

**RTCA Special Committee 209**  
**ATCRBS / Mode S Transponder**  
**Meeting #4**

**Honeywell, Olathe KS**  
**18 – 19 October 2006**

Revision to SC209-WP03-08  
**Proposed Changes to Test Procedures**  
**in RTCA-DO-181C, Section 2.5**

Revision #1 was accomplished during Meeting #4 and the changes or agreements are marked with annotations on each suggested change and highlighted in yellow.

**John Van Dongen**  
**WJH FAA Technical Center**

**SUMMARY**

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

**This paper is a revision to SC209-WP03-08.**

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

### **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<sub>L</sub>. T<sub>L</sub> 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 <sub>L</sub> , T <sub>L</sub> [T <sub>L</sub> ]
Alert Timer:	TC, T <sub>C</sub> [T <sub>C</sub> ]
SPI Timer:	TI, T <sub>i</sub> [T <sub>i</sub> ]
B-Timer:	TR, T <sub>RB</sub> [T <sub>RB</sub> ]
C-Timer:	TR, T <sub>RC</sub> [T <sub>RC</sub> ]
D-Timer:	TR, T <sub>RD</sub> [T <sub>RD</sub> ]

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. [AGREED and will be implemented as indicated above throughout the document including Figures where applicable]

(2) Some of the total pattern values in the pattern definitions per timer are incorrect. These errors are corrected and the pattern definitions are modified to provide more clarity when defining the patterns to be used.

(3) In Test #1, the negative test to try to restart timers with incorrect DI, LOS, LSS etc. starts at 0.3 seconds with the start of the next timer. This needs to be delayed by more than one second so that a failure due to this can be distinguished from the original timer start. This is corrected in the proposed text to start at 3.64 seconds from the original timer start. The 3.64 second delay adds sufficient time to separate the negative test from the original timer start and positions the interrogation group to facilitate the interlaced test sequence.

Also, it is not clear what the 14 negative patterns are to restart the timers. There appears to be 8 patterns, one for each DI code 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. These patterns will fill the SD field in each case with the bit patterns most likely to trick the decoding logic.

(4) The Test #1 sequence as it exists will interrogate the transponder at a rate much higher than it is required to accept for Mode S interrogations. It calls for testing up to 77 timers from 0.04 to 0.28 seconds and it calls for interlacing a new timer test every 0.3 seconds. A new Test #1 sequence is proposed that does not exceed 50 interrogations per second and interlaces the start of the next timer every 2 seconds.

(5) 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 ~~FF-TL~~ timer associated with the received II or SI code and holds the lockout condition for  $18 \pm 1.0$  seconds.

Selective lockout applies only to UF=11 with II or SI corresponding to the running ~~FF-TL~~ 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 [ACCEPTED and implemented]

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 [ACCEPTED, and implemented]

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: ~~62~~ or 4.

Negative test patterns: ~~26~~ 16.

### Pattern Definition of All Other Transponder Designs [ACCEPTED, and implemented]

#### Positive Interrogation Patterns Per Timer

UF: 4 codes.  
DI: 2 codes with LOS=1 ~~or~~ and 1 code with LSS=1. Total: ~~428~~ 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+2.

Negative test pattern: 532.

*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  $18 \pm 1.0$  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<sub>1,1</sub>~~-Timer and Lockout: Timer Duration and Insensitivity to Non-Valid Signals (All Transponders) **[ACCEPTED, and implemented]**

<u>Time (sec)</u>	<u>Action</u>
0.0	Start timer with UF=4.
0.02	Verify lockout to timer's II or SI with UF=11.
0.04 <u>to 1.62</u>	<del>V<sub>T=0-0.28</sub></del> verify non-lockout to all other non-locked out IIS and SIS <u>(times 0.9 and 1.1 will be used for the last 2 steps of the sequence for timers started previously with interlace, see note below).</u>
<del>2.00-3</del>	Start next timer for interlace.
<del>3.64</del>	Try timer restart with correct IIS or SIS and incorrect DI-LOS and DI-LSS combinations ( <del>DI:80 - 7 = 8;</del> <del>LOS:2, LSS:2=14</del> combinations) <u>(see note above).</u>
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.

Note: Test #1 provides the basic timing of a test sequence that satisfies the principles of the test procedure while maintaining a maximum of 50 interrogations per second. Because the test sequence calls for interlacing multisite lockout timers (in this case one is started every 2 seconds), the above sequence will need to accommodate the critical timer verifications that occur at 16.9 and 19.1 seconds relative to the start of each timer. When the test sequence reaches 16.9 and 19.1 seconds after the start of each timer it will be 0.9 and 1.1 after the start of a new timer. Priority is given to verify the lockout of the earlier timer at the correct time, while the verification of non-lockout to all other timers is scheduled around these critical measurements.

Test #2 Multisite ~~T<sub>i</sub>~~ T<sub>L</sub> Timer and Lockout: Restart Capability and Sensitivity to All Valid Formats (Basic-All Transponders) [This procedure will be updated to reflect comments from Don Walker during Meeting #4, and resubmitted before any implementation]

<u>Time (sec)</u>	<u>Action</u>
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<sub>i</sub> Timer and Lockout: Restart Capability and Sensitivity to all Valid Formats (All Other Transponders)~~

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

~~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 (2<sup>nd</sup> 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** [ACCEPTED, and implemented]

(Subparagraph 2.2.16.2.6)

## 4. Recommended Changes to 2.5.4.7 Procedure #7 [ACCEPTED, and implemented]

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**

...

(Subparagraph 2.2.14.4.3+2 – VS code). [ACCEPTED, and implemented]

...

## 5. Recommended Changes to 2.5.4.10 Procedure #10 [will be updated to reflect comments during the meeting and resubmitted]

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 ( $13 \times 12 + 1 = 157$ ,  $157 \times 5 = 785$ ) plus a 12-bit ATCRBS code ( $12 \times 11 + 1 = 133$ ,  $133 + 785 = 918$ ).

### **2.5.4.10 Procedure #10 Altitude Report Tests**

...

#### 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

...

**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**

...

Pattern Selection **[ACCEPTED and implemented]**

The correlation between pulse position in ATCRBS and bit number in Mode S replies is shown in subparagraph ~~2.5.4.10~~2.13.1.2 b.

...

Transponder Designs **[ACCEPTED, and implemented]**

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**

...

Pattern Selection

Of the 4 bits of the RI field, one (14) is controlled by the content of the received interrogation. The remaining three (15-17) show the airspeed code from the fixed direct data interface when bit 14 is ONE, and input from a variable data interface when bit 14 is ZERO. This procedure concerns only the fixed data interface; RI action for the variable data interface is verified in Procedure ~~#7~~17. **[ACCEPTED and implemented]**

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 1200 knots. Bit 15, 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). **[ACCEPTED and implemented]**

...

### **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 #17 Downlink Interface, DFs 0, 16**

(Subparagraph 2.2.13.3.1 a and b – interface) **[ACCEPTED and implemented]**  
(Subparagraph 2.2.17.1.16 – protocol)  
(Subparagraph 2.2.14.4.18 – MV)  
(Subparagraph 2.2.20.1.4)