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**19 June 2001**

# RTCA Special Committee 186, Working Group 5

## ADS-B UAT MOPS

## Meeting #5

## DRAFT 3 of Section 2.2 of the UAT MOPS
## (excluding Section 2.2.4)

**Presented by Chris Moody, Mitre**


| SUMMARY |
| --- |
| The following represents a third draft of Section 2.2. Subsection 2.2.4 is excluded here and will be subsequently presented as a separate document. |

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## 2.1 General Requirements

## 2.2 Equipment Performance – Standard Conditions

### 2.2.1 Definition of Standard Conditions

#### 2.2.1.1 Signal Levels

Unless otherwise noted, the signal levels specified for transmitting devices in this subsection exist at the antenna end of a transmitter-to-antenna transmission line of loss equal to the maximum for which the transmitting function is designed.

Likewise, unless otherwise noted, the signal levels specified for receiving devices in this subsection exist at the antenna end of an antenna-to-receiver transmission line of loss equal to the maximum for which the receiving function is designed.

***NOTE:*** *Transmitting or receiving equipment may be installed with less than the designed maximum transmission line loss. Nevertheless, the standard conditions of this document are based on the maximum design value. Insertion losses internal to the antenna should be included as part of the net antenna gain.*

#### 2.2.1.2 Desired Signals

Unless otherwise specified, the desired signal specified as part of receiver performance requirements is any valid ADS-B Extended Type message.

### 2.2.2 ADS-B Transmitter Characteristics

#### 2.2.2.1 Transmission Frequency

The transmission frequency $f_0$ shall be [978] MHz +/- 20 PPM.

*NOTE: All transmissions from ground stations will operate at the same transmission frequency and with a frequency tolerance of [X] PPM*

#### 2.2.2.2 Modulation Rate

The modulation rate shall be 1.041667 megabaud/ +/- 20 PPM.

Baud = symbol per second

*NOTE: Ground Uplink Messages will use the same modulation type and rate. However, the rate tolerance for these messages will be +/- 2 PPM to support proper demodulation over their longer duration.*

*NOTE: Eachsymbol represents one bit, thus making each bit period 0.96 microsecond*

#### 2.2.2.3 Modulation Type

Data shall be modulated onto the carrier using binary Continuous Phase Frequency Shift Keying. The modulation index, *h*, shall be 0.6; this implies that if the data rate is $R_b$, then the nominal frequency separation between "mark" (binary 1) and "space" (binary 0) is $\Delta f = h \bullet R_b$. A binary 1 shall be indicated by a shift up in frequency from the nominal carrier frequency of $\Delta f/2$ (+312.5 kHz) and a binary 0 by a shift of $-\Delta f/2$ (-312.5 kHz). These frequency deviations shall apply at the optimum sampling points for the bit interval.

*NOTE: Filtration of the transmitted signal will be required to meet the spectral containment requirement of Section 2.2.2.5. This filtration will cause overshoot in the deviation, making the maximum deviation close to +/-450 kHz at points outside the optimum sampling point.*

#### 2.2.2.4 Transmitter Power Output

The UAT transmit function shall have 4 states, defined as follows:

a. <u>Inactive state</u>: During the normal receive operation, the transmitter is in the Inactive state. RF output power at the antenna terminals shall not exceed -80 dBm when measured in a 1 MHz bandwidth.

*NOTE: This unwanted power requirement is necessary to ensure that the ADS-B transmitter does not prevent closely bcated UAT receiving equipment from meeting its requirements. It assumes that the isolation between transmitter and receiver equipment antenna exceeds 20 dB.*

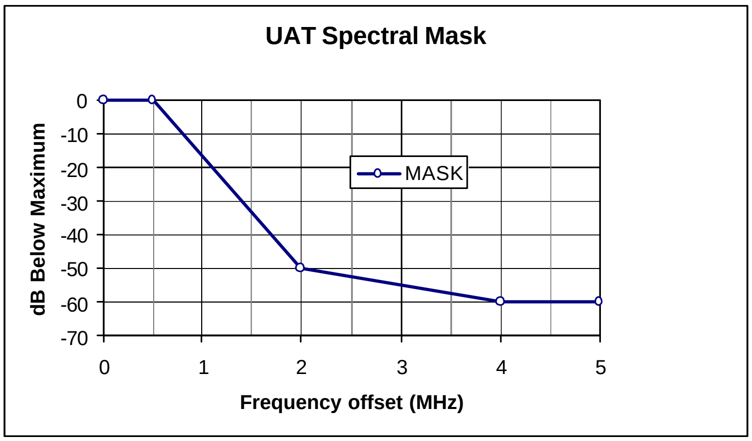
b. <u>Pre-Key state</u>: The transmitter is being prepared to enter the Active state. The Pre-Key state shall have a duration of not to exceed [10] usec. During this state the RF output power at the antenna terminals shall remain at least [20] dB below the minimum power requirement for the appropriate equipment class per Table 2-1.

c. Active state: The Active state begins at the beginning of the Ramp-Up period, and extends until the end of the Ramp-Down period. During the Active state, RF output power at the antenna terminals shall comply with Section 2.2.3.1.1.

d. Post-Key state: The transmitter is transitioning from the Active to the Inactive states. The Post-Key state shall have a duration of not to exceed [10] usec. During this state the RF output power at the antenna terminals shall remain at least [20] dB below the minimum power requirement for the appropriate equipment class per Table 2-1.

### 2.2.2.5 Transmission Spectrum

The spectrum of a UAT transmission shall not exceed the bounds shown in Figure X below:




### 2.2.2.6 Spurious Emissions

[Is a specification in addition to the Mask needed?]

### 2.2.3 Broadcast Message Characteristics

#### 2.2.3.1 ADS-B Message Format

The ADS-B Message format is shown in Figure 2.2.3.1. Each message element is described in detail in the subsections that follow.

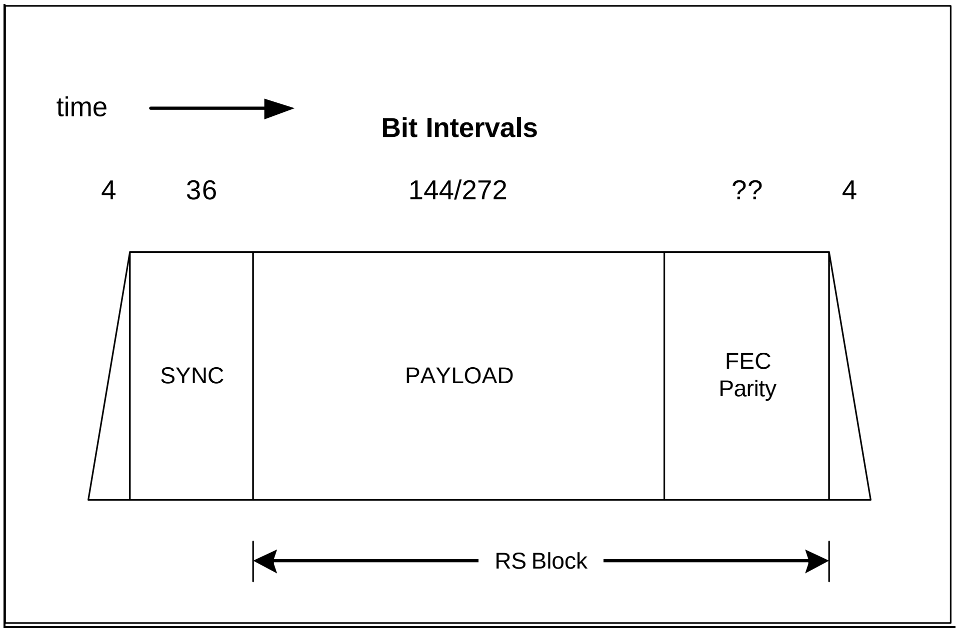



**Figure 2.2.3.1. ADS-B Message Format**

**Why not let ?? = 96/112?**

##### 2.2.3.1.1 Ramp Up/Down

To minimize transient spectral components, the transmitter power shall ramp up and down at the start and end of each burst. The maximum time duration of these ramps shall be no more than 4 bit periods each. Ramp up time is defined as the time between the transmitter power level in the Pre-Key state to 90% of full power output. Ramp down time is defined as the time to decay from full power to the Post-Key level. Full power shall be as specified by the ranges listed in Table 2-1 for the equipment class. During ramp up and down, the modulating data shall be all zeroes.

##### 2.2.3.1.2 Synchronization

Following ramp up, each data burst shall include a 36 bit synchronization sequence. For the ADS-B messages the sequence shall be

111010101100110111011010010011100010

with the left-most bit transmitted first.

#### 2.2.3.1.3 Payload

The format and encoding of the ADS-B message payload is defined in Section 2.2.4.

#### 2.2.3.1.4 FEC Parity

The FEC for the ADS-B message shall be encoded as follows for each ADS-B message length:

a. Basic ADS-B message: This shall be encoded as a RS(30, 18) systematic 256-ary code block with 12 bytes of parity

*NOTE: This code is capable of correcting up to 6 symbol errors per block.*

b. Long ADS-B message: This shall be encoded as a RS(48, 34) systematic 256-ary code block with 14 bytes of parity

*NOTE: This code is capable of correcting up to 7 symbol errors per block.*

For either message length the primitive polynomial of the code shall be as follows:

$$p(x) = x^8 + x^7 + x^2 + x + 1 .$$

The generator polynomial shall be as follows:

$$\prod_{i=120}^{P} (x - a^i) .$$

P = 131 for RS(30,18) code and P = 133 for RS(48,34) code

$a$ is a primitive element of GF(256) and GF(256) is a Galois field of size 256.

### 2.2.3.2 Ground Uplink Message Format

The ground uplink message format is shown in Figure X. Each message element is described in detail in the subsections that follow.

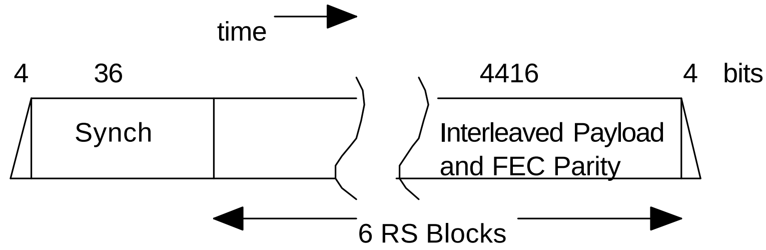



**Figure X. Ground Uplink Message Format**

### 2.2.3.2.1 Ramp Up/Down

To minimize transient spectral components, the ground station transmitter power will ramp up and down at the start and end of each burst. The maximum time duration of these ramps will be no more than 4 bit periods each. Ramp up time is defined as the time between the transmitter power level in the Pre-Key state to 90% of full power output. Ramp down time is defined as the time to decay from full power to the Post-Key level. During ramp up and down, the modulating data shall be all zeroes.

### 2.2.3.2.2 Synchronization

The polarity of the bits of the synchronization sequence is reversed from that used for the ADS-B message, that is, the ones and zeroes are interchanged. This synchronization sequence is

000101010011001000100101101100011101

with the left-most bit transmitted first.

*NOTE: Because of the close relationship between the synchronization sequences used for the ADS-B and Ground Uplink Messages, the same correlator can search for both simultaneously.*

### 2.2.3.2.3 Payload

The Payload consists of two components: the first eight bytes that comprise UAT-Specific Header and bytes 9 through 432 that comprise the Application Data as shown in Table X

**<u>Table X</u>. Format of the Ground Uplink Message Payload.**

| Byte # | Bit 1 | Bit 2 | Bit 3 | Bit 4 | Bit 5 | Bit 6 | Bit 7 | Bit 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | (MSB) | | | | | | | |
| 2 | | | | Ground Station Latitude (WGS-84) | | | | |
| 3 | | | | | | | (LSB) | (MSB) |
| 4 | | | | | | | | |
| 5 | | | | Ground Station Longitude (WGS-84) | | | | |
| 6 | | | | | | | (LSB) | P Valid |
| 7 | PPS Valid | App Data Valid | Spare | Slot ID | | | | |
| 8 | TIS-B Site ID | | | | Spare | | | |
| 9 | | | | Application Data | | | | |
| 432 | | | | | | | | |

### 2.2.3.2.3.1 Header

#### 2.2.3.2.3.1.1 Ground Station Latitude

#### 2.2.3.2.3.1.2 Ground Station Longitude

#### 2.2.3.2.3.1.3 Position Valid

This field is used to indicate that the position in the header is valid

#### 2.2.3.2.3.1.4 PPS Valid

This field is used to indicate that the 1 Pulse per second timing is valid

#### 2.2.3.2.3.1.5 Application Data Valid

This field is used to indicate that the Application Data is valid for operational use.

*NOTE: This field will allow testing and demonstration of new products without impact to operational systems*

#### 2.2.3.2.3.1.6 Slot ID

This field identifies the time slot within which the Uplink message transmission took place.

*NOTE: The Slot ID for certain ground stations may be continuously shifted for maximum interference tolerance to other users sharing the band. Airborne receivers need to have no a priori knowledge of this shifting scheme; this is for ground service providers to coordinate. The actual Slot ID in use for each uplink message will always be properly encoded by the ground station.*

**2.2.3.2.3.1.7 TIS-B Site ID**

This field conveys the reusable TIS-B Site ID that is also encoded with each TIS-B message.

*NOTE: This field supports TIS-B applications that verify TIS-B messages were transmitted from the site located at the Lat/Lon encoded in the UAT-Specific Header portion of the Ground Uplink payload.*

**2.2.3.2.3.2 Application Data**

Definition of the Application Data is beyond the scope of this MOPS and will be provided by other RTCA documents

**2.2.3.2.4 Interleaving of Payload and FEC Parity**

The part of the burst labeled “Interleaved Payload and FEC Parity” in Figure 2-2 shall consist of 6 interleaved Reed-Solomon (RS) blocks. The RS coding shall be of the form RS(92,72), based on 8-bit symbols. The interleaver shall be represented by a 6 by 92 matrix, where each entry is a RS 8-bit symbol. Each row shall comprise a single RS(92,72) block as shown in Figure 2-3. The information shall be transmitted column by column, starting at the upper left corner of the matrix.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | A2 | A3 | | … | | A71 | A72 | PA1 | | … | PA19 | PA20 |
| B1 | B2 | B3 | | … | | B71 | B72 | PB1 | | … | PB19 | PB20 |
| C1 | C2 | C3 | | … | | C71 | C72 | PC1 | | … | PC19 | PC20 |
| D1 | D2 | D3 | | … | | D71 | D72 | PD1 | | … | PD19 | PD20 |
| E1 | E2 | E3 | | … | | E71 | E72 | PE1 | | … | PE19 | PE20 |
| F1 | F2 | F3 | | … | | F71 | F72 | PF1 | | … | PF19 | PF20 |

**Figure 2-3. Ground Uplink Interleaver Matrix**

*NOTE: In Figure 2-3, A1 through A72 are the 72 bytes (8 bits each) of payload information carried in the first RS(92,72) block. PA1 through PA20 are the 20 bytes of FEC parity associated with that block. The bytes are transmitted in the following order:*

*A1,B1,C1,D1,E1,F1,A2,B2,C2,D2,E2,F2,A3,. . .,PC20,PD20,PE20,PF20.*

*On reception these bytes must be deinterleaved so that the RS blocks can be reassembled prior to error correction decoding.*

### 2.2.3.2.5 FEC Parity

The uplink information shall be encoded as a series of 6 RS(92,72) blocks. RS(92,72) is a systematic 256-ary code, with 72 bytes of information augmented by 20 bytes of parity. The primitive polynomial of the code shall be as follows:

$$p(x) = x^8 + x^7 + x^2 + x + 1.$$

The generator polynomial shall be as follows:

$$\prod_{i=120}^{139} (x - a^i).$$

$a$ is a primitive element of GF(256) and GF(256) is a Galois field of size 256.

*NOTE: This code is capable of correcting up to 10 symbol errors per block.*

### 2.2.4 The ADS-B Message Payload

*Due to the weighty nature of this section, it is being provided separately.*

### 2.2.5 Procedures for ADS-B Message Transmission

#### 2.2.5.1 The 1 PPS Time Mark

A 1 PPS Time Mark is used by the ADS-B transmitting subsytem to establish the transmission timing and scheduling of ADS-B messages (i.e., the UAT frame) and also may be used to indicate time of validity of position and velocity. The ADS-B transmitting subsystem shall maintain a 1 PPS UTC-based time mark by the reversionary procedure given below:

a. The primary source of time shall provide a 1 PPS time mark on the UTC second (–700 to +2000 nanoseconds). This source of time shall be stable to within [+/- 100 nanoseconds]. Availability of this source shall cause the ADS-B transmitting subsystem to be in Timing State 1. The leading edge of the Time Mark shall indicate the exact moment +/- 5 milliseconds that represents the time of applicability of Position and Velocity information received from the GPS/GNSS source.

b. The secondary source shall be derived from a free running clock within the ADS-B transmitting subsystem. Lack of availability of either the primary source shall cause the ADS-B transmitting subsystem to be in Timing State 2. The leading edge of the time mark does NOT represent a time of validity of position and velocity. ADS-B transmissions shall not encroach on the Ground Uplink segment for at least 10 minutes after entry into Timing State 2

*NOTE: Timing State 1 is always the preferred condition. Entry into Timing State 2 represents a failure of the primary GPS/GNSS timing source. These reversionary Timing States exist for the following reasons: 1)support ADS-B message transmission using an alternate source of position and velocity, if available; 2)support ADS-B message transmission in absence of position and velocity data in order that any available fields are conveyed (e.g., baro altitude) and 3)that a signal is provided in the event the ground network can; perform an ADS-B-independent localization of the A/V (e.g., multilateration)*

*NOTE: An alternative procedure to maintaining time upon failure of the primary source is to derive time from receipt of Ground Uplink messages by the receiving subsystem per Section 2.2.9.3. When using this procedure, the leading edge of the time mark does NOT represent a time of validity of position and velocity*

-

### 2.2.5.2 Scheduling of ADS-B Messages

#### 2.2.5.2.1 Message Transmission Opportunity

ADS-B message transmissions shall be allocated access to the channel based on one of four possible Message Transmission Opportunities (MTO) to which an actual ADS-B message type will be assigned. These are denoted as MTO-1, MTO-2, MTO-3, and MTO-4

*NOTE: There is no requirement that transmission epoch boundaries be aligned amongst A/Vs; it is used only to ensure proper mix of transmitted message types.*

#### 2.2.5.2.2 Message Transmission Epoch

A message transmission epoch shall consist of exactly eight seconds during which each MTO is sheduled twice as follows: MTO-1, MTO-2, MTO-3, MTO-4, MTO-4, MTO-3, MTO-2, MTO-1…

#### 2.2.5.2.3 ADS-B Message Assignment to MTOs

The message scheduling mechanism shall provide the assignment of ADS-B message types to MTOs as shown in the Table below

| | | ADS-B Message Type Assignment to MTO | | | |
|---|---|---|---|---|---|
| Equipment Class | | MTO-1 | MTO-2 | MTO-3 | MTO-4 |
| A0/A1/ B1 | Minimum | Extended Type 1 | Basic | Basic | Basic |
| | Maximum | | Any Extended Type 2-11 | Any Extended Type 2-11 | Any Extended Type 2-11 |
| A2 | Minimum | | ? | ? | ? |
| | Maximum | | ? | ? | ? |
| A3 | Minimum | | ? | ? | ? |
| | Maximum | | ? | ? | ? |

**ADS-B Message Types**

| Message Type | Payload Type Code | Message Length | Contents |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Basic | 0000 | Short | SV *only* |
| Extended Type 1 | 0001 | Long | SV *plus*<br>Supplemental Type 0 payload |
| Extended Type 2 | 0010 | Long | SV *plus*<br>Supplemental Type 1 payload |
| Extended Type 3-11 | 0011-1011 | Long | SV plus<br>Supplemental externally supplied payload (128 bits) provided "on condition" each epoch |
| Type 12-15 | 11XXX | TBD | TBD |

[I propose to move this Table to Section 2.2.4]

### 2.2.5.2.4 Transmitter Antenna Diversity

For installations that support ADS-B message transmission from dual (diversity) antennas (see section 2-1), the installation shall be configured to transmit through each antenna T=Top; B=Bottom according to the algorithm below:

Transmit antennas shall be alternated against the MTOs of the message transmission epoch in the following pattern every second: T, T, B, B, T, T, B, B, ....

*NOTE: Antenna diversity could be implemented with dual redundant transmitters each connected to its dedicated antenna or from a single transmitter with antenna switching.*

### 2.2.5.2.5 Unavailability of Basic SV Message Payload Fields

a. In any UAT frame interval, each A/V shall at a minimum transmit the Basic ADS-B message regardless of the unavailability of any individual payload field subject to requirements of the transmission timeout specified in Section ??.

b. Any such unavailable payload fields shall be encoded as "unavailable"

### 2.2.5.3 Message Transmit Timing

### 2.2.5.3.1 The Message Start Opportunity (MSO)

ADS-B bursts shall be transmitted at discrete Message Start Opportunities (MSO) chosen by a pseudo-random process. The specific pseudo-random number chosen by an aircraft depends on the aircraft's current position and on the previously chosen random number. The procedure below shall be employed to establish the transmission timing for the current UAT frame *m*.

The desired output of the algorithm is a 12-bit pseudorandom number.

Suppose the previous number is R(m-1) and

N(1) = 12 L.S.B.'s of the current latitude (per encoding of Section X)

N(2) = 12 L.S.B.'s of the current longitude (per encoding of Section X)

where the latitude and longitude are as defined in Section 2.2.4.1.2 and 2.2.4.1.3 respectively. The next random number is then given by

$$R(m) = \{4001 \cdot R(m-1) + N(m \bmod 2)\} \bmod 3200$$

The MSO shall be 752 + Rm

The initial R(m) shall be zero

*NOTE: The latitude and longitude alternate in providing a changing "seed" for the pseudo-random number generation.*

### 2.2.5.3.2 Relationship of the MSO to the Modulated Data

The start of the first symbol/bit of the synchronization sequence shall coincide with the interval offset by 250 usec times the MSO value determined from Section 2.2.5.3.1 to within [+/- 320 nanoseconds].

*NOTE: This is required to support ADS-B range validation by the receiver*

### 2.2.5.4 Time of Applicability of ADS-B Message Payload Fields

### 2.2.5.4.1 UTC Coupled and Non-UTC Coupled Cases for Position and Velocity

The specification of latency requirements for position and velocity cover two distinct cases:

a. The UTC Coupled case is the condition where the position and velocity data are computed and valid at the 1 PPS UTC time mark [+/- ???] also provided by the same navigation system. This case will also correspond to the ADS-B transmitting subsystem being in Timing State 1

b. The Non-UTC Coupled case is the condition where position and velocity data come from an alternate navigation source where UTC time is not available. This case will correspond to the ADS-B transmitting subsystem being in Timing State 2.

### 2.2.5.4.2 Position and Velocity (UTC Coupled, Timing State 1)

At the time of ADS-B message transmission as determined in Section 2.2.5.3.1, position and velocity information encoded in the Latitude, Longitude, N-S Velocity, and E-W Velocity fields shall be valid as of the immediately previous start of second.

*NOTE: Specifically, any extrapolation performed shall be to the start of second and not the time of transmission.*

#### 2.2.5.4.3 Position and Velocity (Non-UTC Coupled)

[To be provided]

#### 2.2.5.4.4 Other Message Payload Fields (UTC or Non-UTC Coupled)

Any change in information affecting the ADS-B message payload fields shall be reflected in the encoding of that field, provided that the change occurs and is available to the ADS-B transmitting subsystem within at least ***X*** milliseconds prior to the next scheduled ADS-B message containing that field. Table 2-15 below shows the value of ***X*** for each field.

**Latency of ADS-B Message Fields**

| ADS-B Message Payload Field | Value of X (Section 2.2.5.4.4) |
|---|---|
| 25-Bit UAT Address | 1000 |
| Latitude | Section 2.2.5.4.2 and 2.2.5.4.3 applies |
| Longitude | Section 2.2.5.4.2 and 2.2.5.4.3 applies |
| NUCp | 100 |
| Turn Indicator | 100 |
| Horizontal Pos Available | 100 |
| UTC Coupled | 100 |
| N-S Velocity | Section 2.2.5.4.2 and 2.2.5.4.3 applies |
| E-W Velocity | Section 2.2.5.4.2 and 2.2.5.4.3 applies |
| Pressure Altitude | 100 |
| Pressure Altitude Rate | 100 |
| A/G State | 100 |
| Geodetic Height Difference | 100 |
| Height Valid | 100 |
| Emergency/Priority Status | 100 |
| Geodetic Height Difference Rate | 100 |
| Aircraft Category subfield | Not changable |
| Flight ID subfield | 1000 |
| Message Start Opportunity | Must use value established by ADS-B transmitting subsystem for the current frame |

### 2.2.6 Receiver Characteristics

#### 2.2.6.1 Sensitivity

A maximum desired signal level of –93 dBm applied at the antenna terminals shall produce a message success rate of 90% or better for Long ADS-B message types. Does this apply to all message types?

### 2.2.6.2 Frequency Capture Range

The receiver shall be capable of successful message detection with the maximum permitted signal frequency offset plus air-air doppler at 1200 knots closure/opening.

### 2.2.6.3 Baud Rate Offset Tolerance

A 90% message success rate shall be achieved when the desired signal is subject to a symbol rate offset of +/- 20 ppm.

### 2.2.6.4 Desired Signal Dynamic Range

The receiver shall continue to achieve a 90% message success rate when the desired signal level is increased to [-10 dBm].

### 2.2.6.5 Back-to-Back Message Reception

[Test to establish minimum receiver recovery time. How to specify and test? Is it important? Is a separate requirement necessary for ADS-B and Ground Uplink?]

### 2.2.6.6 Amplitude Discrimination of Overlapping ADS-B Messages

A 90% or better message success rate for the stronger of two overlapping desired signals shall result when the level of the stronger signal is at –80 dBm and the stronger signal is [6 dB] above the weaker signal under the following conditions:

a. the stronger signal and weaker signal align within +/- 5 usec

b. the weaker signal precedes the stronger signal by 100 usec

### 2.2.6.7 Rejection of Out-of-Band Signals

A 90% message success rate shall be achieved when an unmodulated continuous wave interfering signal of [-30 dBm] is combined with the desired signal at –70 dBm. The interfering signal shall be applied separately + 2 and – 2 MHz offset from $f_0$.

*NOTE: This establishes the receiver's rejection of off channel energy radiated from DME ground stations adjacent to the UAT guard band.*

#### 2.2.6.8 Tolerance to Pulsed Interference

[Test to verify FEC operation and receiver recovery time from high level on channel interfering pulse at around –40 dBm when detecting signal near sensitivity. Test should allow for random pulse placement across the message]

#### 2.2.6.9 Message Time of Receipt

The receiver shall declare a Message Time Of Receipt (MTOR) and include the MTOR value as part of the report issued to the on-board application systems. The MTOR value shall be reported to within [+/- 200 nanoseconds] of the actual value with 95% confidence.

*NOTE: The MTOR value need only be expressed in terms of offset from the 1 PPS UTC time mark just prior to reception.*

#### 2.2.6.10 Receiver Discrimination Between ADS-B and Ground Uplink Message Types

The receiver shall NOT infer message type for decoding based on its location within the UAT frame.

*NOTE: The polarity of the correlation score from the synchronization process is available for distinguishing these message types*

#### 2.2.6.11 Receiver Antenna Switching

Installations that switch a single receiver alternately between top and bottom antennas shall make a switch each second using the following pattern: T, B, T, B…

### 2.2.7 Report Generation Requirements

Reports shall be generated for on-board applications only in response to a received message. Exactly one report shall be generated for each message successfully received.

#### 2.2.7.1 Report Generation on Receipt of ADS-B Message

##### 2.2.7.1.1 Message Integrity Requirements

No ADS-B message payload shall be forwarded as a report unless the FEC parity indicates that there are NO detected errors.

#### 2.2.7.1.2 Report Generation and Integrity

a. Upon receipt of an ADS-B message with no detected errors, a report shall be issued that includes the unaltered payload of the message received and the MTOR (Section 2.2.6.9).

b. Reports shall be issued from the UAT receiver to on-board application systems with an integrity check at least equivalent to a CRC-16.

### 2.2.7.2 Report Generation on Receipt of Ground Uplink Message

#### 2.2.7.2.1 Message Integrity Requirements

a. Each R/S block of the Ground Uplink message shall be individually examined for errors. The payload of each block shall be declared as valid only if there are NO detected errors resulting from FEC Parity decoding.

b. The Ground Uplink message shall be declared as valid only if payloads within EACH individiual R/S Block are declared valid from a) above.

#### 2.2.7.2.2 Report Generation and Integrity

If the requirements of Section 2.2.7.2.1 are met, the Ground Uplink Message payload is created with the steps described below:

a. The individual R/S block payloads are concatenated in the order received.

b. A report shall be issued that includes the unaltered payload of the message received and the MTOR (Section 2.2.6.9).

c. Reports shall be issued from the UAT receiver to on-board application systems with an integrity check at least equivalent to a CRC-16.

## 2.2.8 Receiver Subsystem Throughput Requirements

### 2.2.8.1 Input Message Capacity

[What total ADS-B and Gnd Uplink load is reasonable in full NAS environment?]

### 2.2.8.2 Output Report Latency

[Need reasonable number for latency from message arrival at rx antenna to issuance of report under the load established for 2.2.8.1. Appendix K of DO-242 allows up to 100 ms for "report assembly"]

### 2.2.9 Special Requirements for Transceiver Implementations

#### 2.2.9.1 Transmit-Receive Turnaround Time

The receiver shall be capable of receiving a desired signal within [2] ms of the ramp down of a transmitted signal.

#### 2.2.9.2 Receive-Transmit Turnaround Time

The transmitter shall be capable of commencing transmission of an ADS-B message within [2] ms after arrival of a successfully received desired signal

#### 2.2.9.3 Estimated 1 PPS

In the absence of an external 1 PPS UTC time mark, the receiver shall provide a 1 PPS UTC estimated time mark to the transmitter when at least one Ground Uplink message is received per UAT frame. This estimated time mark shall be sufficiently accurate to prevent ADS-B message transmissions from straying outside the ADS-B segment as long as the Ground Uplink messages are being received.

[When should this be a requirement? It seems this capability matters only if the installation supports an alternate navigation input to ADS-B]