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ATCRBS / Mode S Transponder

Meeting #3

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Proposed Changes and Corrections to Test Procedures in RTCA-DO-181C, Section 2.5

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SUMMARY

This Working Paper is a continuation of recommended changes, corrections and improvements to the DO-181C Test Procedures that were initially addressed in Working Paper SC209-WP2-05R1. This Working Paper includes recommended changes after reviewing the first 17 test procedures in section 2.5.

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1. Recommended Changes to §2.5.4.5 Procedure #5

The following is section §2.5.4.5 Procedure #5 Selective Lockout Tests from DO-181C with corrections and proposed changes to improve the test and provide clarity to insure that the test is conducted as intended.

(1) The Lockout Timer designation is inconsistent. It appears as both TL and T_l. T_L appears elsewhere in this document.

Note:
There are a number of timers associated with the transponder protocol. Throughout the document, the identification of the timers is inconsistent. The following is a list of timers and how they are identified in the MOPS:

Non-Selective Lockout Timer:	TD
Selective Lockout Timer:	TL, T_L, T_l
Alert Timer:	TC, T_C
SPI Timer:	TI, T_i
B-Timer:	TR, T_{RB}
C-Timer:	TR, T_{RC}
D-Timer:	TR, T_{RD}

The timer designation sometimes uses a subscript character but not always, and sometimes uses all upper case but not always. A consistent designation for these timers should be selected and used throughout the document.

(2) In the pattern definitions the text is corrected to reflect the correct number of interrogation patterns per timer.

(3) In Test #1, the negative test to try to restart timers with incorrect DI, LOS, LSS etc. needs to be delayed from the start of the next timer. A delay of 4.5 seconds is adequate and is used to be consistent with Test #2. This delay is needed to provide a large enough time difference from when the timer was originally set to determine if the timer was erroneously restarted. Also, it is not clear what the 14 negative patterns are to restart the timers. There appears to be 8 patterns as follows: For each value of DI (0 – 7) set the IIS or SIS code correctly. For DI code values where there is no IIS or SIS subfield within the SD field, set the corresponding bits (bits 17-20 for IIS or 17-22 for SIS). If DI=1 or 7, set LOS=0, for all other values of DI, set bit 26=1. If DI=3, set LSS=0, for all other values of DI, set bit 23=1.

(4) The second Test #2 (for All Other Transponders) is not designed properly to test all combinations of the timer restart capability. It attempts to restart the timer 3 times after the timer was started using all UF codes. Each restart is delayed 4.5 seconds from the last, and each is tested 2.1 seconds prior to their nominal expiration (this was probably supposed to be 1.1 seconds). The problem with this test is that if the last timer restart was successful, those prior to it were not tested. Any subsequent timer restart will eliminate the ability to test interim timer restarts. It is

recommended that this test be eliminated and transponders with Comm-A capability simply repeat the first Test #2 with long interrogations (UF=20 and 21).

§2.5.4.5 Procedure #5 Selective Lockout Tests

(Subparagraph §2.2.16.2.5)

Selective lockout is initiated on receipt of a correctly addressed interrogation UF=4,5,20,21 containing DI=1, 7; LOS=1 and IIS from 1 to 15, or DI=3, LSS=1 and SIS from 1 to 63. This starts the ~~TL~~ T_L timer associated with the received II or SI code and holds the lockout condition for 18 ±1.0 seconds.

Selective lockout applies only to UF=11 with II or SI corresponding to the running ~~TL~~ T_L timer.

The lockout state, duration, termination and restart are defined and tested as described in subparagraph 2.5.4.4. Negative tests follow the same procedures and have the same purpose as described in subparagraph 2.5.4.4.

Pattern Definition for ~~Basic~~ Level 1 Transponders

Positive Interrogation Patterns Per Timer

UF: 2 codes.
DI: 2 codes with LOS=1 or 1 code with LSS=1~~3 codes~~. Total: ~~5~~ 4 patterns for II timers, 2 patterns for SI timers starting lockout.
~~LOS: 1 code.~~
~~LSS: 1 code.~~

Total Interrogation Patterns Per Timer

UF: 2 codes.
DI: ~~7~~ 2 codes with LOS=0,1; 1 code with LSS=0, 1;
5 codes with SD field bits 23 & 26 = 1 Total: ~~32~~ 20 possible patterns for II timers, 18 possible patterns for SI timers.

Positive test patterns: ~~6~~2 or 4.
Negative test patterns: ~~26~~16.

Pattern Definition of All Other Transponder Designs

Positive Interrogation Patterns Per Timer

UF: 4 codes.

DI: 2 codes with LOS=1 or~~and~~ 1 code with LSS=1. Total: ~~12~~8 patterns for II timers, or 4 patterns for SI timers starting lockout.

Total Interrogation Patterns Per Timer

UF: 4 codes.
DI: ~~7~~ 2 codes with LOS= 0,1; 1 code with LSS=0,1;
5 codes with SD field bits 23 & 26 = 1 Total: ~~32~~ 40 possible patterns for II timers, 36 possible patterns for SI timers.

Positive test patterns: 4 or 8~~12~~.
Negative test pattern: ~~5~~32.

Note: The 8 negative test patterns per UF code are as follows: For each value of DI (0 – 7) set the IIS or SIS code correctly. For DI code values where there is no IIS or SIS subfield within the SD field, set the corresponding bits (bits 17-20 for IIS or 17-22 for SIS). If DI=1 or 7, set LOS=0, for all other values of DI, set bit 26=1. If DI=3, set LSS=0, for all other values of DI, set bit 23=1.

Test Sequence

Because 78 timers, each running 18 ±1.0 seconds, are involved, a test sequence is shown here that minimizes the time needed, while providing a comprehensive validation of transponder performance.

Principle of Test Sequence

A lockout timer is started by a surveillance or Comm-A interrogation and with the next interrogation, the lockout state is verified for UF=11 with the corresponding II or SI. Just before the earliest and just after the latest timer runout duration, lockout and non-lockout state is verified.

Timer intervals must be interlaced to verify their independence and to save time.

The requirement that each timer can be restarted while running must also be verified.

Test #1 Multisite, T_L~~1~~ Timer and Lockout: Timer Duration and Insensitivity to Non-Valid Signals (All Transponders)

Time (sec)	Action
0.0	Start timer with UF=4.

0.02	Verify lockout to timer's II or SI with UF=11.
0.04	To 0.28 verify non-lockout to all other non-locked out IIS and SIS
0.3	Start next timer for interlace.
4.5	Try timer restart with correct IIS or SIS and incorrect DI-LOS and DI-LSS combinations (DI:80 – 7 = 8, LOS:2, LSS:2=14 combinations) (see note above).
16.9	Verify lockout to timer's II or SI with UF=11.
19.1	Verify non-lockout.

If the last test fails, the timer either runs too long or has been restarted by a non-valid signal.

Test #2 Multisite T_1 T_L Timer and Lockout: Restart Capability and Sensitivity to All Valid Formats (Basic All Transponders)

Time (sec)	Action
0.0	Start timer with UF=4.
0.02	Verify lockout to timer's II or SI.
4.5	Restart timer with UF=5.
21.4	Verify lockout for timer's II or SI.
23.6	Verify non-lockout for timer's II or SI.

Interlace all timers in approximately 0.3-second intervals.

If the test at 21.4 seconds fails, the timer has not been restarted.

Test #3 Multisite TL Timer and Lockout: Restart Capability and Sensitivity to All Valid Formats with Long Interrogation Types (Level N Transponders and Above)

If the equipment under test is designed to accept long format interrogations, repeat Test #2 except use UF=20 and UF=21 in place of the UF=4 and UF=5 interrogations.

Test #2 Multisite T_1 Timer and Lockout: Restart Capability and Sensitivity to all Valid Formats (All Other Transponders)

Time (sec)	Action
0.0	Start timer with UF=4.
0.02	Verify lockout to timer's II or SI.
4.5	Restart timer with UF=5.
9.0	Restart timer with UF=20.
13.5	Restart timer with UF=21.
20.4	Verify lockout for timer's II or SI.
24.9	Verify lockout for timer's II or SI.
30.4	Verify lockout for timer's II or SI.
32.6	Verify non-lockout for timer's II or SI.

Interlace all timers in approximately 0.3-second intervals

If any one of the tests at 20.4, 24.9, or 30.4 seconds fail, the timer has not been restarted.

2. Correct flowchart Figure 2-12.

Figure 2-12 (2nd Page) needs "yes" and "no" added to the conditional test blocks.

3. Recommended Changes to §2.5.4.6 Procedure #6

Section 2.5.4.6 Procedure #6 Squitter Verification needs to add a reference to the requirements section.

2.5.4.6 Procedure #6 Squitter Verification

(Subparagraph 2.2.16.2.6)

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4. Recommended Changes to §2.5.4.7 Procedure #7

There is an incorrect requirement section reference in procedure 2.5.4.7

2.5.4.7 Procedure #7 FS and VS Protocol/Code Tests

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(Subparagraph 2.2.l4.4.3~~1~~2 – VS code).

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5. Recommended Changes to §2.5.4.10 Procedure #10

The Altitude Report Tests (Procedure #10) omits identifying the DF=20 format as one that contains the altitude code. In the proposed change below, this is corrected as well as updating the test to reflect the transponder "level" terminology. The 918 replies is correct if there are 5 Mode S replies (DF=0,4,16,17,20) used with 13 altitude bits (13x12+1= 157, 157x5=785) plus a 12-bit ATCRBS code (12x11+1=133, 133+785=918).

2.5.4.10 Procedure #10 Altitude Report Tests

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Transponder Designs

In ATCRBS replies only 11 of the possible 13 pulses are used; X and D1 are not part of the code. Additionally, some transponders may not need the capability to transmit the D2 and/or D4 pulses which start at 62,000 and 30,750 ft respectively. At the other extreme, a transponder with the capability to report altitude in meters must have the capability to transmit ONEs in all 13 bits of the AC field. If the maximum number of bits in the altitude code is n, the total number of patterns required by the above pattern selection recommendation is n(n-1)+1.

Transponders may report altitude in up to ~~four~~ six reply formats ~~only~~depending on the design level: ATCRBS Mode C, DF=0, DF=4, (Level 1 and above); ~~and~~ the airborne position squitter, DF=17, (extended squitter capability); and ~~if so equipped,~~ in DF=16 and DF=20 (Level 2 and above). The total number of replies that should be verified for a given transponder design is the product of the number of altitude reply formats and the number of recommended test patterns for that transponder. This number ranges from a minimum of 364 replies tested for a ~~basic~~ Level 1 transponder with 10 altitude code bits to a maximum of 918 replies tested for a ~~data link~~Level 2e and above transponder with 13 altitude code bits.

Test Sequence

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6. Recommended Changes to §2.5.4.11 Procedure #11

The 4096 code tests (Procedure #11) contains an incorrect reference to a subparagraph that is supposed to show a correlation between pulse position in ATCRBS and bit number in Mode S replies. Also, the test procedure is modified to use the transponder “level” terminology.

2.5.4.11 Procedure #11 4096 Code Tests

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Pattern Selection

The correlation between pulse position in ATCRBS and bit number in Mode S replies is shown in subparagraph ~~2.5.4.10~~2.2.13.1.2 b.

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Transponder Designs

The ~~basic~~ level 1 transponder reports the 4096 code in ATCRBS Mode A replies and in DF=5; 264 replies must be verified.

All other transponders report the 4096 code in ATCRBS Mode A replies and in DF=5, 21; 396 replies must be verified.

7. Recommended Changes to §2.5.4.12 Procedure #12

The RI, Acquisition and Maximum Airspeed test (Procedure #12) contains an incorrect reference to test procedure #7 (it should reference test procedure #17). Also, the test procedure is modified to use the transponder "level" terminology.

2.5.4.12 Procedure #12 RI, Acquisition and Maximum Airspeed

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Pattern Selection

Of the 4 bits of the RI field, one (14) is controlled by the content of the received interrogation. The remaining three (l5-l7) show the airspeed code from the fixed direct data interface when bit 14 is ONE, and input from a variable data interface when bit l4 is ZERO. This procedure concerns only the fixed data interface; RI action for the variable data interface is verified in Procedure #~~7~~17.

To be verified are code 0 and codes 8 through 14 of subparagraph 2.2.14.4.25.

Transponder Designs

The airspeed codes range to l200 knots. Bit l5, if ONE, characterizes all airspeeds above 300 knots. Transponders may not have inputs for airspeeds above that limit.

~~The basic~~A level 1 transponder requires interrogations with UF=0, AQ=0, 1 and RL=0 (2 interrogation patterns).

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8. Recommended Changes to §2.5.4.17 Procedure #17

There is a typographical error in Procedure 17. Correct first reference to 2.2.13.3.1 a and b.

2.5.4.17 Procedure #l7Downlink Interface, DFs 0, 16

(Subparagraph 2.2.13.3.1 a and b – interface)
(Subparagraph 2.2.17.1.16 – protocol)
(Subparagraph 2.2.14.4.18 – MV)
(Subparagraph 2.2.20.1.4)