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ATCRBS / Mode S Transponder MOPS Maintenance
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More Proposed Changes for Comm-B Test Procedures

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SUMMARY

This Working Paper refines change proposals that were originally made in SC209-WP12-08R1 and makes recommendations for changes to the Comm-B protocol tests to provide additional negative testing to insure that DI codes are processed properly and do not incorrectly modify Comm-B transponder states.

1. Introduction

At the previous RTCA SC-209/EUROCAE WG-49 meeting, WP SC209-WP12-08R1 recommended several changes to the Comm-B Protocol tests in DO-181D, §2.5.4.18. After the EUROCAE Joint Session, further discussion was held at the FAA Technical Center concerning the correctness of some of the changes that had been entered and accepted in WP12-08R1.

This WP builds on the improvements to the MOPS suggested by WP12-08R1, and further changes are recommended as discussed below.

2. Discussion

a) Two editorial changes that moved some text under more appropriate section headings:

1) Moved the sentence “To ‘set the B-bit’, use DR=1 and ... “ to the area above the Test Sequence heading.

2) Moved the sentence “If PC is not required to be 4, ... “ to the area above the Test Sequence Heading.

The above two sections of text were out of place in their original locations.

b) The note in the Required Negative Tests section was changed for clarity.

c) In the table containing the expected transponder states as a function of interrogation pattern, there were four alternative conditions removed (Interrogation patterns 14 and 15, transponder states 5 and 6) because it is not necessary to set the conditions that will cause these states in the test matrix since they are covered by negative testing and/or other test matrix conditions.

2.5.4.18

Procedure #18: Comm-B Protocol

(§2.2.19.1.12 through §2.2.19.1.12.4)

(§2.2.19.2.2 through §2.2.19.2.3.1)

(§2.2.19.2.3.3 through §2.2.19.2.3.5)

(§2.2.19.2.1.2 – UM)

(Figure 2-20 – Flowchart)

This test procedure verifies that the Comm-B protocol is carried out correctly.

The test procedure follows the notation of transponder states and of interrogation patterns as shown in the flowchart.

Transponder States

The transponder states are defined by the combinations of conditions E through I, where:

E	=	B-register set: B-bit inserted.
F	=	T-register set: Message has been transmitted.
G	=	Timer runs: For multisite only.
I	=	Next message waiting.

There are six possible states as shown below:

#	E	F	G	I	
1	0	0	0	0	No B-bit, others impossible or inconsequential.
2	1	0	0	0	B-Register set, message not extracted
3	1	1	0	0	Message extraction, not multisite protocol.
4	1	1	0	1	As above, next message waiting.
5	1	1	1	0	In multisite, interrogation with wrong IIS can not close out.
6	1	1	1	1	In multisite, next message waiting

State 5 must be tested with all 15 IIS codes.

It is not necessary to test State 6 with all IIS codes with all interrogation patterns. However, the IIS used in the multisite reservation should be changed each time the transponder has to be returned to State 6 after a previous interrogation pattern that changed it to another State.

Interrogation Patterns							
#	A	B	C	D	K	L	
1	0	0	0	0	0	0	Ordinary interrogation, asking for short reply.
2	0	0	0	0	0	1	Ground-initiated Comm-B extraction (FIS etc).
3	0	0	0	0	1	0	Air-initiated Comm-B extraction, not multisite. For State 2, run 2 cases, one use any interrogation to satisfy condition K with DI≠3 and the second case use RR=16 with DI=3 and RRS=0
4	0	1	0	0	0	0	Multisite, but not for Comm-B. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
5	0	1	0	0	0	1	Ground-initiated Comm-B extraction, multisite not for Comm-B. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
6	0	1	0	0	1	0	Air-initiated Comm-B extraction, multisite not for Comm-B. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
7	0	1	0	1	0	0	Multisite closeout for Comm-B. (IIS sensitive: States 2-4 use IIS=0 and IIS≠0, State 5 use all 16 IIS codes)
8	0	1	0	1	0	1	Multisite closeout for Comm-B and ground initiated Comm-B extraction. (IIS sensitive: States 2-4 use IIS=0 and IIS≠0, State 5 use one incorrect IIS and the correct IIS)
9	0	1	0	1	1	0	Multisite closeout for Comm-B and attempt to extract a possible message still waiting at the air-initiation interface. (IIS sensitive: States 2-4 use IIS=0 and IIS≠0, State 5 use one incorrect IIS and the correct IIS)
10	0	1	1	0	0	0	Multisite reservation with wrong RR, see next line. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
11	0	1	1	0	0	1	Attempt at multisite reservation with wrong RR. Transponder must not accept reservation. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
12	0	1	1	0	1	0	Multisite reservation, correct. (IIS sensitive: States 2-4 use all 16 IIS codes, State 5 use one incorrect IIS and the correct IIS)
13	1	0	0	0	0	0	Non-selective cancellation. For State 3, run 2 cases, one use RR < 16 with DI≠3 and the second case use RR < 16 and DI=3
14	1	0	0	0	0	1	Non-selective cancellation and ground initiated Comm-B extraction. For States 3 and 5, specifically run 3 cases, one use RR=16 with DI=3 & RRS≠0, the second case use RR≠16 and DI=3, and third use RR=16 with DI=7, and RRS≠0.

Interrogation Patterns							
#	A	B	C	D	K	L	
15	1	0	0	0	1	0	Non-selective cancellation and attempt to extract possible message still waiting at the air-initiation interface. For States 2, 3 and 4, run 2 cases, one use any interrogation to satisfy condition K with DI≠3 and the second case use RR=16 with DI=3 and RRS=0
16	1	1	0	0	0	0	Non-selective cancellation, multisite not for Comm-B. (IIS sensitive: State 5 use all 16 IIS codes)
17	1	1	0	0	0	1	Non-selective cancellation with ground initiated Comm-B extraction, multisite not for Comm-B. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
18	1	1	0	0	1	0	Non-selective cancellation and attempt to extract possible message still waiting at air-initiation interface, multisite not for Comm-B. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
19	1	1	0	1	0	0	Non-selective cancellation and multisite closeout, cancel non-selective message and close out multisite message if IIS is correct. (IIS sensitive: State 5 use all 16 IIS codes)
20	1	1	0	1	0	1	Non-selective cancellation and multisite close-out and ground-initiated Comm-B extraction. Will cancel non-selective message and will close out multisite message if IIS is correct. Will extract Comm-B. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
21	1	1	0	1	1	0	Same as above, except with air-initiated extraction. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
22	1	1	1	0	0	0	Non-selective cancellation and reservation with wrong RR. Cancel but make no reservation. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
23	1	1	1	0	0	1	Non-selective cancellation and reservation with wrong RR. Cancel but make no reservation. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
24	1	1	1	0	1	0	Non-selective cancellation and reservation. Cancel and make reservation. (IIS sensitive: States 5 & 6 use one incorrect IIS and the correct IIS)

A =	PC=4:	Cancellation
B =	DI=1:	Multisite in effect
C =	MBS=1:	Multisite reservation
D =	MBS=2	Multisite closeout
K² =	RR=16 with DI ≠ 7 and DI ≠ 3, or with DI=7 or DI=3 and RRS=0 ¹	Air initiated MB extraction
L =	RR larger than 15 but not according to code K above	Ground MB extraction

¹ Use of RR=16 and DI=3 and RRS=0 only when specified in interrogation pattern.

² Condition K also includes conditions M and N.

The symbols A, B, C, etc., correspond to the symbols on the flowchart (Figure 2-20).

For IIS sensitive interrogation patterns, use IIS≠0 unless stated in the table.

For State 6, always use the correct IIS code with the exception of interrogation pattern 24, where an incorrect IIS code is also used.

When the IIS code must not equal ZERO (0), or must be incorrect, the value used should be varied with different interrogation patterns.

Interrogation patterns 10, 11, 22, 23 are forbidden to the sensor. They must be used to verify that the transponder makes reservations only when the reservation is accompanied by extraction of the message.

To 'set the B-bit', use DR=1 and DR=3 commands alternately during the test sequence.

If PC is not required to be 4, use all other codes. If MBS is not required to be 1 or 2, use codes 0 and 3. If RR is required to be less than 16, use all codes less than 16.

Test Sequence.

All 1435 combinations of the transponder states and interrogation patterns must be used. Additional interrogations may be needed to set transponder states. The test sequence may be set up so that when the transponder enters a given state, all interrogation patterns are used that will not change the state, followed by patterns that will. The test then proceeds with the newly acquired state.

~~To 'set the B-bit', use DR=1 and DR=3 commands alternately during the test sequence.~~

UM Field Verification

During the test sequence when the DI is required to be 1, alternately use RSS=0 and 1, and when DI is not required to be 1, alternately use DI=0 and 7, so that the reply will contain IIS and IDS in the UM field according to §2.2.19.1.9. DI=3 is required for certain interrogation patterns and transponder states in order to verify that attempts to cancel a Comm-B via PC=4 when DI=3 does not incorrectly cancel the message and to verify that interrogations with RR=16 DI=3 and RRS=0 do not set the T register.

These fields are used to verify the Comm-B reservation status and associated IIS as a result of each interrogation pattern and transponder state.

Required Negative Tests

Concurrent tests are part of the sequence above.

~~If PC is not required to be 4, use all other codes. If MBS is not required to be 1 or 2, use codes 0 and 3. If RR is required to be less than 16, use all codes less than 16.~~

Inserted tests must be interspersed within the sequence.

Insert interrogations of formats other than UF=4, 5, 20, 21 and verify that they have no effect on the protocol.

Such interrogations should constitute one percent of the total number of interrogations used.

The interrogation patterns 2 and 14 must include, when RR=16 is used, the combinations of RR=16 with DI=3 or 7 and RRS Codes 1 through 15. It must be verified that these combinations do not cause the air-initiated Comm-B message to be transmitted.

Additional interrogation sequences are required to verify that SD content is not misinterpreted as Comm-B multisite reservation or cancellation requests when DI is not equal 1. Use the following interrogations using all DI values other than 1 with SD content consistent with the Comm-B multisite reservation or cancellation requests required by interrogation patterns 7 and 12 as if DI were equal to 1:

Interrogation pattern 7 DI≠0 or 7, State 5 (IIS correct) – expected results 5 a,d,e

Interrogation pattern 7 DI=0 and 7, State 5 (IIS correct) – expected results 5 a,d,f

Interrogation pattern 8 DI≠0 or 7, State 5 (IIS correct) – expected results 5 a,d,e,j

Interrogation pattern 8 DI=0 and 7, State 5 (IIS correct) – expected results 5 a,d,f,j

Interrogation pattern 12 DI≠3 or 7, State 2 – expected results 3 b,d,e,j

Interrogation pattern 12 RR=16, DI=3 and RRS=0, State 2 – expected results 2 b,d,e,j

Note: ~~Interrogation pattern 12 can not be tested with DI=7 since the SD content would conflict with RR=16 and DI=7 and RRS=0 required for Kcontain RRS≠0 when the equivalent bits for MBS=1 (for DI=1) are set.~~

Additional interrogation sequences are required to verify that SD content is not misinterpreted as containing an IIS code (when DI≠0, 1 or 7) when a multisite reservation is active and a non-selective cancellation is requested. Use the following interrogations using all DI values other than 0, 1 or 7 with SD content consistent with the correct IIS in bits 17-20 for interrogation patterns 13 and 15:

Interrogation pattern 13 State 5 (IIS correct) – expected results 5 a,d,e

Interrogation pattern 15 State 5 (IIS correct) – expected results 5 b,d,e,j

Timer Duration and Automatic Closeout Test

Arrange the sequence so that the timer runs out occasionally. Verify timer duration and closeout.

Either during the test sequence or in a separate test, verify that interrogation patterns 10, 11, and 12 do not restart the timer when the transponder is in state 5 and the IIS is incorrect. Verify that interrogation patterns 10 and 11 do not restart the timer when the transponder is in state 5 and the IIS is correct. Verify that interrogation pattern 12 does restart the timer when the transponder is in state 5 and the IIS is correct.

Simultaneous Tests

While the transponder is undergoing the verification of the B-protocol, the number of interrogations and replies can be used to make tests for interface action, message content, etc. Such tests are described in Procedures 19 through 23.

Expected Transponder States as a Function of Interrogation Pattern and Prior Transponder State:

Interrogation Pattern	Transponder State						
	1	2	3	4	5 (IIS incorrect)	5 (IIS correct)	6
1	1 a,c,e	2 a,d,e	3 a,d,e	4 a,d,e	5 a,d,f	5 a,d,f	6 a,d,f
2	1 b,c,e,i	2 b,d,e,i	3 b,d,e,i	4 b,d,e,i	5 b,d,f,i	5 b,d,f,i	6 b,d,f,i
3	1 b,c,e,h	3 b,d,e,j or 2 b,d,e,j ^{3,5}	3 b,d,e,j	4 b,d,e,j	5 b,d,f,j	5 b,d,f,j	6 b,d,f,j
4	1 a,c,e	2 a,d,e	3 a,d,e	4 a,d,e	5 a,d,f	5 a,d,f	6 a,d,f
5	1 b,c,e,i	2 b,d,e,i	3 b,d,e,i	4 b,d,e,i	5 b,d,f,i	5 b,d,f,i	6 b,d,f,i
6	1 b,c,e,h	3 b,d,e,j	3 b,d,e,j	4 b,d,e,j	5 b,d,f,j	5 b,d,f,j	6 b,d,f,j
7	1 a,c,e	2 a,d,e	3 a,d,e	4 a,d,e	5 a,d,f	1 a,c,e	2 a,d,e
8	1 b,c,e,i	2 b,d,e,i	3 b,d,e,i	4 b,d,e,i	5 b,d,f,i	1 b,c,e,i	2 b,d,e,i
9	1 b,c,e,h	3 b,d,e,j	3 b,d,e,j	4 b,d,e,j	5 b,d,f,j	1 b,c,e,h	3 b,d,e,k
10	1 a,c,e	2 a,d,e	3 a,d,e	4 a,d,e	5 a,d,f,l	5 a,d,f,l	6 a,d,f
11	1 b,c,e,i	2 b,d,e,i	3 b,d,e,i	4 b,d,e,i	5 b,d,f,i,l	5 b,d,f,i,l	6 b,d,f,i
12	1 b,c,e,h	5 b,d,g,j or 3 b,d,e,j ¹	5 b,d,g,j or 3 b,d,e,j ¹	6 b,d,g,j or 4 b,d,e,j ¹	5 b,d,f,j,l	5 b,d,f,j,m	6 b,d,f,j
13	1 a,c,e	2 a,d,e	1 a,c,e or 3 a,d,e ⁴	2 a,d,e	5 a,d,f	1 a,c,e	2 a,d,e
14	1 b,c,e,i	2 b,d,e,i	1 b,c,e,i or 3 b,d,e,i ⁴	2 b,d,e,i or 4 b,d,e,i ⁴	5 b,d,f,i	1 b,c,e,i 1 b,c,e,i or 5 b,d,e,i⁴	2 b,d,e,i or 6 b,d,e,i⁴
15	1 b,c,e,h	3 b,d,e,j or 2 b,d,e,j ^{3,5}	1 b,c,e,h or 3 b,d,e,j ³	3 b,d,e,k or 4 b,d,e,j ³	5 b,d,f,j	1 b,c,e,h or 5 b,d,e,j³	3 b,d,e,k or 6 b,d,e,j³
16	1 a,c,e	2 a,d,e	1 a,c,e	2 a,d,e	5 a,d,f	1 a,c,e	2 a,d,e
17	1 b,c,e,i	2 b,d,e,i	1 b,c,e,i	2 b,d,e,i	5 b,d,f,i	1 b,c,e,i	2 b,d,e,i
18	1 b,c,e,h	3 b,d,e,j	1 b,c,e,h	3 b,d,e,k	5 b,d,f,j	1 b,c,e,h	3 b,d,e,k
19	1 a,c,e	2 a,d,e	1 a,c,e	2 a,d,e	5 a,d,f	1 a,c,e	2 a,d,e
20	1 b,c,e,i	2 b,d,e,i	1 b,c,e,i	2 b,d,e,i	5 b,d,f,i	1 b,c,e,i	2 b,d,e,i
21	1 b,c,e,h	3 b,d,e,j	1 b,c,e,h	3 b,d,e,k	5 b,d,f,j	1 b,c,e,h	3 b,d,e,k
22	1 a,c,e	2 a,d,e	1 a,c,e	2 a,d,e	5 a,d,f	1 a,c,e	2 a,d,e
23	1 b,c,e,i	2 b,d,e,i	1 b,c,e,i	2 b,d,e,i	5 b,d,f,i	1 b,c,e,i	2 b,d,e,i
24	1 b,c,e,h	5 b,d,g,j	1 b,c,e,h	5 b,d,g,k	5 b,d,f,j	1 b,c,e,h	5 b,d,f,k,m or 6 b,d,f,j,l ²

¹ If IIS = 0

² If IIS is incorrect

³ If RR=16 DI=3 and RRS=0

⁴ If DI=3

⁵ Follow with interrogation pattern 13 and verify State 2 result

Verification Required:

a	Short Reply (DF=4, 5)
b	Long Reply (DF=20, 21)
c	DR = 0, No Downlink Request
d	DR = 1 or 3, Request to Send Comm-B
e	UM = No Comm-B reservation or no content
f	UM = IDS = 1, Comm-B Reservation Active, IIS = Value Set with Transponder State
g	UM = IDS = 1, Comm-B Reservation Active, IIS = Value in Interrogation
h	MB = All 0's
i	MB per RR
j	MB Contains 1 st Comm-B Message Inserted
k	MB Contains 2 nd Comm-B Message Inserted
l	Verify Multisite Timer is not Restarted
m	Verify Multisite Timer is Restarted