLOT 04 ASSIGNMENT CODE								42
FRAME N SLOT 05 ASSIGNMENT CODE								43
FRAME N SLOT 06 ASSIGNMENT CODE								44
FRAME N SLOT 07 ASSIGNMENT CODE								45
FRAME N SLOT 08 ASSIGNMENT CODE								46
FRAME N SLOT 09 ASSIGNMENT CODE								47
FRAME N SLOT 10 ASSIGNMENT CODE								48
FRAME N SLOT 11 ASSIGNMENT CODE								49
FRAME N SLOT 12 ASSIGNMENT CODE								50
FRAME (N+1) SLOT 01 ASSIGNMENT CODE								51
FRAME (N+2) SLOT 02 ASSIGNMENT CODE								52
0	0	0	0	PRIORITY				53
SYSTEM TABLE VERSION								54
								55
OPERATING FREQUENCIES (THIS GS)								56
								57
UTC SYNC	GROUND STATION ID (GS 2)							58
OPERATING FREQUENCIES (GS 2)								59
								60
GROUND STATION ID (GS 3) (LSB)								61
				UTC SYNC	GROUND STATION ID (GS 3) (MSB)			62
OPERATING FREQUENCIES (GS 3)								63
								64
FCS								65
								66
0	0	0	0	0	0	0	0	67

Figure 4. SPDU (Page 2 of 2)

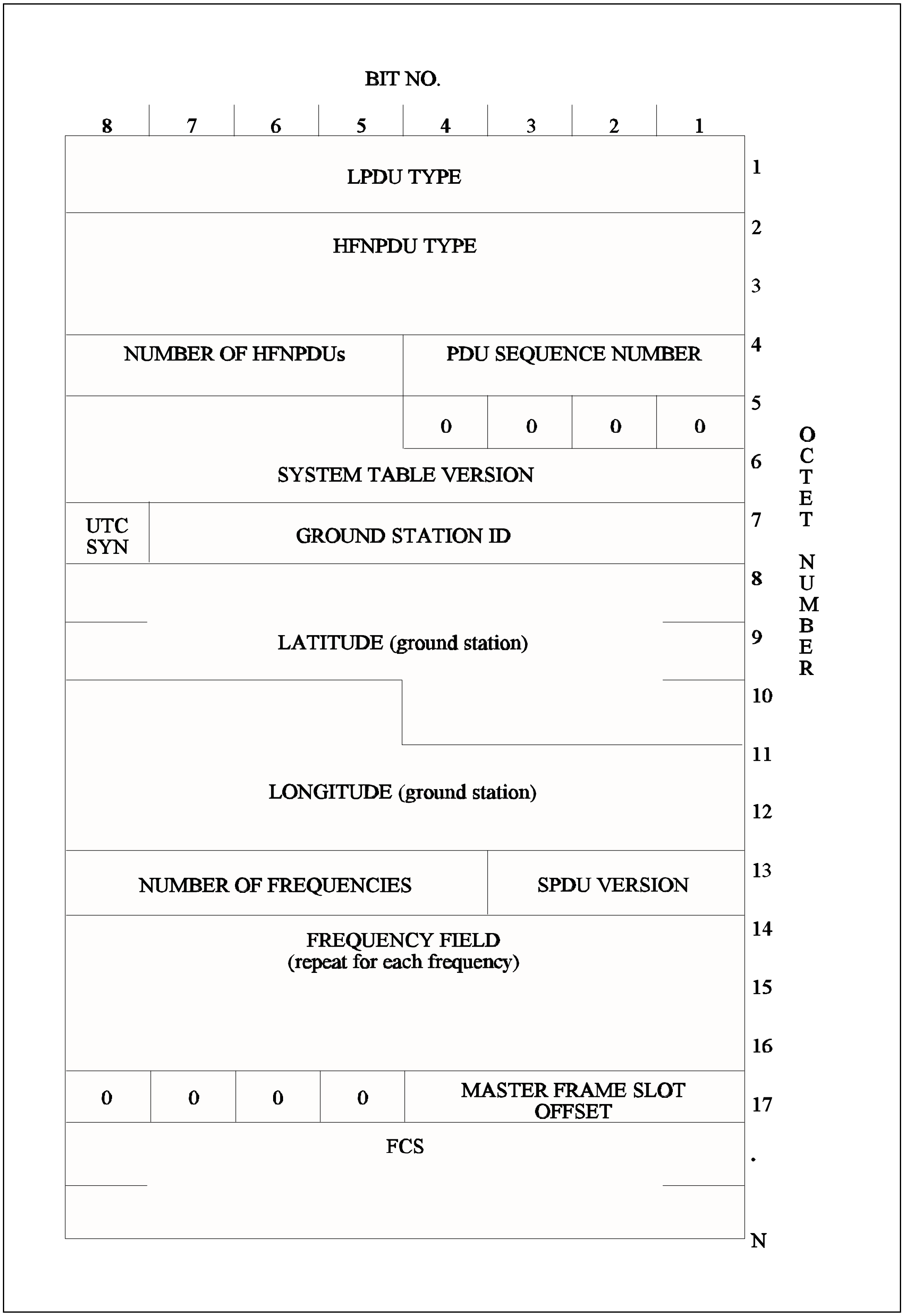

Figure 5. System table LPDU

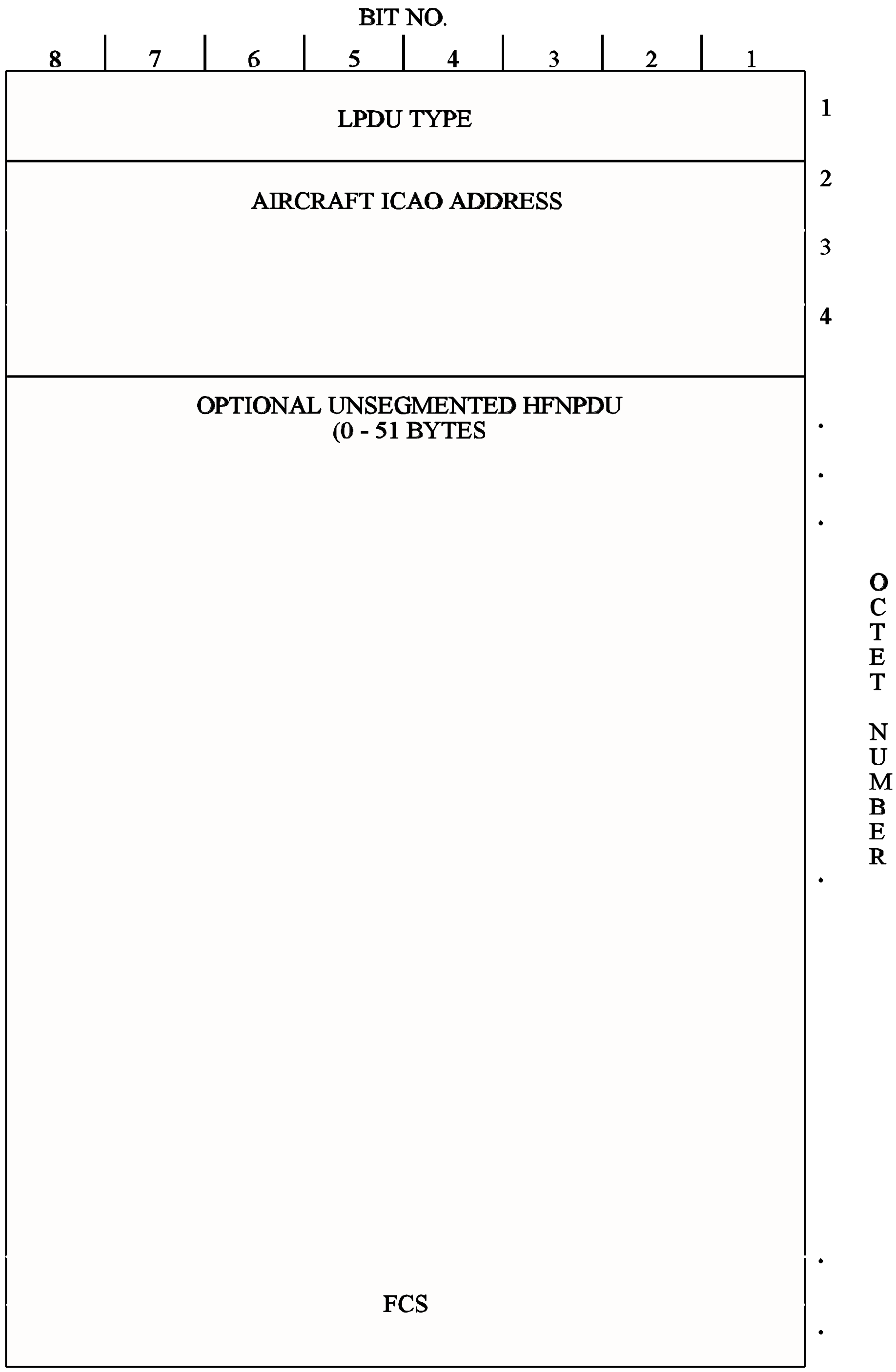

Figure 6. Log-on request and log-on request resume LPDU

BIT NO.

8	7	6	5	4	3	2	1	OCTET NUMBER
LPDU TYPE								1
AIRCRAFT ICAO ADDRESS								2
								3
								4
AIRCRAFT ID								5
0	0	0	0	k (transmit window size)				6
D(R)					0	0	0	7
D(R) vect								8
FCS								9
								10

Figure 7. Log-on confirm and log-on resume confirm LPDU

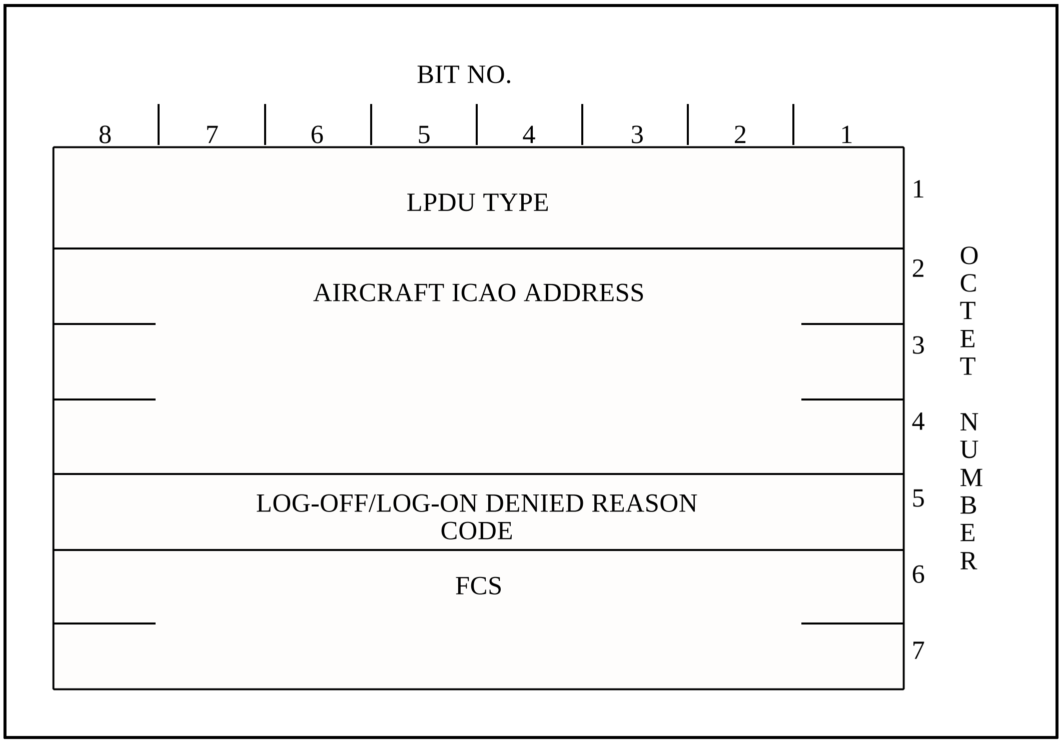

Figure 8. Log-off request and log-on denied LPDU

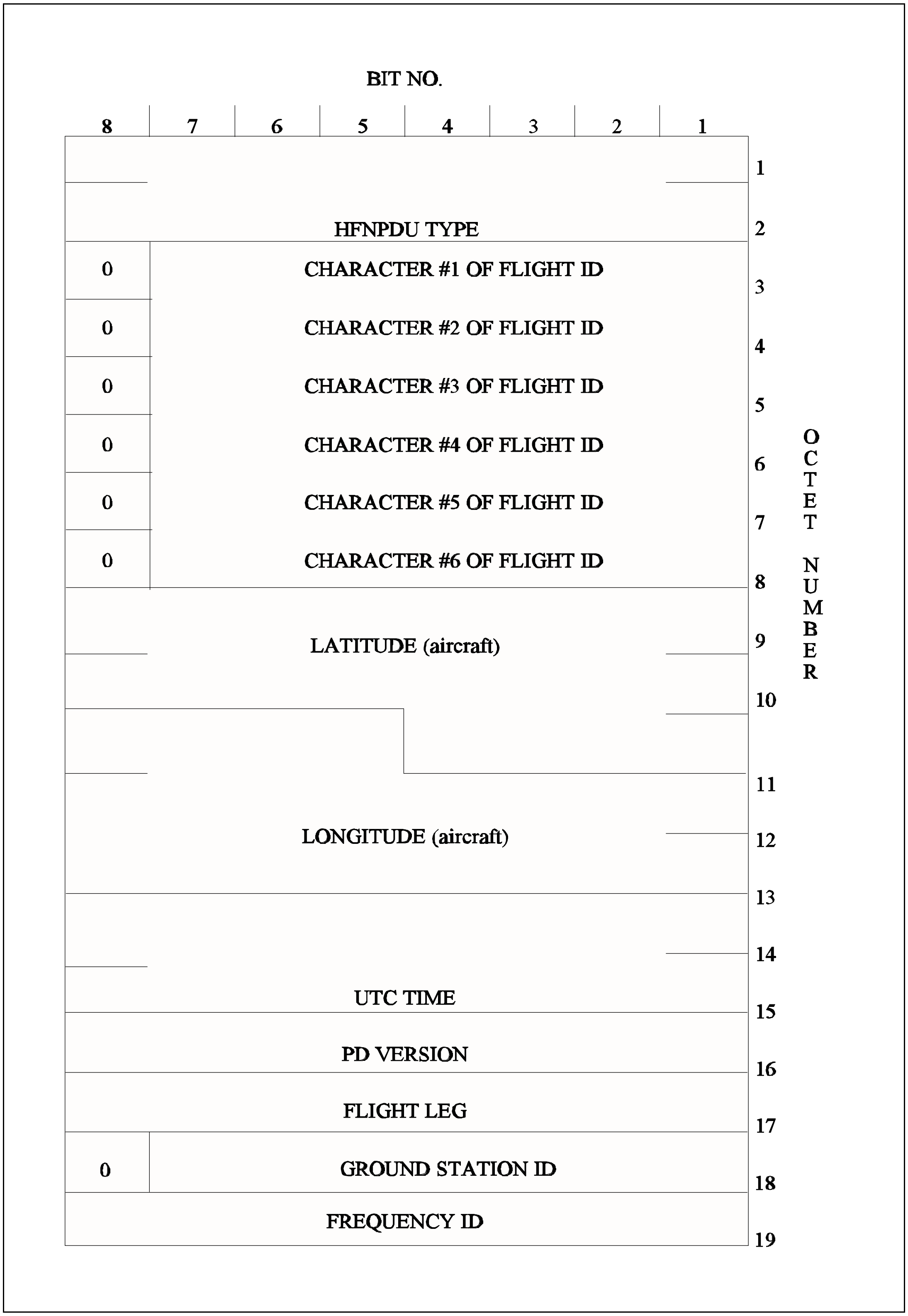

Figure 9. Performance data HFNPDU (Page 1 of 3) (optional)

BIT NO. 8 7 6 5 4 3 2 1

	Octet Number
FREQUENCY SEARCH COUNTS (PREVIOUS FLIGHT LEG)	20
	21
FREQUENCY SEARCH COUNTS	22
	23
HF DATA DISABLED TIMES (PREVIOUS FLIGHT LEG)	24
	25
HF DATA DISABLED TIMES (CURRENT FLIGHT LEG)	26
	27
NUMBER OF MPDUs RECEIVED (1800 bits/s)	28
NUMBER OF MPDUs RECEIVED (1200 bits/s)	29
NUMBER OF MPDUs RECEIVED (600 bits/s)	30
NUMBER OF MPDUs RECEIVED (300 bits/s)	31
NUMBER OF MPDUs RECEIVED WITH ERRORS (1800 bits/s)	32
NUMBER OF MPDUs RECEIVED WITH ERRORS (1200 bits/s)	33
NUMBER OF MPDUs RECEIVED WITH ERRORS (600 bits/s)	34
NUMBER OF MPDUs RECEIVED WITH ERRORS (300 bits/s)	35
NUMBER OF RECEIVED SPDUs	36
	37
NUMBER OF SPDUs WITH ERRORS OR NOT RECEIVED	38

Figure 9. Performance data HFNPDU (Page 2 of 3) (optional)

BIT NO. 8	7	6	5	4	3	2	1	OCTET NUMBER
NUMBER OF MPDUs TRANSMITTED								39
NUMBER OF MPDUs TRANSMITTED								40
NUMBER OF MPDUs TRANSMITTED								41
NUMBER OF MPDUs TRANSMITTED								42
DELIVERED MPDUs (1800 bits/s)								43
DELIVERED MPDUs (1200 bits/s)								44
DELIVERED MPDUs (600 bits/s)								45
DELIVERED MPDUs (300 bits/s)								46
FREQUENCY CHANGE CODE								47

Figure 9. Performance data HFNPDU (Page 3 of 3) (optional)

BIT NO.

8	7	6	5	4	3	2	1	OCTET NUMBER
HFNPDU TYPE								1
								2
0	CHARACTER #1 OF FLIGHT ID							3
0	CHARACTER #2 OF FLIGHT ID							4
0	CHARACTER #3 OF FLIGHT ID							5
0	CHARACTER #4 OF FLIGHT ID							6
0	CHARACTER #5 OF FLIGHT ID							7
0	CHARACTER #6 OF FLIGHT ID							8
LATITUDE (aircraft)								9
								10
				LONGITUDE (aircraft)				11
								12
								13
UTC TIME								14
								15

Figure 10. Frequency data HFNPDU (Page 1 of 2) (optional)

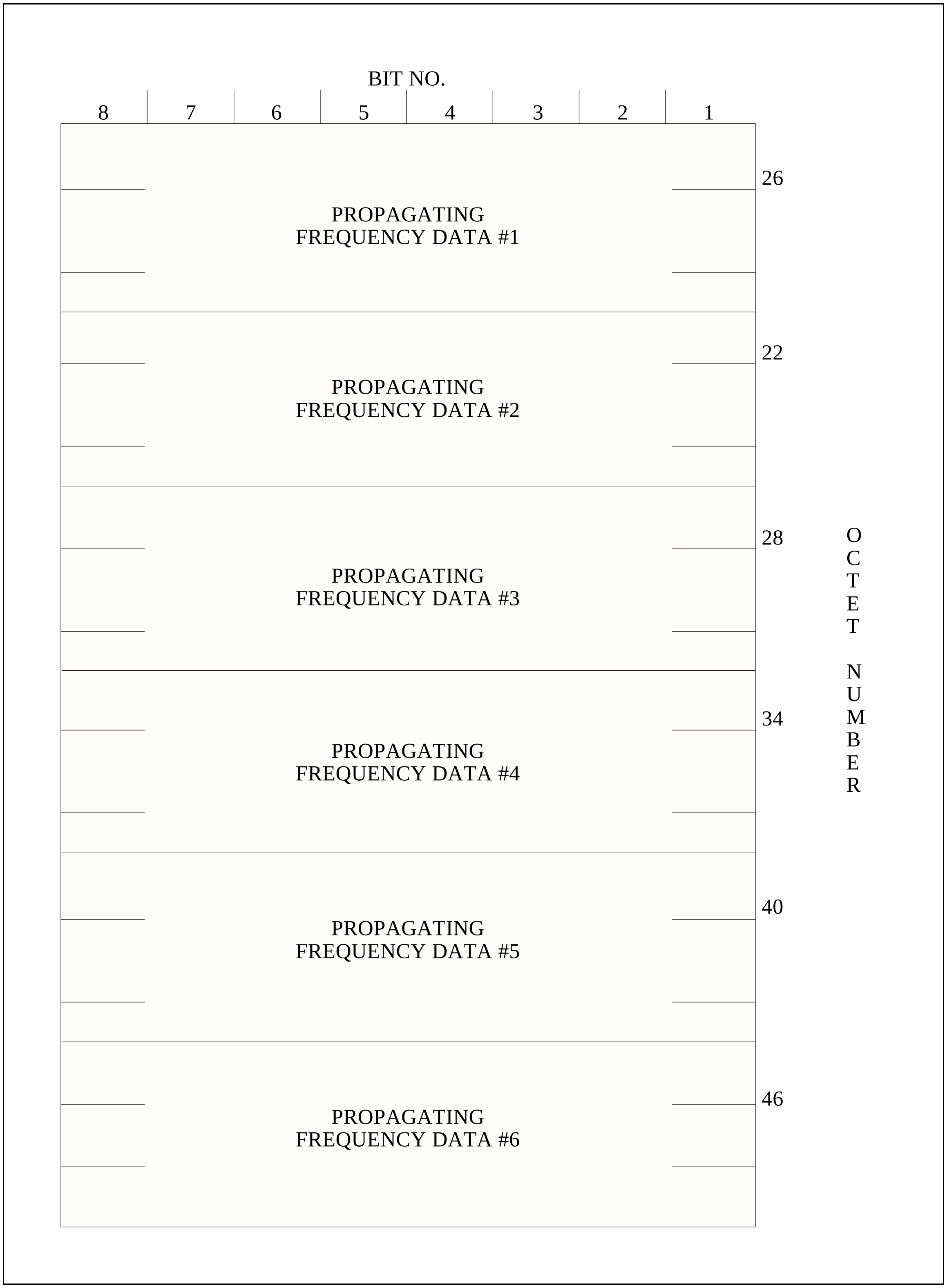

Figure 10. Frequency data HFNPDU (Page 2 of 2) (optional)

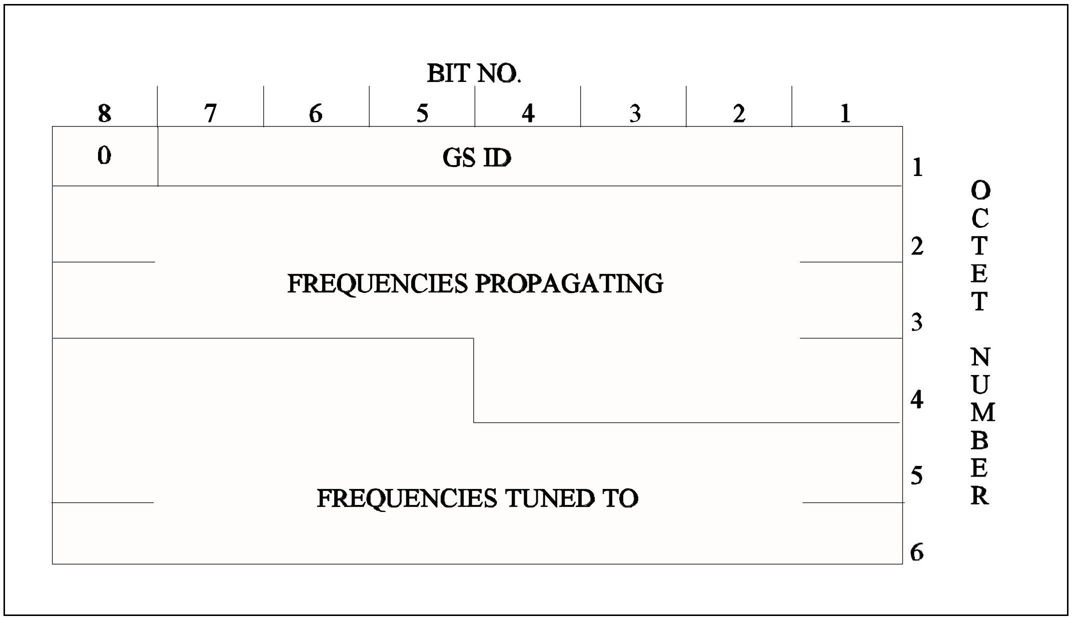

Figure 11. Propagating frequency data (optional)

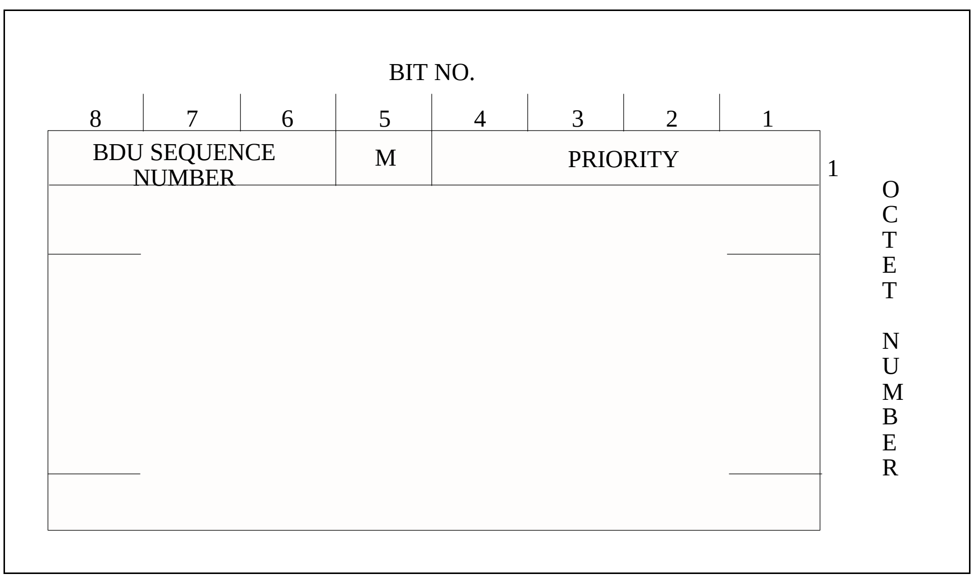

Figure 12. Basic data unit

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ATTACHMENT 2

SIGNAL UNIT FIELD DESCRIPTIONS, CODING AND DESIGNATIONS

FIELD DESCRIPTIONS

NUMBER	DESCRIPTION
1	OPERATING FREQUENCIES
2	AIRCRAFT ICAO ADDRESS
3	AIRCRAFT ID
4	CHANGE NOTE
5	SYSTEM TABLE VERSION
6	DDR - DOWNLINK DATA RATE
7	FCS
8	FLIGHT LEG
9	FLIGHT ID
10	FLUSH FIELD
11	TDMA FRAME INDEX
12	TDMA FRAME OFFSET
13	FREQUENCIES PROPAGATING
14	FREQUENCIES TUNED TO
15	FREQUENCY FIELD
16	FREQUENCY ID
17	FREQUENCY SEARCH COUNTS
18	C - FREQUENCY UTILIZATION FLAG
19	GROUND STATION ID
20	LATITUDE
21	LONGITUDE
22	H
23	HF DATA DISABLED TIMES
24	HFNPDU TYPE
25	LOGOFF REQUEST/LOG-ON DENIED REASON CODE
26	LPDU
27	LPDU SIZES
28	LPDU TYPE
29	M
30	MASTER TDMA FRAME SLOT OFFSET
31	N1
32	N2
33	NAC
34	NF
35	NLP
36	NUMBER OF FREQUENCIES
37	NUMBER OF PACKETS
38	P

NUMBER	DESCRIPTION
39	PD VERSION
40	PDU SEQUENCE NUMBER
41	PRIORITY
42	PROPAGATING FREQUENCY DATA
43	REQUEST DATA
44	RLS FLAG
45	SEQUENCE NUMBER
46	SLOT ACKNOWLEDGEMENT CODES
47	SLOT ASSIGNMENT CODES
48	SLOT SEL
49	T
50	UDR - UPLINK DATA RATE
51	UPLINK ACK
52	UTC TIME
53	VERSION
54	I
55	D(R)
56	D(R) vect
57	U(R)
58	U(R) vect
59	k
60	UTC SYNC
61	NUMBER OF MPDUs RECEIVED
62	NUMBER OF MPDUs RECEIVED WITH ERRORS
63	NUMBER OF RECEIVED SPDUs
64	NUMBER OF SPDUs WITH ERRORS OR NOT RECEIVED
65	DELIVERED MPDUs
66	NUMBER OF MPDUs TRANSMITTED
67	FREQUENCY CHANGE CODE
68	NUMBER OF HFNPDUs
69	FREQUENCY FIELD
70	BDU SEQUENCE NUMBER
71	RN
72	D(S)
73	U(S)

FIELD CODING AND DESIGNATIONS

For fields containing numeric values, the least significant bit of the least significant octet shall be transmitted first continuing to the most significant bit of the most significant octet.

1. **OPERATING FREQUENCIES (20 bits)**

This field is used to indicate the operating frequencies. This field is repeated for this ground station and two other ground stations. In each 20-bit field, bit 1 indicates whether the highest frequency assigned to the ground station is on-the-air (bit set to 1) or off-the-air (bit set to 0). Bit 2 provides the same information for the next highest frequency and so on. If the ground station has fewer than 20 frequency assignments, the bits corresponding to the unassigned frequencies shall be set to 0.

2. **AIRCRAFT ICAO ADDRESS (3 octets)**

The aircraft ICAO address field shall contain a unique 24-bit address that identifies the aircraft.

3. **AIRCRAFT ID (8 BITS)**

As each aircraft is logged on, it shall be assigned a sequential value in the Active Aircraft Table (AAT). The "available" flag in the AAT shall be set to zero for each "logged on" aircraft.

Code	Function
00h	Broadcast value
01h - FDh	Legal value
FEh	Reserved
FFh	Log-on

4. **CHANGE NOTE (2 bits)**

The Change Notice Code in the SPDU shall indicate the ground station status for this ground station.

Code	Function
0	No change, same frequency, GS up
1	Channel down
2	Upcoming frequency change
3	Ground Station down

5. **SYSTEM TABLE VERSION (12 bits)**

The System Table Version field shall uniquely identify the HFDL System Table contents from all others within the range of 0 to 4095. The System Table Version number shall be incremented by one each time a revision is made to the contents of the HFDL System Table. The revision that follows 4095 resets the field to zero. This allows aircraft to detect the relative age of System Table numbers and System Tables.

Code	Function
0 - 4095	System Table Version Number

6. **DDR - DOWNLINK DATA RATE (3 bits)**

The downlink data rate shall be determined by the size of the MPDU (number and type of LPDUs to be transmitted) and the quality of the link.

Code	Function
000	Reserved
001b	300 bits/s
010b	600 bits/s
011b	1 200 bits/s
100b	1 800 bits/s

7. **FCS (Frame Check Sequence) (16 bits)**

A 16-bit Cyclical Redundency Check (CRC), shall be computed, starting with 1) the first bit of the first byte in the SPDU and ending with the last bit in the Operating Frequency field; 2) the first bit in the MPDU Header and ending with the last bit in the LPDU Sizes field of the last AA field; or 3) the first bit of the LPDU type field and ending with the last bit of the payload field. The CRC encoder shall be the International Telecommunication Union, Telecommunication Standardization Sector (ITU-T) -16 bit generator.

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

seeded with all 1's.

8. **FLIGHT LEG (1 octet) (optional)**

The flight leg ID shall identify the current flight leg. It shall be incremented by one every time the aircraft takes off. When the flight leg count reaches 255, the next increment shall reset it to zero.

The flight leg value that is in place when a performance data packet is being saved for transmission shall be used in the packet. The flight leg value shall be retained across power cycles of the HFDR.

9. **FLIGHT ID (6 octets) (optional)**

This field shall contain the airline flight number identifier if known. Otherwise, it may be set to all zeros. The six octets of this field shall be set as follows:

octet 1	most significant bit set to zero;
octet 1	lower seven bits set to character #1 (MSB of Flight ID);
octet 2	most significant bit set to zero;
octet 2	lower seven bits set to character #2;
octet 3	most significant bit set to zero;
octet 3	lower seven bits set to character #3;
octet 4	most significant bit set to zero;
octet 4	lower seven bits set to character #4;
octet 5	most significant bit set to zero;
octet 5	lower seven bits set to character #5;
octet 6	most significant bit set to zero;
octet 6	lower seven bits set to character #6 (LSB of Flight ID).

Characters 7 and 8, if available, are not included in the Flight Number ID field.

10. **FLUSH FIELD (8 bits)**

Eight 0s shall be appended after the FCS to flush the HF modem convolutional encoder.

11. **TDMA FRAME INDEX (12 bits)**

The Frame Index is defined as the integer part of the UTC (in seconds since midnight) at the beginning of the first slot (SPDU) in the frame divided by the frame period (also in seconds). Frames are numbered 0 to 2699 when the frame period is 32 seconds. The initial Frame Index after a frequency change shall be determined from the UTC at the time of transmission of the first SPDU. The Frame Index increments by 1 every time a new SPDU is transmitted.

Code	**Function**
0 - 2699	Count of frames since midnight

12. **TDMA FRAME OFFSET (4 bits)**

These four bits shall indicate the Frame Offset (in number of slots) relative to a master TDMA frame starting exactly at 0000 UTC.

Code	**Function**

0 - 12 Offset relative to a master TDMA frame starting at exactly at 0000 UTC

13. **FREQUENCIES PROPAGATING (20 bits) (optional)**

The 20 bits encoded shall indicate which frequencies are propagating (bit set to 1 indicates SPDU was received on that frequency) and which are not (bit set to 0 indicates that SPDU was not received).

14. **FREQUENCIES TUNED TO (20 bits) (optional)**

The 20 bits encoded shall indicate which frequencies were tuned to during the frequency search. Bit set to 1 indicates frequency was tuned, and bit set to 0 indicates the frequency was not attempted.

15. **FREQUENCY FIELD (4 octets)**

The Frequency Field shall be defined as follows:

1 2 3 4	5 6 7 8	1 2 3 4	5 6 7 8	1 2 3 4	5 6 7 8
100's Hz	1's KHz	10's KHz	100's KHz	1's MHz	10's MHz

16. **FREQUENCY ID (1 octet)**

This field shall identify the frequency for which the performance data applies. Its range is 1 (highest frequency assigned to the ground station) to 20.

17. **FREQUENCY SEARCH COUNTS (32 bits) (optional)**

The first 16 bits shall contain the number of times the aircraft has tuned to a new frequency in the previous flight leg. The second 16 bits shall contain the number of times the aircraft has tuned to a new frequency in the current flight leg.

18. **C -FREQUENCY UTILIZATION FLAG (1 bit)**

Reserved

19. **GROUND STATION ID (7 bits)**

The ground station Identification number shall identify the ground station.

Code	**Function**
0 - 127	Ground Station ID

20. **LATITUDE (20 bits)**

The latitudinal location of the ground station or aircraft shall be encoded in a 20-bit signed integer field using two's complement notation. This value represents a signed fraction of 180 degrees (the value 7FFFF hexadecimal will equate to 180 degrees, and the value 80001 hexadecimal will equate to -180 degrees). Positive numbers represent northern latitudes, and negative values represent southern latitudes.

21. **LONGITUDE (20 bits)**

The longitudinal location of the ground station or aircraft shall be encoded in a 20-bit signed integer field using two's complement notation. This value represents a signed fraction of 180 degrees (the value 7FFFF hexadecimal will equate to 180 degrees, and the value 80001 hexadecimal will equate to -180 degrees). Positive numbers represent eastern latitudes, and negative values represent western latitudes.

22. **H (1 bit)**

This bit shall be used to determine the mix of slots to be reserved. It is part of the Reservation Request field. It applies if the Slot Selection bit is zero.

Code	**Function**
0	Request N2 slots + N1 slots
1	Request N2 slots + N1 slots

23. **HF DATA DISABLED TIMES (32 bits) (optional)**

The first 16 bits shall indicate the total time in seconds that HF data was not enabled in the previous flight leg. The second 16 bits shall indicate the total time in seconds that HF data was not enabled in the current flight leg.

24. **HFNPDU TYPE (2 octets)**

If the first octet is coded as FFh, the HFNPDU is defined as follows:

FFh D0h	System Table Uplink
FFh D1h	Performance Data Downlink (optional)
FFh D2h	System Table Request
FFh D3h	Reserved
FFh D4h	Reserved

FFh	D5h	Frequency Data Downlink (optional)
FFh	D6-DDh	Reserved
FFh	DEh	Delayed Echo Application (Uplink and Downlink) (Optional)
FFh	FFh	Enveloped Data

If the first octet is not coded as FFh, the HFNPDU shall be encoded as described in Section 4 (Subnetwork Layer) of the Appendix to the HFDL SARPs.

25. **LOG-OFF REQUEST/LOG-ON DENIED REASON CODE (8 bits)**

The reason code for an aircraft log-on being denied (Log-On Denied LPDU, LPDU Type 2Fh) shall be indicated as follows:

00h	Reserved
01h	Aircraft ID not available
02h	HFDL Ground Station Sub-system does not support RLS
03h-FFh	Reserved

The reason code for an aircraft Log-off Request (LPDU Type 3Fh) shall be indicated as follows:

00h	Reserved
01h	Not within slot boundaries
02h	Downlink sent in uplink slot
03h	RLS protocol error
04h	Invalid aircraft ID
05h	HFDL Ground Station Sub-system does not support RLS
06h	Other
07h-FFh	Reserved

26. **LPDU (5 - 256 octets)**

The LPDUs (Link Protocol Data Unit) are user data packets that are encapsulated into the MPDU (Media Access Protocol Data Unit).

27. **LPDU SIZES (8 bits)**

This field shall indicate the length (in octets minus one) of the LPDU encapsulated within this MPDU. If there is more than one LPDU, there will be a corresponding LPDU Sizes field for each LPDU.

28. **LPDU TYPE (1 octet)**

If the first bit of the LPDU Type is a 1, then the LPDU Type shall be encoded as follows:

Type	Payload
1Dh	Unnumbered Acknowledged Data
0Dh	Unnumbered Data
———	HFDL System Table HFNPDU
———	Enveloped Data Block HFNPDU
———	Performance Data HFNPDU
———	System table Request HFNPDU
———	Frequency Data HFNPDU
8Fh	Log-on Request (Normal)
BFh	Log-on Request (DLS)
4Fh	Log-on Resume
9Fh	Log-on Confirm
5Fh	Log-on Resume-Confirm
2Fh	Log-on Denied
3Fh	Log-off Request

If the first bit of the LPDU Type is a 0, then this LPDU is a numbered LPDU and shall be encoded as follows:

Bits 2 and 3 are the segment RN (Reference Number)
Bits 4 through 8 are the D(S) or U(S) value

29. **M (1 bit)**

The M bit indicates whether or not the HFNPDU or BDU is the last in an M bit sequence. A “1” indicates more, a “0” indicates the last HFNPDU or BDU in the sequence.

30. **MASTER TDMA FRAME SLOT OFFSET (4 bits)**

Shall indicate which slot in the Master Frame a particular frequency's SPDU will be broadcast.

31. **N1 (3 bits)**

If slot selection = 0 and H = 0, N1 shall be the number of remaining medium priority slots, plus low priority slots required for transmission. If slot selection = 0 and H = 1, N1 shall be the number of remaining high priority slots, plus medium priority slots, plus low priority slots required for transmission.

32. **N2 (3 bits)**

If slot selection = 0 and H = 0, N2 shall be the number of medium priority slots. If slot selection = 0 and H = 1, N2 shall be the number of high priority slots.

33. **NAC (3 bits)**

It shall be calculated as the number of Aircraft Address fields in the MPDU header minus one.

34. **NF (7 bits)**

Used for slot reservations. NF represents the number of frames following the current frame in which one slot is requested. Only valid when SLOT SEL = 1.

35. **NLP (4 bits)**

The NLP shall be the number of LPDUs encapsulated within the MPDU.

36. **NUMBER OF FREQUENCIES (5 bits)**

The number of frequencies field in the system table shall be the number of frequencies authorized for packet service at the ground station.

37. **NUMBER OF PACKETS (4 bits)**

This field shall identify the total number of HFNPDUs (1 to 16) minus one used to broadcast the entire system table.

38. **P (1 bit)**

Parity bit. For uplink and downlink MPDUs the parity bit shall be set to make the octet odd.

39. **PD VERSION (1 octet) (optional)**

This field shall identify the version number and contents of the performance data HFNPDU.

40. **PDU SEQUENCE NUMBER (1 octet)**

The PDU sequence number shall be used to identify the PDU (Protocol Data Unit) within the various HFNPDUs used to broadcast an entire HFDL System Table. It contains two subfields, the Sequence Number and Number of Packets.

41. **PRIORITY (4 bits)**

This field shall contain the lowest packet priority level accepted by the ground station. The aircraft and the ground station shall discard and not transmit data at priorities lower than the minimum accepted priority.

Code	Function
0 - 15	Minimum priority accepted by this ground station. Default is currently 7.

42. **PROPAGATING FREQUENCY DATA (6 octets)**

This is one of up to six fields of six octets length each that shall contain data that indicate which frequencies are propagating from which ground station to the current aircraft position and which frequencies that the aircraft is tuned to.

43. **REQUEST DATA (2 octets)**

Each bit in this 16-bit field shall correspond to an HFDL System Table HFNPDU. The "first transmitted bit" in the two-octet field shall be a request for the first HFNPDU and the "last transmitted bit" shall be a request for the 16th HFNPDU. If this is the first request by an aircraft HFDL function, all of the bits in this field shall be 1. If an HFNPDU or HFNPDUs are lost on the subsequent broadcast uplink, the appropriate bit, or bits, shall be set to 1 in the HFDL System Table request and only those HFNPDUs shall be uplinked by the HFDL ground station.

44. **RLS FLAG (Reliable Link Service Protocol) (1 bit)**

This flag shall indicate whether the ground station is using RLS or not.

Code	**Function**
0	Not using RLS
1	Using RLS

45. **SEQUENCE NUMBER (4 bits)**

The sequence number subfield shall contain a sequence number (0 to 15) that identifies the order of the HFNPDU within the sequence of HFNPDUs used to broadcast the entire system table. It is a subfield of the PDU Sequence Number field in the HFDL System Table HFNPDU.

46. **SLOT ACKNOWLEDGEMENT CODES (36 octets)**

Thirty-six octets (288 bits) shall be used to broadcast a 12-bit acknowledgment field for 24 non-SPDU previous slots. The relationship between each 12-bit acknowledgment field and the slot being acknowledged is shown as follows:

	12b	12b	12b	12b	12b	12	12b	12b	12b	12b	12b	12b
frame	n-3	n-3	n-2	n-2	n-2	n-1	n-1	n-1	n-1	n-1	n-1	n-1
slot	s11	s12	s01	---	s12	s01	s02	s03	---	s08	s09	s10

Each 12-bit field shall be further sub-divided as shown below:

8b	4b
Aircraft ID	Code

Acknowledgments to downlinks sent using a single slot shall be represented as follows:

If one to four LPDUs are transmitted in the slot, then the bits have the following meaning:
slot acknowledgment field bit 1 acknowledges LPDU 1
slot acknowledgment field bit 2 acknowledges LPDU 2
slot acknowledgment field bit 3 acknowledges LPDU 3
slot acknowledgment field bit 4 acknowledges LPDU 4

If five to eight LPDUs are transmitted in the slot, then the bits have the following meaning:
slot acknowledgment field bit 1 acknowledges LPDU 1 and 2
slot acknowledgment field bit 2 acknowledges LPDU 3 and 4
slot acknowledgment field bit 3 acknowledges LPDU 5 and 6
slot acknowledgment field bit 4 acknowledges LPDU 7 and 8

Acknowledgments to downlinks sent using double slots are represented as follows:

If one to eight LPDUs are transmitted in the slots, the bits have the following meaning:
slot 1 acknowledgment field bit 1, acknowledges LPDU 1
slot 1 acknowledgment field bit 2, acknowledges LPDU 2
slot 1 acknowledgment field bit 3, acknowledges LPDU 3
slot 1 acknowledgment field bit 4, acknowledges LPDU 4
slot 2 acknowledgment field bit 1, acknowledges LPDU 5
slot 2 acknowledgment field bit 2, acknowledges LPDU 6
slot 2 acknowledgment field bit 3, acknowledges LPDU 7
slot 2 acknowledgment field bit 4, acknowledges LPDU 8

If nine to 15 LPDUs are transmitted in the slots, then the bits have the following meaning:
slot 1 acknowledgment field bit 1, acknowledges LPDU 1 and 2
slot 1 acknowledgment field bit 2, acknowledges LPDU 3 and 4
slot 1 acknowledgment field bit 3, acknowledges LPDU 5 and 6
slot 1 acknowledgment field bit 4, acknowledges LPDU 7 and 8
slot 2 acknowledgment field bit 1, acknowledges LPDU 9 and 10
slot 2 acknowledgment field bit 2, acknowledges LPDU 11 and 12
slot 2 acknowledgment field bit 3, acknowledges LPDU 13 and 14
slot 2 acknowledgment field bit 4, acknowledges LPDU 15

Note.— A bit containing a logical "1" shall represent positive acknowledgement (ACK), and a bit containing a logical "0" shall represent negative acknowledgement (NAK).

47. SLOT ASSIGNMENT CODES (12 octets)

Twelve octets (96 bits) shall be used to broadcast an 8-bit assignment code for 12 non-SPDU future slots. Assignments for the two slots immediately after the SPDU are not assigned in this SPDU, but were assigned in the previous SPDU. The relationship between each slot assignment and the slot position relative to the current SPDU slot is defined as follows:

	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b
frame	n	n	n	n	n	n	n	n	n	n	n+1	n+1
slot	s03	s04	s05	s06	s07	s08	s09	s10	s11	s12	s01	s02

Code	**Function**
00	Reserved for uplinks
FE_H	Assigned for random access
FFH	Reserved

01_H - FD_H Assigned to that particular aircraft ID

48. **SLOT SEL (1 bit)**

It shall determine what type of slots are reserved.

Code	Function
0	Low, medium or high slots reserved.
1	One slot reserved NF frames (or later) from the current frame.

49. **T (1 bit)**

Type of MPDU.

Code	Function
0	Uplink LPDU
1	Downlink LPDU

50. **UDR - UPLINK DATA RATE (3 bits)**

The uplink data rate shall be determined by the size of the MPDU (number and type of LPDUs to be transmitted) and the quality of the link.

Code	Function
000	Reserved
001b	300 bits/s
010b	600 bits/s
011b	1 200 bits/s
100b	1 800 bits/s

51. **UPLINK ACK (16 bits)**

This field shall contain the uplink data rate (3 bits) and 13 bits of zeros (not used).

52. **UTC TIME (UNIVERSAL COORDINATED TIME) (2 octets)**

This field shall indicate time expressed in seconds (UTC divided by 2) with a resolution of 2 seconds.

53. **SPDU VERSION (2 bits)**

SPDU version field. Initially the version field shall be set to 00. Ideally, all ground stations should broadcast SPDUs with the same initial version. However, if a significant change is ever deemed necessary after initiation of the service, the SPDU version should be changed. The SPDU version field provides the means to indicate that a significant change in the format of the SPDU has been introduced. If a change should ever be needed, some ground stations may continue to use the older version in order to allow for a gradual update of all aircraft software.

Code	**Function**
0 - 3	SPDU version number

54. **I – (ISO 8208)**

This flag is used to indicate whether the ground station currently supports the ISO 8208 Subnetwork Access Protocol. A setting of 0 shall indicate that the ground station supports the delivery of enveloped messages only. A setting of 1 indicates that the ground station supports the delivery of both ISO 8208 and enveloped messages.

Code	**Function**
0	8208 Protocol Implementation not supported
1	8208 Protocol Implementation supported

55. **D(R)**

This field shall be a 5-bit value which defines a downlink sequence number representing the oldest downlink LPDU not yet received by the Ground Station Sub-system from the Aircraft during a RLS transmission. The field is set to a value of 0 in the Log-On Confirm and to the current settings at the ground station in the Log-On Resume Confirm.

56. **D(R) vect**

This field shall be an 8-bit value that determines which LPDUs have been received and which LPDUs have been lost in transit from the aircraft to the ground station. Each bit indicates whether or not each of the LPDUs starting with sequence number D(R)+1 to D(R)+8 has been received by the ground station. Bit 1 is set to zero if the numbered LPDU having sequence number D(R)+1 has not been received, otherwise it is set to 1.Bit 8 is set to zero if the numbered LPDU having sequence number D(R)+8 has not been received, otherwise it is set to 1. The D(R)vect is set to 0 in the Log-On Confirm and to the current settings at the ground station in the Log-On Resume-Confirm.

57. **U(R)**

This field shall be a 5-bit value which defines an uplink sequence number representing the oldest uplink LPDU not yet received by the aircraft from the Ground Station Sub-system during a RLS transmission.

58. **U(R)vect**

This field shall be an 8-bit value that determines which LPDUs have been received and which LPDUs have been lost in transit from the ground station to the aircraft. Each bit indicates whether or not each of the LPDUs starting with sequence number U(R)+1 to U(R)+8 has been received by the aircraft. Bit 1 is set to zero if the numbered LPDU having sequence number U(R)+1 has not been received, otherwise it is set to 1. Bit 8 is set to zero if the numbered LPDU having sequence number U(R)+8 has not been received, otherwise it is set to 1.

59. **k**

A four bit field indicating the transmit window size for outstanding packet acknowledgements. The value is calculated as the transmit window size + 1. Therefore the value can range from 1 to 16. The value is only used in RLS transmissions.

60. **UTC SYNC - SYNCHRONIZATION FLAG (1 bit)**

Ground Station Synchronization Flag. This flag indicates whether the ground station SPDU transmission is synchronized to Universal Coordinated Time (UTC) or not.

Code	Function
0	Not synchronized to UTC time.
1	Synchronized to UTC time.

61. **NUMBER OF MPDUs RECEIVED (optional)**

Each field is a single octet indicating the number of uplink MPDUs received on the identified frequency at each baud rate (1800, 1200, 600, and 300). The counts are initialized at zero when the aircraft logs on the identified frequency and ground station and the appropriate counts are incremented by one to a maximum of FFh whenever an uplink MPDU (not a SPDU) is received.

62. **NUMBER OF MPDUs RECEIVED WITH ERRORS (optional)**

Each field is a single octet indicating the number of uplink MPDUs received with errors (errors detected in at least one of the LPDUs or the header) on the identified frequency at each baud rate (1800, 1200, 600, and 300). The counts are initialized at zero when the aircraft logs on the identified frequency and ground station and the appropriate counts are incremented by one to a maximum of FFh whenever an uplink MPDU (not a SPDU) is received.

63. **NUMBER OF RECEIVED SPDUs (optional)**

A two octet field containing the total number of SPDUs received error free during the time the aircraft was tuned to the identified frequency.

64. **NUMBER OF SPDUs WITH ERRORS OR NOT RECEIVED (optional)**

A one octet field containing the number of SPDUs which were received with errors or were not received during the time the aircraft was tuned to the frequency. Note that SPDUs not received while the aircraft was in voice mode are not included in this count.

65. **DELIVERED MPDUs (optional)**

Each field is a single octet indicating the number of downlink MPDUs delivered successfully on the first try (all LPDUs in the MPDU positively acknowledged by the ground station) at each baud rate (1 800, 1 200, 600, and 300). The counts are initialized at zero when the aircraft sent the Log-On Request on the identified frequency and ground station and the appropriate counts are incremented by one whenever a downlink MPDU is transmitted and when the acknowledgments are received on subsequent SPDUs.

66. **NUMBER OF MPDUs TRANSMITTED (optional)**

Each field is a single octet indicating the number of downlink MPDUs transmitted on the identified frequency at each baud rate (1 800, 1 200, 600, and 300). The counts are initialized at zero when the aircraft sent the Log-On Request on the identified frequency and ground station and the appropriate counts are incremented by one whenever a downlink MPDU is transmitted and when the acknowledgments are received on subsequent SPDUs.

67. **FREQUENCY CHANGE CODE (optional)**

This is a one octet field. The first four bits contain a code that indicates the reason for the last frequency change. It is set to 0 when it was the first frequency search of the current flight leg. It is set to 1 when the change was due to too many negative acknowledgements. It is set to 2 when the change was due to SPDUs no longer received. It is set to 3 when the switch resulted due to HF Data Disabled. It is set to 4 when the switch was due to a ground station frequency change notice. It is set to 5 when the change was due to a ground station down/channel down notice. It is set to 6 when the change is due to poor uplink channel quality. If there has been no frequency search or change since the last performance data HFNPDU was sent, it is set to 7. The upper four bits are reserved for future definition (set to 0).

68. **NUMBER OF HFNPDUs**

The four most significant bits of the PDU Sequence Number identifies the total number of HFNPDUs (1 to 16) minus one used to broadcast the entire system table.

69. **FREQUENCY FIELD**

A three octet field containing the highest assigned frequency for packet data service and the ground station and proceeding to the lowest assigned frequency. The frequency is encoded as six 4-bit BCD digits with the first transmitted BCD digit representing the 100 Hz increment and the sixth transmitted BCD digit representing the 10 MHz increment. The two most significant bits are always set to zero.

70. **BDU SEQUENCE NUMBER**

A three-bit field indicating the sequence number of BDUs in the HFNPDU. The value ranges from 0 to 7. There can be a maximum of eight BDUs per HFNPDU. The first BDU has a value of 0, the second BDU has a value of 1. The nth BDU has a value of n-1.

71. **RN (Reference Number)**

The Reference Number identifies the HFNPDU segment in the LPDU Type field of a Numbered Data LPDU. The Reference Number is encoded in bits 2 and 3 of the LPDU Type field.

72. **D(S)**

A five-bit downlink sequence number embedded in the LPDU Type field of the downlink Numbered Data LPDU. The D(S) value is encoded in bits 4 through 8 of the LPDU Type field.

73. **U(S)**

A five-bit uplink sequence number embedded in the LPDU Type field of the downlink Numbered Data LPDU. The D(S) value is encoded in bits 4 through 8 of the LPDU Type field.

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