

RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS

Meeting #25

Response to AI24-08: UAT Ground Station Feedback Mechanism
Revision 2

Prepared by Warren J. Wilson

The MITRE Corp.

SUMMARY

This working paper is a follow-up to Action Item 24-08. It proposes changes to the UAT MOPS to allow for an Uplink Feedback mechanism as described in UAT-WP-24-13. This response has been coordinated with Chris Moody (MITRE) and Mike Garcia (ITT).

To provide for an Uplink Feedback mechanism as described in UAT-WP-24-13 the two following changes should be made:

- (1) Replace the word “Reserved” in the bottom row of Table 2-13 with the words “UPLINK FEEDBACK.”
- (2) Replace §2.2.4.5.2.9 with the text provided below.
- (3) Replace §2.4.4.5.2.9 with the text provided below. (Note that the proposed test procedure tests only a subset of all the possible “Score” values. If necessary, the procedure can be extended to probe all possible conditions individually.)

WG5 should be aware that the procedure described in the indented part of §2.2.4.5.2.9 presumes that the ground stations schedule their Ground Uplink messages as described in the current ground system specification (Essential Services Specification, Version 1.3, 5 September 2008, §3.2.2.2.4.4.2). If this scheduling procedure is changed, the proposed monitoring method would need to change accordingly.

Recommendation: It is recommended that WG5 consider adding this new feature to DO282B. If so, WG5 should consider whether the limited test procedure is sufficient.

2.2.4.5.2.9 “Uplink Feedback” Encoding

The “Uplink Feedback” field is a 3-bit field (bits 6 through 8 of byte 17) that **shall** be transmitted whenever the “ADDRESS QUALIFIER” field is set to “0,” “1,” “4” or “5.” This field reports on the number of successful Ground Uplink messages that were successfully received on a particular Data Channel (see below) in the previous ~~31~~ 32 seconds. The identity of the Data Channel to be reported on in any given second and the method for determining the success rate **shall** be based on the prescribed “time slot rotation” as follows:

The ground stations use the 32 uplink slots in the Ground Segment (see §1.3.2) on a rotating basis. A rotating set of time slots is called a Data Channel. A ground station that is assigned Data Channel “N” will transmit in time slot “N” in UTC second 0, time slot “N+1” in second 1 and so on. After reaching time slot 32, it will “wrap around” and resume its rotation in time slot “1” in the following second. During any second in which Data Channel “N” ~~corresponds with~~ is scheduled to be transmitted in time slot “1” the “Uplink Feedback” field contains information on the recent performance of Data Channel “N” ~~,”~~ so that the relationship between the UTC second (T) and the Data Channel (N) being reported on is given by the following: In other words, during UTC second T, all ADS-B transmissions report on the performance of Data Channel $N = 32 - (T + 31) \bmod 32$.

$$\underline{\quad} \quad (T + N) \bmod 32 = 1$$

In UTC second T, the UAT reports the Code for $Score(T)$, which can be defined as follows:

$$\underline{\quad} \quad Score(T) = \sum_{k=1}^{32} S(T - 33 + k, k)$$

The function $S(., .)$ is defined as

$S(t, s) = 1$ if there was a successful Uplink decode in Time Slot=s in UTC second t

and

$S(t, s) = 0$ if there wasn’t a successful Uplink decode in Time Slot=s in UTC second t

For example, in UTC second 3217 the Data Channel being reported on is #16 and the definition of the Score value is

$$\underline{\quad} \quad Score(3217) = \sum_{k=1}^{32} S(3184 + k, k)$$

Note: This procedure obviates the need to use extra bits to identify explicitly the Data Channel to which the feedback pertains. It also ensures that each participant will report on each of the 32 possible Data Channels once each 32 seconds --- providing timely feedback.

The format of this field shall be as shown in Table 2-37a.

Table 2-37a: “Uplink Feedback” Encoding

Feedback Code	Score (1)
111	31 <u>32</u>
110	30 <u>31</u>
101	28 to 29 <u>29 to 30</u>
100	25 to 27 <u>26 to 28</u>
011	21 to 24 <u>22 to 25</u>
010	13 to 20 <u>14 to 21</u>
001	0 to 12 <u>1 to 13</u>
000	No Information <u>0</u>

(1) The Score is the number of successful Ground Uplink messages received on a particular Data Channel out of a possible ~~31~~ 32.

~~If there is no available information on Ground Uplink reception performance, this field shall be set to ALL ZEROs.~~

Transmit-only Equipage Classes (B0 through B3) shall set this field to ALL ZEROs.

2.4.4.5.2.9 Verification of “Uplink Feedback” Encoding (§2.2.4.5.2.9)

Purpose/Introduction:

The “Uplink Feedback” field is a 3-bit field (bits 6 through 8 of byte 17) that **shall** be transmitted whenever the “ADDRESS QUALIFIER” field is set to “0,” “1,” “4” or “5.” This field reports on the number of successful Ground Uplink messages that were successfully received on a particular Data Channel in the previous ~~31~~ 32 seconds.

The format of this field **shall** be as shown in **Table 2-37a**.

~~If there is no available information on Ground Uplink reception performance, this field shall be set to ALL ZEROs.~~

Transmit-only Equipage Classes (B0 through B3) **shall** set this field to ALL ZEROs.

Measurement Procedure:

For UUTs capable of receiving Ground Uplink messages follow Steps 1 through 6 below.

~~For UUTs not capable of receiving Ground Uplink messages (e.g. Equipment Classes B0 through B3) follow Step 7.~~

Step 1: Test Set-up

Configure the UUT to receive ~~Ground Uplink from a UAT ground station~~ messages from a UAT Ground Uplink Message source and to transmit ADS-B Payload Types according to the sequence specified for its particular Equipment Class.

Configure the ground station to be able to transmit valid Ground Uplink messages on only Data Channel “N” as defined in §2.2.4.5.2.9. Adjust the power of the ground station’s signal so that it is between -61 dBm and -51 dBm at the input to the UUT (approximately 30 dB to 40 dB above sensitivity).

Repeat the following Steps 2 through 6 for N = 1, 12 and 23.

Step 2: Perfect Reception (Score = ~~31~~ 32)

Transmit one Ground Uplink message every second for at least 128 seconds. Verify that the ADS-B message transmitted in second $T_k = (33-N) \bmod 32 + 32k$ has the “Uplink Feedback” field encoding “111.” Verify that the “Uplink Feedback” field encoding is ~~“001”~~ “000” for ADS-B messages transmitted during every other one-second interval.

Step 3: Imperfect Reception (Score = ~~30~~ 31)

Transmit one Ground Uplink message every second, except if $T_j = (33-N) \bmod 32 + 32j - 1$, for at least 128 seconds. Verify that the ADS-B message transmitted in second $T_k = (33-N) \bmod 32 + 32k$ has the “Uplink Feedback” field encoding “110.” Verify that the “Uplink Feedback” field encoding is ~~“001”~~ “000” for ADS-B messages transmitted during every other one-second interval.

| Step 4: Imperfect Reception (Score = ~~29~~ 30)

Transmit one Ground Uplink message every second, except if $T_j = (33-N) \bmod 32 + 32 j - 1$ or $T_j = (33-N) \bmod 32 + 32 j - 2$, for at least 128 seconds. Verify that the ADS-B message transmitted in second $T_k = (33-N) \bmod 32 + 32 k$ has the “Uplink Feedback” field encoding “101.” Verify that the “Uplink Feedback” field encoding is “~~001~~ 000” for ADS-B messages transmitted during every other one-second interval.

| Step 5: Imperfect Reception (Score = 13)

Transmit a Ground Uplink message only in seconds $T_j = (33-N) \bmod 32 + 32 j - i$ (with $i = 1$ through 13) for at least 128 seconds. Verify that the ADS-B message transmitted in second $T_k = (33-N) \bmod 32 + 32 k$ has the “Uplink Feedback” field encoding “~~010~~ 001.” Verify that the “Uplink Feedback” field encoding is “~~001~~ 000” for ADS-B messages transmitted during every other one-second interval.

| Step 6: No Reception (Score = 0)

Disconnect or turn off the ground station. Verify that the ADS-B message transmitted every second has the “Uplink Feedback” field encoding “~~010~~ 000.”

| Step 7: ~~No Information Condition~~ Transmit-Only Equipment Classes

For at least 128 seconds, verify that the ADS-B message transmitted by the UUT every second has the “Uplink Feedback” field encoding “000.”