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Proposed Changes for Comm-B
Revision 1

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In Response to Action Item 11-05

SUMMARY

This Working Paper builds on change proposals that were originally made in SC209-WP11-09R1 and makes recommendations for changes to the Comm-B protocol tests to provide additional negative testing to insure that DI codes are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-WP11-09R1 recommended a change to the Comm-B Protocol flowchart contained in DO-181D Figure 2-20 to account for the difference in handling required when RR=16 and DI=3 and RRS=0. An interrogation of this type allows the extraction of a Comm-B message if available but can not set the T register. Also, any interrogation with DI=3 should not closeout a Comm-B which the agreed change proposed by WP11-09R1 corrected a hole in the existing flowchart. Also, there were problems with the Comm-B protocol tests and recommended changes to the tests contained in DO-181D were presented in the WP.

This WP builds on the improvements to the MOPS suggested by WP11-09R1, and further changes are recommended as discussed below. Also, this WP 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. These suggested changes are related to discussion at the last meeting during presentation of Working Paper SC209-WP11-08. **Action Item 11-05** was assigned to reverse the changes agreed upon to the interrogation acceptance protocol. This WP simply suggests changes to the test procedures without requirements changes.

2. Discussion

Changes to the Comm-B protocol flowchart, Figure 2-20 in DO-181D (ED-73C, Figure 3-18), and the enhanced Comm-B protocol flowchart, DO-181D, Figure 2-25 (ED-73C, Figure 3-18A), are required to protect against DI=3 canceling a Comm-B message with PC=4 when RR does not equal 16.

Therefore, the decision box “O” is required so that when DI=3, the additional checks for PC=4 are not made. Additionally, to reflect the changes to the process with DI=3 and to respond to the concern that adequate testing needs to be provided to protect against Comm-B reservations / cancellations with an incorrect or unassigned DI code, changes are included to the Comm-B test procedures in §2.5.4.18 of DO-181D. Negative tests have been added for the purpose of checking proper DI decoding. The negative tests are not exhaustive as the number of interrogations to test every permutation is not practical. Interrogation sequences 8 and 9 are used to verify that the transponder does not allow a multisite closeout if DI is not 1, for the cases when a Comm-B is requested and for the case when it is not requested. Interrogation pattern 12 is used with DI not equal to 1 but with the SD containing the Comm-B multisite cancellation request to attempt a multisite Comm-B reservation with the wrong DI code. The one exception is a test of DI of 7 since this would not satisfy condition K required for interrogation pattern 12.

Interrogation sequences 13 and 15 are used 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. SD contains data consistent with the correct IIS in bits 17-20 for interrogation patterns 13 and 15 to exercise this negative test.

ED-73C, §5.5.8.18 does not appear to have been updated to the same state as DO-181D, §2.5.4.18. We therefore recommend a discussion regarding whether or not additional changes should be made to ED-73C to bring it into harmonization with the detail in DO-181D.

Additional discussion 11/18/2010 (John Van Dongen): I am making several changes to the test procedure per the concerns raised by the working group. The changes do not include additional interrogation patterns for decision blocks “M” and “N” but I do believe that those blocks will be adequately tested with the test procedure below. Those decision blocks work together with decision block “K” in the flowchart to either direct the path UP to decision block “E” or DOWN to decision block “O”. Interrogation pattern

14 includes variations that will test all combinations to go in the downward direction and interrogation pattern 15 includes variations to do the same in the upward direction.

The original variations included for interrogation pattern 14 were also incorrectly calling for an RR value less than 16 and that conflicts with the basic definition of the interrogation pattern ($L = RR > 15$). This has been corrected.

The last table that shows the results to look for as each interrogation pattern intersects with each transponder state was updated to include more conditions that depend on DI value. The font was changed to superscript for the footnotes below the table as well.

The recommended changes to the Comm-B and Enhanced Comm-B Figures, as well as the test procedure in DO-181D, §2.5.4.18 are shown below:

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 32 cases, one use RR=16 with DI≠3 & RRS≠0, and the second case use RR≠16 and DI=3, and third use RR=16 with DI≠3=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.

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 K

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 or 5 b,d,e,i ⁴	2 b,d,e,i or 6 b,d,e,i ⁴
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,j ³	3 b,d,e,k or 6 b,d,e,j ³
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