RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS

Proposed Text for FIS-B MASPS Appendix F Describing UAT Uplink Services

Author: T. Mosher, UPS AT, SC-186 WG-5 Member

SUMMARY

This working paper describes how the Application Data field of a UAT Ground Uplink message is used to transport Uplink services to airborne participants. A new method is proposed such that multiple uplink services (FIS-B, TIS-B …) can define their own data product formats independent from each other.

This final version (Rev. A) of this working paper is hereby submitted by WG-5 to RTCA/SC-195, for inclusion in Change 1 to DO-267 (FIS-B MASPS) Appendix F.

When originally published, the FIS-B MASPS contained a placeholder in Appendix F.2, stating "…this section is reserved…and will outline the radio subsystem/frame layer format used within the UAT design to achieve equivalent functional performance" to VDL Mode 2, as described in Appendix F.1 (included below).

This working paper supplies draft text to complete §F.2. The existing text of §F.1 is provided for reference.

Appendix F EXCEPTIONS TO STRICT COMPLIANCE WITH ISO 3309

Strict compliance with all the provisions of ISO 3309 may not be appropriate for some implementations. Exceptions to strict compliance with ISO 3309 are outlined below.

F.1 VDL Mode 2 Unnumbered Information Link Layer Frame Format

Table F.1 Link Layer Frame Format

	Bit Number (First Bit Transmitted ↓)

Description	Octet No.	8	7	6	5	4	3	2	1
Flag	0	0	1	1	1	1	1	1	0
Destination Address Field	1	d_{22}	d_{23}	d_{24}	d_{25}	d_{26}	d_{27}	A/G	0
	2	d_{15}						d_{21}	0
	3	d_8						d_{14}	0
	4	d_1						d_7	0
Source Address Field	5	s_{22}	s_{23}	s_{24}	s_{25}	s_{26}	s_{27}	C/R	0
	6	s_{15}						s_{21}	0
	7	s_8						s_{14}	0
	8	s_1						s_7	1
Link Control Field	9	0	0	0	0	0	0	1	1
Information Field	N-2	FIS-B A P D U							
Frame Check Sequence	N-1	fcs_9							fcs_{16}
	N	fcs_1							fcs_8
Flag	N+1	0	1	1	1	1	1	1	0

Note: ISO 3309 states that a transmitter may include more than one frame in a single physical layer transmission, with a single flag separating each frame.

F.1.1 Flag

Flag is a unique HDLC bit sequence to delimit the start and end of each APDU transported by the data link layer. FIS-B frames shall be delimited by this unique sequence of bits by setting the Flag octet to '01111110' binary.

F.1.2 Destination Address Field

The Destination Address Field is a 28-bit field comprised of a 24-bit Aircraft Specific Address field (d_1 through d_{24}), a 3-bit Address Type field (d_{25} through d_{27}), and a 1-bit Air/Ground (A/G) Transmitter field. The nominal broadcast destination address encoding is taken from Table 6-8, Broadcast Address Encoding, of the VDL Mode 2 SARPs. The nominal broadcast destination is all aircraft and assumes all ones in the specific destination address field. In the future, use of aircraft specific destination addressing (unicast) within the specific destination address field is not precluded.

F.1.2.1 Aircraft Specific Address

This 24-bit address (d_1 through d_{24}) shall be set to all ones (1s) for FIS-B frames to denote a broadcast destination address as encoded in Table 6-8 of the VDL Mode 2 SARPs. Future implementations will support aircraft specific addressing (unicast) utilizing 24-bit aircraft addressing.

F.1.2.2 Address Type

This 3-bit type field field (d_{25} through d_{27}) shall be set to '100' binary to signify "ALL AIRCRAFT" type. It is expected that this destination type field will remain constant for all broadcast UI frames. Future implementations will support an appropriate address type field for aircraft specific addressing.

F.1.2.3 A/G Transmitter

This bit represents the location of the transmitting station as being either airborne or on the ground, as defined is Section 6.5.3.3.3.1 of the VDL Mode 2 SARPs. This bit shall be set to '1' for FIS-B, since the transmitting station is on the ground.

F.1.3 Source Address Field

The Source Address Field is a 28-bit field comprised of a 24-bit Ground Specific Address field (s_1 through s_{24}), a 3-bit Address Type field (s_{25} through s_{27}), and a 1-bit Command/Response (C/R) bit. This address field is described in detail in the Section 6.5.3.3.3 through Section 6.5.3.3.3.7 in the VDL Mode 2 SARPs.

F.1.3.1 Broadcast Source Address

This 24-bit address (s_1 through s_{24}) shall be the ICAO delegated ground address.

F.1.3.2 Address Type

This 3-bit type field (s_{25} through s_{27}) shall be set to '101' binary to signify "ICAO DELEGATED ADDRESS" type. Its encoding is taken from Table 6-7, Address Type Field Encoding, of the VDL Mode 2 SARPs. It is expected that this field will change depending on the source of the broadcast UI frames.

F.1.3.3 C/R Bit

The Command-Response (C/R) bit shall be set to '0' to indicate that the UI frame is a command. The C/R bit is described in Section 6.5.3.3.3.2 of the VDL Mode 2 SARPs.

F.1.4 Link Control Field

This field indicates the purpose of the frame. It shall be set to '00000011' binary to represent the UI command as detailed in Section 7.3 of ISO 4335. This binary setting includes the Poll/Final (P/F) bit, which is described in Section 6.5.3.7 of the VDL Mode 2 SARPs and Section 6.2.3 of ISO 4335. All commands, other than the UI command require a response. The AVLC commands and responses are detailed in Table 6-9 of the VDL Mode 2 SARPs.

F.1.5 Information Field

This field shall be used to transfer FIS-B APDUs. The requirements for the information field are given in the FIS-B ASE format specification.

F.1.6 Frame Check Sequence

FIS-B shall contain a 16-bit frame checking sequence as described in ISO 3309, Section 4.6 and Annex A .

F.2 Universal Access Transceiver Radio Subsystem/Frame Layer Format

The Universal Access Transceiver (UAT) is a multi-purpose aeronautical data link system designed to deliver broadcast services, including FIS-B, using a single wide-band communication channel. The controlling document for the UAT data link is RTCA/DO-xxx, "Minimum Operational Performance Specifications for ADS-B Systems using Universal Access Transceivers", abbreviated as "UAT MOPS" in the text below.

The UAT data link offers equivalent capabilities to ISO standard HDLC protocol described in ISO/IEC specification 3309 and 4335 for FIS-B framing, as specified in Section 3.4 of this document. Consistent with the requirements in Section 3.4, some Data Link Services (e.g., synchronization and error correction) are an integral part of the UAT transmission frame, while others (e.g., station identification) are supported in the message formats and can be varied as necessary by the controlling subsystem.

The notation syntax of the UAT MOPS is used in the text below, for consistency of specifying bit ordering within UAT messages.

F.2.1 FIS-B Product Framing

The framing of FIS-B messages is accomplished by encapsulating them as the Payload of a Ground Uplink Message, as described in §2.2.3.2 of the UAT MOPS.

The Ground Uplink Payload is composed of an eight-byte UAT-Specific Header, followed by 424 bytes of Application Data. The Application Data field is further composed of Information Frames ("I-Frame 1" through "I-Frame N") of uplink service data, as shown in Figure F.1.

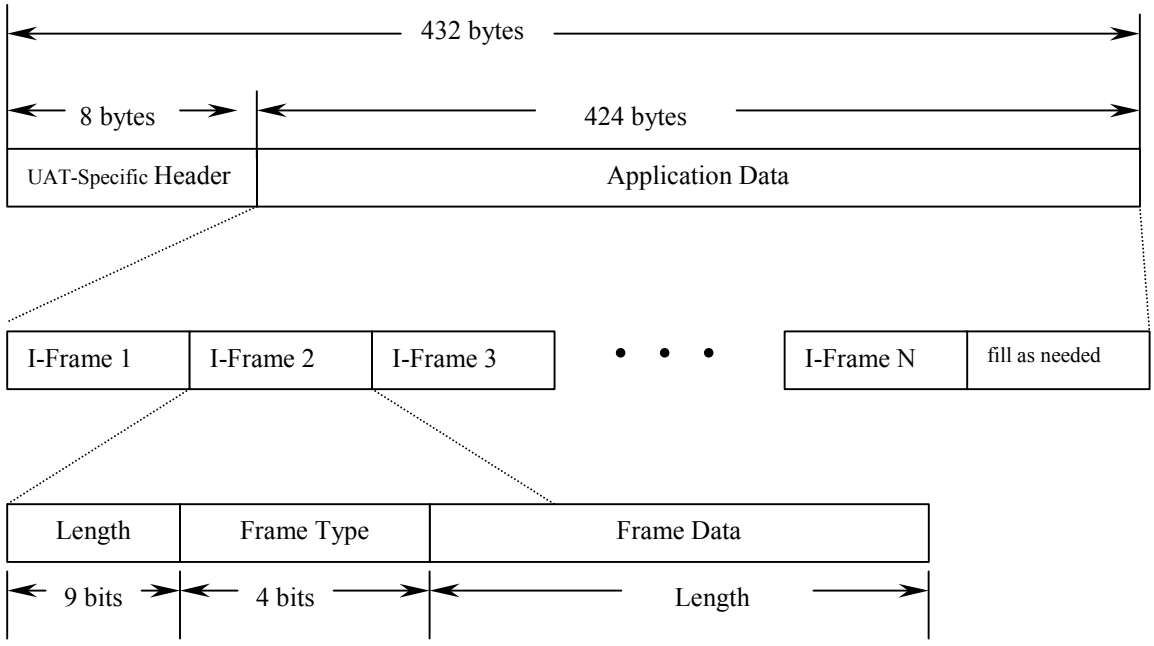

Figure F.1 - FIS-B Product Framing

Each of the fields illustrated in Figure 1 are discussed in the following subparagraphs.

F.2.1.1 UAT-Specific Header

The UAT-Specific Header is an 8-byte field that contains information on the location of the uplink site, the time slot used to send the present message, validity flags for position, time, and application data, and other fields as described in UAT MOPS §2.2.3.2.2.

F.2.1.2 Application Data

The Application Data is a fixed-length field of 424 bytes. The Application Data consists of Information Frames, and always consists of an integral number of bytes. Any remaining unused portion of the field filled with ZERO bytes.

F.2.2 Information Frame

Each Information Frame consists of 'N' bytes, comprising three fields formatted as described in the Table 2:

Table F.2 - Information Frame

Byte #	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
1	MSB	**Length**						
2	LSB	**Reserved**			MSB	**Frame Type**		LSB
3 - N	**Frame Data**							

Note that the Byte numbers in this table are relative to the beginning of the current Information Frame.

The **Length** field (Byte 1: Bit 1 through Byte 2: Bit 1) is a 9-bit field that contains the length of the Frame Data field in bytes. Values range from 0 through 422 (decimal). The Length value is always equal to 'N-2'.

The **Reserved** field (Byte 2: Bits 2 through 4) is a 3-bit field that is reserved for future use, and will be set to the ZERO value in equipment that complies with this document.

The **Frame Type** field (Byte 2: Bits 5 through 8) is a 4-bit field that contains the indication for the format of the Frame Data field. The Frame Types are defined in Table 3.

Table F.3 - Frame Types

MSB **Value** (binary) LSB	**Frame Data Format**
0 0 0 0	FIS-B APDU with Short Header
0 0 0 1	FIS-B APDU with Long Header
0 0 1 0	TIS-B System Frame
all other values	Reserved

Each Frame Data format is described in the following subparagraphs. The Frame Data field is always an integral number of bytes in length.

F.2.2.1 Frame Data Format For FIS-B APDU with Short Header

When the Frame Type is the binary value "0 0 0 0", the Frame Data contains an APDU Header, followed by the APDU Data, as described in §3.6, Appendix D, and Appendix E of this document. See subparagraph F.2.4 regarding the APDU Header format.

F.2.2.2 Frame Data Format for FIS-B APDU with Long Header

When the Frame Type is the binary value "0 0 0 1", the Frame Data contains the Destination and Source Address Fields as shown in Table F.1 of this document, followed by the APDU Header and APDU Data as discussed in §F.2.2.1 above. This allows for future expansion of capabilities as discussed in §F.1.2 and §F.1.3.

Table F.4 - Frame Data Format for FIS-B APDU with Long Header

Byte #	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
1	**A/G**	MSB	**Addr Type**	LSB	MSB			
2	**Destination Address**							
3								
4				LSB	**C/R**	MSB	**Addr Type**	LSB
5	MSB							
6	**Source Address**							
7								LSB
8 - N	**APDU Header** and **APDU Data**							

The **A/G** field is described in §F1.2.3, and occupies Byte 1: Bit 1.

The **Destination Address Type** field occupies Byte 1: Bits 2 through 4, and is described in §F.1.2.2. Byte 1: Bit 2 (MSB) corresponds to "d_{27}" in Table F.1 of this document.

The **Destination Address** field is described in §F.1.2.1. Byte 1: Bit 5 (MSB) corresponds to "d_{24}", and Byte 4: Bit.4 (LSB) corresponds to "d_1", in Table F.1 of this document.

The **C/R** field is described in §F1.3.3, and occupies Byte 4: Bit 5.

The **Source Address Type** field occupies Byte 4: Bits 6 through 8, and is described in §F.1.3.2. Byte 4: Bit 6 (MSB) corresponds to "s_{27}" in Table F.1 of this document.

The **Source Address** field is described in §F.1.3.1. Byte 5: Bit 1 (MSB) corresponds to "s_{24}", and Byte 7: Bit.8 (LSB) corresponds to "s_1", in Table F.1 of this document.

The **APDU Header** and **APDU Data** are as described in §3.6, Appendix D, and Appendix E of this document. See §F.2.4 regarding the APDU Header format.

> *Note: If the Destination Address field is set to indicate that the message is a broadcast intended for all aircraft, and if there is no requirement that the receiving airborne application have knowledge of the ICAO delegated Ground Station address, then the FIS-B APDU can be communicated more efficiently by use of the Short Header format (see §F.2.2.1).*

F.2.2.3 Frame Data Format for TIS-B System Frames

When the Frame Type is the binary value "0 0 1 0", the Frame Data contains System information required to support the TIS-B Uplink service. TIS-B System Frames will contain information describing the status of each provided service, including availability, service type, service volume, etc. Specification of the Frame Data contents for TIS-B System Frames is beyond the scope of this document. Note that TIS-B target track information is conveyed using ADS-B formatted messages (see UAT MOPS for details).

F.2.3 Equivalence to VLD Mode 2 Frame Format

The following subparagraphs discuss the equivalence of the UAT implementation with the implementation described in §F.1 of this document.

F.2.3.1 Addressing and Link Control

For broadcast services, the Short Header format may be used to efficiently communicate FIS-B messages. The location of the ground transmitter is provided in the UAT-Specific Header (UAT MOPS §2.2.3.2.2.1).

For applications where Destination and Source Addresses are required, the Long Header format may be used.

Since the Link Control field (see §F.1.4) is defined as a fixed value for FIS-B service, it need not be transmitted as part of the message.

F.2.3.2 Message Integrity

The entire Ground Uplink Message is validated using a Reed-Solomon Forward Error Correction (FEC) parity method (Sections 2.2.3.2.3 and 2.2.3.2.4 in the UAT MOPS) providing 120 bytes of parity. The undetected message error rate for UAT Ground Uplink messages is approximately 1.3×10^{-12} (see Appendix M of the UAT MOPS).

F.2.3.3 Compatibility and Report Assembly

For installations where compatibility with existing avionics equipment is desired, the VLD Mode 2 link layer frame format specified in §F.1 can be reconstructed by the UAT receiving subsystem's Report Assembly function without loss of content or accuracy.

F.2.4 APDU Header for UAT data link

For the UAT data link, the first two bytes of the APDU Header (the APDU Header Identifier field) as shown in Appendix D of this document, are omitted. The Information Frame Type, as discussed in §F.2.2 above, provides the equivalent functionality. If required, the ADPU Header Identifier field may be re-inserted by the UAT receiving subsystem's Report Assembly function.