**Connectionless VDL Mode 2 Standards Impacts**

Comments from Tom McGuffin,

**High-Level Requirements**

1. HDLC Optional Functions Aircraft and ground stations that desire to use UI frames to exchange data should indicate support for UI frames in the HDLC optional functions XID public parameter (specifically bit “c” described by A631-7 Table 4-2A and Table 4-2B). Aircraft and ground stations should use connectionless VDL Mode 2 only if they both indicate support for UI frames.
2. Addressing In order to support ground station diversity for downlinks, an aircraft should use the ground station broadcast address of a particular DSP as the destination address of a downlink UI frame used to exchange data (unlike a downlink INFO frame, which contains a specific ground station address as its destination address). As ICAO Doc 9776 2nd Ed. Table II-5-3 and Table II-5-4 describe, the type field bits are set to 100 (ICAO-administered) or 101 (ICAO-delegated) and the specific address field bits are set to the DSP’s system mask with the each of the remaining bits set to 1. Additionally, in order to support ground station diversity for uplinks an aircraft should accept all UI frames addressed to the aircraft that contain a ground station address with the system mask of the DSP with which it desires to communicate as its source address, even if the aircraft has not previously received a frame from or sent a frame to the ground station and the ground station isn’t present in the aircraft’s PECT. No other addressing changes relative to INFO frames are necessary (a downlink UI frame has the aircraft address as its source address, and an uplink UI frame has the ground station address as its source address and the aircraft address as its destination address).
3. UI Frames Support A DSP should indicate support for exchanging data using UI frames via a new UI frames support ground-initiated information private parameter in its GSIF. In particular, the DSP should use bit 1 to indicate whether it supports AOA packets in UI frames (0 = no, 1 = yes), bit 2 to indicate whether it supports VDL 8208 packets in UI frames (0 = no, 1 = yes), and bit 3 to indicate whether it supports VDL IP packets in UI frames (0 = no, 1 = yes). (Note: A631-7 Table 2-1-4 indicates that both ground station and aircraft support of UI frames is optional.)

do not

1. Network Layer Protocol Identification Aircraft and ground stations that generate a UI frame containing one of the various packet types should generate the packets as follows for encapsulation in the UI frame:
a) for an AOA packet, precede the ACARS block with an IPI of 0xFF and an EIPI of 0xFF (to indicate that ACARS is the network layer protocol per A618-8);
b) for a VDL 8208 packet, precede the 8208 PDU with an IPI of TBD without an EIPI (to indicate that ATN is the network layer protocol per ATN SARPS 9705;

c) for a VDL IP packet, precede the IP packet with an IPI of 0x8E without an EIPI (to indicate that IPv6 is the network layer protocol per ISO 9577:1999(E) Annex C).
2. Frequency Management The existing frequency acquisition, frequency establishment, frequency maintenance, and frequency change mechanisms for connection-oriented VDL Mode 2 are also used for connectionless VDL Mode 2 with certain relatively minor changes. Although no link needs to be established for connectionless VDL Mode 2, an AVLC-level downlink-uplink message exchange for connectionless VDL Mode 2 frequency establishment is desirable as a common mechanism for ACARS, OSI, and IPS.

*Frequency acquisition* The avionics use the existing frequency acquisition (i.e., selection, including search, recovery, and CSC fallback) mechanisms to acquire a VDL Mode 2 frequency.

*Frequency establishment* The avionics send an XID\_CMD\_LE (P=1) with the ground station broadcast address of a particular DSP as the destination address and the DSP sends an XID\_RSP\_LE (F=1) in response. (The downlink XID provides useful parameters such as the aircraft position, destination airport, etc.) If the avionics receive the XID\_RSP\_LE (F=1), then they consider connectionless VDL Mode 2 to be available and proceed to frequency maintenance. If the avionics do not receive the XID\_RSP\_LE (F=1) after T3 x N2, then they consider connectionless VDL Mode 2 to be unavailable and proceed to frequency acquisition.

*Frequency maintenance* The avionics use the existing TG2 and T4 mechanisms to maintain a VDL Mode 2 frequency.

When the airborne TG2 timer expires (default = 240 seconds), the avionics send an XID\_CMD\_HO (P=1) with the ground station broadcast address of a particular DSP as the destination address and the DSP sends an XID\_RSP\_HO (F=1) in response. If the avionics receive the XID\_RSP\_HO (F=1), then they consider connectionless VDL Mode 2 to be available and remain in frequency maintenance. If the avionics do not receive the XID\_RSP\_HO (F=1) after T3 x N2, then they consider connectionless VDL Mode 2 to be unavailable and proceed to frequency acquisition.

When the airborne T4 timer expires (default = 20 minutes), the avionics send an RR (P=1) with the ground station broadcast address of a particular DSP as the destination address and the DSP sends an RR (F=1) in response. If the avionics receive the RR (F=1), then they consider connectionless VDL Mode 2 to be available and remain in frequency maintenance. If avionics do not receive the RR (F=1), then they consider connectionless VDL Mode 2 to be unavailable and proceed to frequency acquisition.

*Frequency change* The avionics use the existing FSL and GRAIHO mechanisms to change VDL Mode 2 frequencies (which means that avionics should accept a GRAIHO without having an established link) with two exceptions: (a) the GRAIHO may not contain the RGSL parameter, and if it does then the avionics should ignore it; and (b) on the new frequency the avionics send the XID\_CMD\_HO (P=1) with the ground station broadcast address of a particular DSP as the destination address and DSP sends the XID\_RSP\_HO (F=1) in response. If the avionics receive the XID\_RSP\_HO (F=1), then they consider connectionless VDL Mode 2 to be available and proceed to frequency maintenance. If the avionics do not receive the XID\_RSP\_HO (F=1) after T3 x N2, then they consider connectionless VDL Mode 2 to be unavailable and proceed to frequency acquisition.

1. Acknowledgments No AVLC-level acknowledgements to UI frames are necessary (like how RR frames acknowledge receipt of INFO frames). Instead, higher-level protocols perform any necessary recovery. In the case of AOA, appropriate timers and counters for connectionless VDL Mode 2 should be added to those already defined for connection-oriented VDL Mode 2 in A618 Section 11.

**Standards Impacts Matrix**

|  |  |
| --- | --- |
|  | **Impacts** |
| **Standard** | *1. HDLC Optional Functions* | *2. UI Frames Addressing* | *3. UI Frames Support* | *4. Network Layer Protocol Identification* | *5. Frequency Management* | *General Description* |
| A631-7 | **yes**(add 7.16) | **yes**(add 7.4.3) | **yes**(add 7.16) | **yes**(add 7.16, amend Appendix G for various packet types) | **yes**(add 9.8.3) | **yes**(add 7.16) |
| Doc 9776 2nd Ed. | **no**(see Part I 3.4.2.1, Part II 5.4.2.2, Table II-5-47) | **no**(see Part II 5.3.3.3 and 5.3.3.4, Table II 5-3, Table II-5-4) | **yes**(add Part II 5.4.2.7.9, Table II-5-48, Table II-5-49; amend Table II-5-47 a, b, c) | **n/a** | **yes?** | **yes**(amend Part II 5.3.11.5) |
| DO-224C | **no**(see 3.2.2.5.2.2, Table 3-48) | **no**(see 3.2.2.4.2.3 and 3.2.2.4.2.4) | **yes**(add 3.2.2.5.2.7.9, Table 3-46a, Table 3-46b; amend Table 3-48 a, b, c) | **yes**(add 3.2.3.1.4 for VDL IP packets) | **yes?** | **yes**(amend 3.2.2.4.10.5) |
| DO-281B / ED-92B | **no**(see 2.4.5.5.2.2) | **no**(see 2.4.5.4.2.3 and 2.4.5.4.2.4) | **yes**(amend 2.4.5.4.9.5) | **n/a** | **yes?** | **yes**(amend 2.4.5.4.9.5) |
| A618-8 | **n/a** | **n/a** | **n/a** | **no**(see 11.1.1) | **n/a** | **yes**(add 11.1.4, amend 11.4) |
| A758 | **n/a** | **n/a** | **n/a** | **no**(see 5.4.1.2.3) | **n/a** | **no**(see 5.4.1.2.3) |
| ATN SARPS?IPS SARPS? |  |  |  |  |  |  |

**Draft Standards Changes**

*UI Frames Addressing*

**(A631) 7.4.3 UI Frames Addressing**

An aircraft should use the ground station broadcast address of a particular DSP as the destination address of a UI frame used to exchange data. As ICAO Doc 9776 Second Edition Table II-5-3 and Table II-5-4 describe, the type field bits are set to 100 (ICAO-administered) or 101 (ICAO-delegated) and the specific address field bits are set to the DSP’s system mask with the each of the remaining bits set to 1.

Additionally, in order to support ground station diversity an aircraft should accept all UI frames addressed to it that contain a ground station address with the system mask of the DSP with which it desires to communicate as its source address.

No other UI frame addressing differences exist relative to INFO frames; a downlink UI frame has the aircraft address as its source address, and an uplink UI frame has the ground station address as its source address and the aircraft address as its destination address.

*UI Frames Support*

**(Doc 9776) Part II 5.4.2.7.9 / (DO-224) 3.2.2.5.2.7.9 UI Frames Support Parameter**

This parameter indicates whether the ground station supports exchanging data (AOA packets, VDL 8208 packets, and/or VDL IP packets) using UI frames. It shall be encoded as shown in Table 5-II-48 and Table 5-II-49 / Table 3-46a and Table 3-46b.

**(Doc 9776) Table II-5-48 / (DO-224) Table 3-46a UI Frames Support Parameter Format**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter ID | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| Parameter length | n8 | n7 | n6 | n5 | n4 | n3 | n2 | n1 |
| Parameter value | 0 | 0 | 0 | 0 | 0 | ui | u8 | ua |

**(Doc 9776) Table II-5-49 / (DO-224) Table 3-46b UI Frames Support Parameter Values**

| **Bit** | **Name** | **Value** | **Description** |
| --- | --- | --- | --- |
| 1 | ua | ua = 0 | AOA packets in UI frames not supported and/or requested |
| ua = 1 | AOA packets in UI frames supported and/or requested |
| 2 | u8 | u8 = 0 | VDL 8208 packets in UI frames supported and/or requested |
| u8 = 1 | VDL 8208 packets in UI frames not supported and/or requested |
| 3 | ui | ui = 0 | VDL IP packets in UI frames not supported and/or requested |
| ui = 1 | VDL IP packets in UI frames supported and/or requested |
| 4 | Reserved | 0 | Reserved for future use |
| 5 | Reserved | 0 | Reserved for future use |
| 6 | Reserved | 0 | Reserved for future use |
| 7 | Reserved | 0 | Reserved for future use |
| 8 | Reserved | 0 | Reserved for future use |

*Network Layer Protocol Identification*

**(A631) Appendix G Network Layer Protocol Identification for VDL Mode 2 Link Layer**

(See Appendix G in A631-8 draft.)

I think Appendix G is incomplete. It does not specify IPI for 8208

Section G-2 omits IPI info for 8208

Figure G-2 8028 example is incomplete.

Table G-3 should be added with 8208 packet example.

*Frequency Management*

**(A631) 9.8.3 Connectionless VDL Mode 2 Frequency Management**

Aircraft and ground stations should perform VDL Mode 2 frequency management for connectionless operation (exchanging data using UI frames without an established AVLC link) the same way they do for connection-oriented operation (exchanging data using INFO frames via an established AVLC link). Notably, even without having an established AVLC link aircraft stations should accept an autotune command (which for connectionless operation may not contain the Replacement Ground Station List parameter).

*General Description*

 **(A631) 7.16 Connectionless Data Exchange Using UI Frames**

In addition to connection-oriented VDL Mode 2 data exchange using INFO frames via an established AVLC link, connectionless VDL Mode 2 data exchange may occur using UI frames without an established AVLC link. Relevant technical considerations for this capability include the following:

* HDLC Optional Functions Aircraft and ground stations that desire to use UI frames to exchange data should indicate support for UI frames in the HDLC optional functions XID public parameter, specifically bit “c” described by Table 4-2A and Table 4-2B in Attachment 4.
* Addressing An aircraft station should use the ground station broadcast address of a particular DSP as the destination address of a downlink UI frame used to exchange data. Additionally, an aircraft should accept all uplink UI frames addressed to it from the DSP with which it desires to communicate, regardless of the specific ground station (source) address. Section 7.4.3 contains additional detail.
* UI Frames Support A ground station indicates support for exchanging data (AOA packets for ACARS, VDL 8208 packets for ATN, and/or VDL IP packets for IPS) using UI frames via the UI frames support parameter in its GSIF. In particular, the DSP should use bit 1 to indicate whether it supports AOA packets in UI frames (0 = no, 1 = yes), bit 2 to indicate whether it supports VDL 8208 packets in UI frames (0 = no, 1 = yes), and bit 3 to indicate whether it supports VDL IP packets in UI frames (0 = no, 1 = yes).
* Network Layer Protocol Identification Aircraft and ground stations that generate a UI frame containing one of the various packet types should generate the packets as follows for encapsulation in the UI frame:
a) for an AOA packet, precede the ACARS block with an IPI of 0xFF and an EIPI of 0xFF (to indicate that ACARS is the network layer protocol per ARINC Specification 618);
b) for a VDL 8208 packet, precede the CLNP PDU with an IPI of TBD and no EIPI (to indicate that CLNP (ISO 8473) is the network layer protocol per ISO 9577:1999(E) Annex C) and packet data formatting defined by ISO 8208;
c) for a VDL IP packet, precede the IP packet with an IPI of 0x8E but no EIPI (to indicate that IPv6 is the network layer protocol per ISO 9577:1999(E) Annex C). Appendix G contains additional detail.
* Frequency Management Frequency acquisition and recovery remain the same for connectionless VDL Mode 2 as for connection-oriented VDL Mode 2, although AVLC-level downlinks (and uplink responses) are necessary to establish and maintain communications for connectionless VDL Mode 2.

Operationally, aircraft and ground stations may simultaneously perform connection-oriented and connectionless VDL Mode 2 data exchange using INFO and UI frames respectively. It may be desirable, for example, to exchange a certain packet type in INFO frames via an AVLC link while at the same time exchanging another packet type in UI frames without an AVLC link. It should also be noted that there are no AVLC acknowledgements to UI frames (as RR frames acknowledge receipt of INFO frames); instead, higher level protocols perform any necessary recovery.

This means that aircraft stations do not switch between connection-oriented and connectionless data exchange in the same sense that they switch between VDL Mode 2 and VDL Mode 0/A. It also means that an aircraft station may establish an AVLC link only when it intends to exchange data using INFO frames. When the aircraft station terminates an AVLC link, however, it should send a DISC (disconnect) message to indicate the termination to the ground station.

**(Doc 9776) Part II 5.3.11.5 / (DO-224) 3.2.2.4.10.5 UI Frame**

*[Existing: UI frames shall be used solely to support connectionless data transfer required to provide broadcast services.]*

UI frames shall be used to support connectionless data transfer for multicast and broadcast services.

**(A618) 11.1.4 UI Frame Use**

In addition to exchanging AOA packets in INFO frames via an established AVLC link, AOA packets may also be exchanged in UI frames without an established AVLC link.

**11.1.4.1 Downlink UI Frame Processing**

In the downlink direction, the primary precondition for an aircraft to send a downlink UI frame containing an AOA packet to a DSP is receipt of a GSIF from that DSP indicating that it supports exchange of AOA packets in UI frames. The steps to send a downlink UI frame containing an AOA packet from ACARS avionics to a DSP are as follows:

Step 1 – The avionics generate an AOA packet by prefixing the ACARS block with an IPI of 0xFF and an EIPI of 0xFF.

Step 2 – The avionics generate a UI frame according to ARINC Specification 631 with the ground station broadcast address of the desired DSP in the frame’s destination address field, the aircraft address in the frame’s source address field, and the AOA packet in the frame’s information field.

Step 3 – The avionics send the UI frame and start VAT7UI.

Note 1: Although the avionics does not expect an AVLC acknowledgment to the UI frame, they wait to receive an ACARS acknowledgement to the ACARS block before sending another UI frame containing an AOA packet. A UI frame containing a different data format such as an 8208 ATN/OSI or IPS can be transmitted while waiting for the UI frame containing the ACARS acknowledgement.

Note 2: The DSP should set the configurable maximum size of an AVLC frame (defined by the AVLC N1 parameter) consistently within a given region and to no less than 251 octets (in order to accommodate the maximum size of a UI frame containing an AOA packet).

Step 4 – The DSP receives the UI frame at one or more ground stations and extracts the AOA packet and then the ACARS block.

Step 5 – The DSP generates an AOA packet containing the ACARS acknowledgement to the extracted ACARS block by prefixing the acknowledging ACARS block with an IPI of 0xFF and an EIPI of 0xFF.

Step 6 – The DSP generates a UI frame according to ARINC Specification 631 with the aircraft address in the frame’s destination address field, the selected ground station address in the frame’s source address field, and the AOA packet containing the acknowledging ACARS block in the frame’s information field.

Step 7 – The DSP sends the UI frame with the AOA packet containing the acknowledging ACARS block according to its ground station selection logic.

Step 8 – The avionics receive the UI frame, extract the AOA packet and then the acknowledging ACARS block, and stop VAT7UI.. If VAT7UI. expires before receiving the AOA packet containing the acknowledging ACARS block and the AOA retries have not been exhausted then the avionics shall transmit the AOA packet again and restart VAT7UI. . If VAT7UI. expires before receiving the AOA packet containing the acknowledging ACARS block and AOA retries are exhausted then the avionics shall consider the AOA connection to be no comm? Or connectionless is no comm?

**11.1.4.2 Uplink UI Frame Processing**

In the uplink direction, the primary precondition for a DSP to send an uplink UI frame containing an AOA packet to an aircraft is receipt of a downlink UI frame containing an AOA packet from that aircraft. The steps to send an uplink UI frame containing an AOA packet from a DSP to ACARS avionics are as follows:

Step 1 – The DSP generates an AOA packet by prefixing the ACARS block with an IPI of 0xFF and an EIPI of 0xFF.

Step 2 – The DSP generates a UI frame according to ARINC Specification 631 with the aircraft address in the frame’s destination address field, the selected ground station address in the frame’s source address field, and the AOA packet in the frame’s information field.

Step 3 – The DSP sends the UI frame and starts VGT1UI.

Note 1: Although the DSP does not expect an AVLC acknowledgment to the UI frame, it waits to receive an ACARS acknowledgement to the ACARS block before sending another UI frame containing an AOA packet. A UI frame containing a different data format such as an 8208 ATN/OSI or IPS can be transmitted to the aircraft while waiting for the UI frame containing the ACARS acknowledgement.

Note 2: The DSP should set the configurable maximum size of an AVLC frame (defined by the AVLC N1 parameter) consistently within a given region and to no less than 251 octets in order to accommodate the maximum size of a UI frame containing an AOA packet.

Step 4 – The avionics receive the UI frame and extract the AOA packet and then the ACARS block.

Step 5 – The avionics generate an AOA packet containing the ACARS acknowledgement to the extracted ACARS block by prefixing the acknowledging ACARS block with an IPI of 0xFF and an EIPI of 0xFF.

Step 6 – The avionics generate a UI frame according to ARINC Specification 631 with the ground station broadcast address of the DSP in the frame’s destination address field, the aircraft address in the frame’s source address field, and the AOA packet containing the acknowledging ACARS block in the frame’s information field.

Step 7 – The avionics send the UI frame with the AOA packet containing the acknowledging ACARS block.

Step 8 – The DSP receives the UI frame, extracts the AOA packet and then the acknowledging ACARS block, and stops VGT1UI. If VGT1UI expires before receiving the AOA packet containing the acknowledging ACARS block and the AOA retries have not been exhausted then the ground station shall transmit the AOA packet again and restart VGT1UI. If VGT1UI expires before receiving the AOA packet containing the acknowledging ACARS block and AOA retries are exhausted then the ground station shall consider the AOA connection to be no comm?
Note: the acknowledging ACARS block can be an ACARS reject message such as Q5 or QX.

**(A618) 11.4.1 Ground-Based Timers**

| **Timer** | **Value** | **Name** | **Notes** |
| --- | --- | --- | --- |
| VGT1UI | 10 seconds | No Ack Timer |  |
| VGT4UI | 660 seconds | Incomplete Downlink Message Delivery Timer | 5.4.14 |

**(A618) 11.4.2 Airborne Timers**

| **Timer** | **Value** | **Name** | **Notes** |
| --- | --- | --- | --- |
| VAT1UI | 240 seconds | Contact Timer | Optional |
| VAT3UI | 600 seconds | Tracker Timer |  |
| VAT4UI | 90 seconds | Message Assembly Timer | 5.4.2.4 |
| VAT7UI | 6-12 seconds | No Ack Timer | Variable, uniformly distributed between 6 and 12 seconds |
| VAT8 | 600 seconds | UBI reset timer | 5.4.2.8 |
| VAT10UI | 600 seconds | Multi-Block Message Timer | 5.4.2.10 |

**(A618) 11.4.6 Ground Counters**

|  |  |  |  |
| --- | --- | --- | --- |
| **Counter** | **Value** | **Name** | **Notes** |
| VGC1UI | 3 per station,9 total | Transmission Counter | 5.4.3 |

**(A618) 11.4.7 Airborne Counters**

|  |  |  |  |
| --- | --- | --- | --- |
| **Counter** | **Value** | **Name** | **Notes** |
| VAC1UI | 3-6 | Transmission Counter | FYI, Worst case 6x12=72 seconds |