**RTCA Special Committee 209**

**ATCRBS / Mode S Transponder MOPS Maintenance**

**Meeting #14**

**In Joint Session with EUROCAE WG-49**
**Host: Rockwell Collins, Inc.**
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# Proposal for the Correction of BDS Register SWAP Issues

**Revision 3**

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Multiple instances of transponder replies containing data from registers other than those interrogated for have been reported in SC-209/WG-49 and ICAO ASP and TSG meetings over the last year or two. The latest report being that presented by Pierre Ruault in SC-209 WP12-23. A preliminary proposal to rectify the situation was presented during SC-209/WG-49 meeting in Paris in November, 2010. Since that time, several other proposals have been entertained and discussed within the working groups.

This Working Paper proposes the latest agreed method which is based on first receiving a command bit from the interrogator to overlay register information over the parity in the reply to the interrogation. The parity is established by first performing a Modulo-2 Sum of the Address ("AA") field with the register number. The results are then used to generate a Data Parity (DP) field in the same manner that the AP field is currently generated. In an effort to minimize impact to current transponders in the field, the method also provides for the transponder to annunciate capability to support the DP field.

A previous version of this Working Paper performed the Modulo-2 Sum of the "AA" with the register number using the least significant 8 bits of the "AA". This Working Paper has been updated to perform the Modulo-2 Sum using the most significant 8 bits of the "AA". (changes made since the previous version are highlighted in "blue".

This document presents the required MOPS changes and Test Procedures for both RTCA/DO-181D/E and EUROCAE ED-73C/E.

**Introduction:**

The primary purpose of this document is to present proposed changes to correct BDS Register Swap issues as discussed in the abstract provided on the cover page.

Part A of this document presents the necessary MOPS changes and Test Procedures for RTCA Document No. DO-181D/E to address the BDS Swap Issue.

Part B of this document presents the necessary MOPS changes and Test Procedures for EUROCAE ED-73C/E.

Note that the test procedures do not do exhaustive testing of all possible combinations as it should be sufficient to demonstrate recognition of the Overlay Command and verify that the appropriate Data Parity field is inserted into the downlink reply as opposed to the AP field.

Appropriate XCEL worksheets demonstrating the DP field generation will be provided along with this document to the Working Group Secretary for distribution as needed.

It should be noted that the method proposed herein provides a method for the transponder to declare its capability to support the new Data Parity (DP) field.

The method is designed such that all transponders do not have to generate the Data Parity (DP) field all the time. It is only generated when the transponder is capable and is so commanded by the interrogator.

Modification of the existing Mode-S parity scheme is minimal. Currently, the discrete address of the transponder is used to overlay parity in generation of the AP field. The method proposed herein simply performs a Modulo-2 sum of the Register Number being used in the reply with the "AA" field to develop the "Modified AA" ("MAA") field. The "MAA" field is then used to replace the "AA" field used directly to develop the DP field. Upon receipt of the reply, all the interrogator has to do is Modulo-2 Sum the last 24 bits of the reply with the expected Register Number and the result should be the original discrete address or "AA".

**ALL CHANGES PROPOSED IN THIS DOCUMENT ARE IN "RED" FONT AND HIGHLIGHTED IN "YELLOW".**

**CHANGES THAT WERE PREVIOUSLY MADE TO THE SECTIONS BEING ADDRESSED WERE PREVIOUSLY HIGHLIGHTED IN YELLOW BY THE WORKING GROUP SECRETARY. SUCH AREAS HAVE HAD THE HIGHLIGHTING CHANGED TO "BLUE" IN THIS DOCUMENT SO AS NOT TO BE CONFUSED WITH THE CHANGES BEING PROPOSED IN THIS DOCUMENT.**

## Part A: Proposed Changes to RTCA DO-181D/E:

~~**1. In section 1.4.4, insert an entry for the Overlay Command Capability (OCC) as an optional feature before the entry for "SI" and insert a new entry into Table 1-1:**~~

~~**Overlay Command Capability (OCC)** – transponders with the ability to overlay Register information over the parity in the reply when commanded by the interrogator, also have the capabilities of §1.4.3.2, §1.4.3.3, §1.4.3.4 or §1.4.3.5 (see §2.2.19.1.12.1, §2.2.19.1.12.2 & §2.2.19.1.12.6.2).~~

~~These additional features and corresponding identification codes are summarized in Table 1-1:~~

~~**Table 1-1: Transponder Optional Additional Features**~~

| ~~Additional Features~~ | ~~ID Code~~ |
|---|---|
| ~~TCAS Compatibility~~ | ~~a~~ |
| ~~Antenna Diversity~~ | ~~d~~ |
| ~~Extended Squitter~~ | ~~e~~ |
| ~~Dataflash~~ | ~~f~~ |
| ~~Hijack Mode Capability~~ | ~~h~~ |
| ~~Elementary Surveillance (only)~~ | ~~l~~ |
| ~~Enhanced Surveillance (including Elementary Surveillance)~~ | ~~n~~ |
| ~~Overlay Command Capability~~ | ~~o~~ |
| ~~Surveillance Identifier Code (SI)~~ | ~~s~~ |

**1. In section 1.4.3.2, add a bullet "h"**

h. Overlay Command Capability (see §2.2.19.1.12.1, §2.2.19.1.12.2 & §2.2.19.1.12.6.2)

**2. In section 2.2.14.4, modify Table provided in Figure 2-7 by adding:**

a. the **"DP"** (Data Parity) subfield as shown in the following table.

b. the **"OVC"** (Overlay Command) subfield to the "SD" field as shown in the following table.

| | | BITS | | FORMATS | | REFERENCE PARAGRAPH (S) | |
|---|---|---|---|---|---|---|---|
| **FIELD** | **SUB FIELD** | **NO.** | **POSITION** | **UP** | **DOWN** | **CONTENT** | **PROTOCOL** |
| **DP** | | 24 | 89-112 | | X | §2.2.14.4.12 | §2.2.19.1.12.1, §2.2.19.1.12.2 |
| MB | | | | | | | |
| | **OCC** | **1** | **47** | | **X** | **§2.2.19.1.12.6.2** | **§2.2.19.1.12.6.2** |
| SD | | 16 | 17-32 | X | | §2.2.14.4.35 | §2.2.19.1.12.1, §2.2.19.2 |
| | MES | 3 | 23-25 | X | | §2.2.19.2.1.1 | §2.2.20.1.3.1, §2.2.20.2.3.1 |
| | **OVC** | 1 | 28 | X | | §2.2.19.2.1.1.h | §2.2.19.1.12.1, §2.2.19.1.12.2 |
| | RCS | 3 | 24-26 | X | | §2.2.23.1.7 | §2.2.23.1.6 |

**3. Change Section 2.2.14.4.11 to read as follows:**

**2.2.14.4.11 Designator Identification**

This three-bit (bits 14 – 16) uplink field identifies the coding contained in the SD field in formats UF=4, 5, 20 and 21. The codes are:

| Code | Description |
|---|---|
| 0 | SD contains IIS (see §2.2.19.2.1.1), bits **21-27** and **29-32** are not assigned, and bit **28** contains the "OVC" (Overlay Command) (see §2.2.19.2.1.1.h). |
| 1 | SD contains multisite II lockout and multisite data link protocol information (see §2.2.19.2.1.1) |
| 2 | SD contains Extended Squitter control information (see §2.2.23.1.6) |
| 3 | SD contains multisite SI lockout information (see §2.2.19.2.1.1), extended data readout (see §2.2.19.1.12.2), and bit **28** contains the "OVC" (Overlay Command) (see §2.2.19.2.1.1.h). |
| 4 | Signifies SD Not assigned |
| 5 | Signifies SD Not assigned |
| 6 | Signifies SD Not assigned |
| 7 | SD contains extended data readout request (see §2.2.19.1.12.2) and bit **28** contains the "OVC" (Overlay Command) (see §2.2.19.2.1.1.h). |

## 4. Add new section 2.2.14.4.12 as follows to define the Data Parity downlink field.

### 2.2.14.4.12 DP Data Parity

This 24 bit (bits 89 – 112) downlink field contains the parity overlaid on a "Modified AA" field established by performing a modulo-2 summation (e.g., Exclusive-Or function) of the discrete address most significant 8 bits and BDS1, BDS2, where BDS1 and BDS2 are provided by the "RR" and "RRS" as specified in §2.2.19.1.12.1 and §2.2.19.1.12.2.

Example:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Discrete Address | = | AA AA AA Hex | = | 1010 | 1010 | 1010 | 1010 | 1010 | 1010 |
| BDS1, BDS2 | = | 5F 00 00 Hex | = | 0101 | 1111 | 0000 | 0000 | 0000 | 0000 |
| Discrete Address | ⊕ | BDS1, BDS2 Hex | = | 1111 | 0101 | 1010 | 1010 | 1010 | 1010 |
| "Modified AA" | = | F5 AA AA Hex | = | 1111 | 0101 | 1010 | 1010 | 1010 | 1010 |

where "⊕" prescribes modulo-2 addition

The resulting "Modified AA" field then represents the 24 bit sequence (a1,a2…a24) that **shall** be used to generate the DP field in accordance with §2.2.18.2.1.c.

***Note1:*** *Effectively, the most significant 8 bits of the discrete Address (e.g., "AA" field) are first modulo-2 summed with the Register number of the register being provided in the reply. The result of that process is then used to generate the DP field.*

***Note 2:*** *When the interrogator receives the reply, the parity decoder will decode the received "DP" into an equivalent modified "AA." The interrogator can then modulo-2 sum the most significant 8 bits of this modified "AA" with the intended register BDS1, BDS2 with the result being the original "AA" used in the interrogation that requested the reply.*

## 5. In section 2.2.19.1, make the following changes in Figure 2-14.

### Uplink Formats

| Format # | UF | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 0000 | - 3 - | RL: 1 | - 4 - | AQ: 1 | DS: 8 | - 10 - | AP: 24 | . . . Short Special Surveillance |
| 4 | 0 0100 | PC : 3 | RR : 5 | DI : 3 | SD : 16 | | | AP: 24 | . . . Surveillance. Altitude Request |
| 5 | 0 0101 | PC : 3 | RR : 5 | DI : 3 | SD : 16 | | | AP : 24 | . . . Surveillance, Identity Request |
| 11 | 0 1011 | PR : 4 | IC : 4 | CL : 3 | - 16 - | | | AP : 24 | . . . Mode S-Only All-Call |
| 16 | 1 0000 | - 3 - | RL: 1 | - 4 - | AQ: 1 | - 18 - | MU: 56 | AP: 24 | . . . Long Special Surveillance |
| 20 | 1 0100 | PC : 3 | RR : 5 | DI : 3 | SD : 16 | MA : 56 | | AP: 24 | . . . Comm-A, Altitude Request |
| 21 | 1 0101 | PC : 3 | RR : 5 | DI : 3 | SD : 16 | MA : 56 | | AP: 24 | . . . Comm-A, Identity Request |

### Downlink Formats

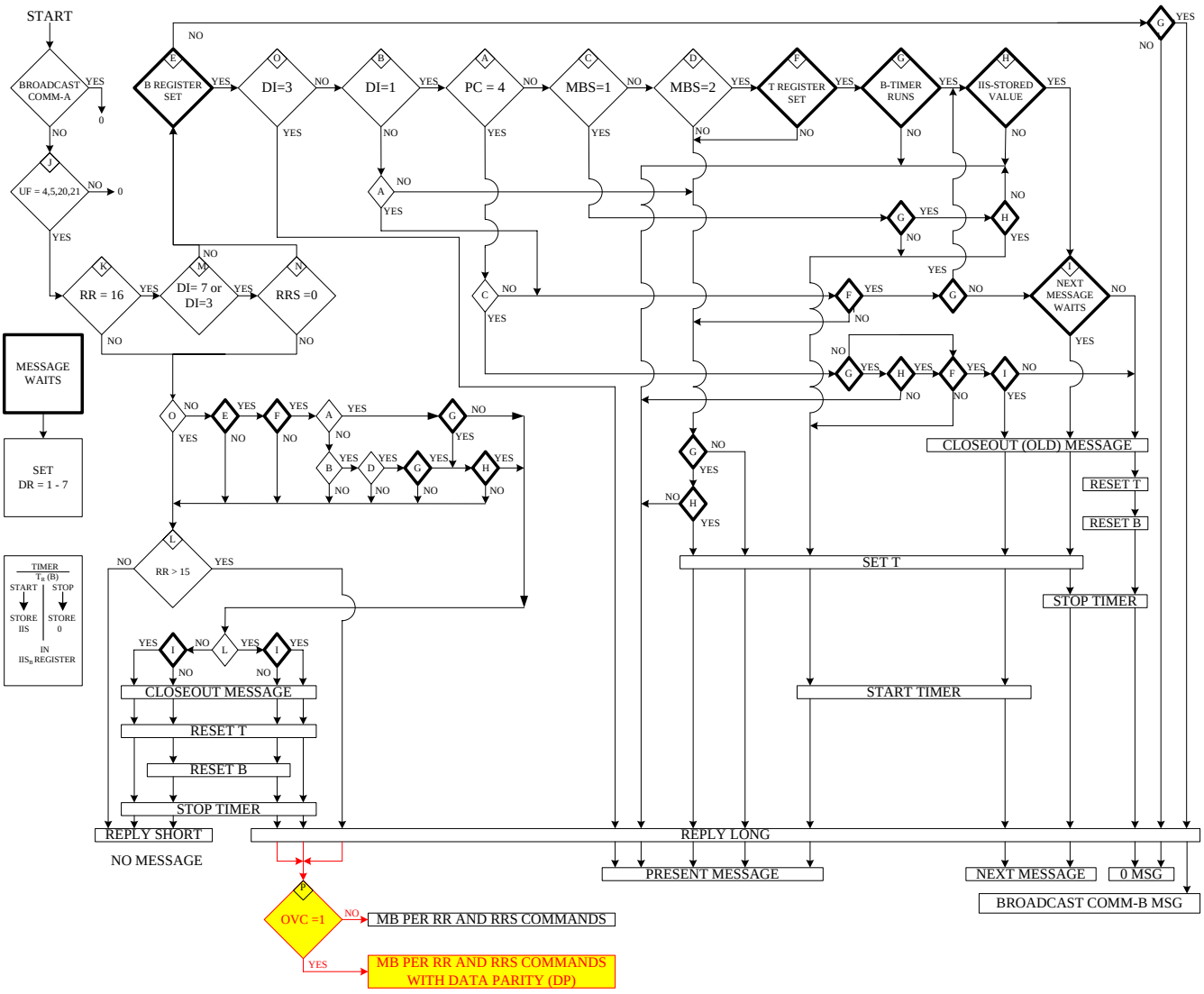
| Format # | DF | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 0000 | VS: 1 | CC: 1 | -1- | SL: 3 | -2- | RI: 4 | -2- | AC: 13 | AP: 24 | . . . Short Special Surveillance |
| 4 | 0 0100 | FS : 3 | DR : 5 | UM : 6 | AC : 13 | | | | | AP: 24 | . . . Surveillance. Altitude |
| 5 | 0 0101 | FS : 3 | DR : 5 | UM : 6 | ID : 13 | | | | | AP : 24 | . . . Surveillance, Identity |
| 11 | 0 1011 | CA : 3 | | AA : 24 | | | | | | PI : 24 | . . . All-Call Reply |
| 16 | 1 0000 | VS: 1 | -2- | SL: 3 | -2- | RI: 4 | -2- | AC: 13 | MV: 56 | AP: 24 | . . . Long Special Surveillance |
| 17 | 1 0001 | CA : 3 | | AA : 24 | | | | ME : 56 | | PI: 24 | . . . Extended Squitter |
| 20 | 1 0100 | FS: 3 | DR: 5 | UM: 6 | AC: 13 | MB: 56 | | | | AP: 24<br>DP:24 | . . . Comm-B, Altitude<br>(see Note 4) |
| 21 | 1 0101 | FS : 3 | DR : 5 | UM : 6 | ID : 13 | MB : 56 | | | | AP: 24<br>DP:24 | . . . Comm-B, Identity<br>(see Note 4) |

**Figure 2-14: All Level 2 Transponders: Formats**

***Notes:***

1. *Uplink and downlink formats 16 are used in TCAS applications.*
2. *The PC, RR, DI and SD fields do not apply to a Comm-A Broadcast Interrogation.*
3. *Downlink format 17 is only used for Extended Squitter and is optional.*
4. *The Data Parity (DP) (see §2.2.14.4.12) is used if it has been commanded by the OVC (see 2.2.19.2.1.1.h) in accordance with §2.2.19.1.12.1 and §2.2.19.1.12.2.*

## 6.a. In section 2.2.19.1.12, change Figure 2-20 to the following:




## 6.b. In section 2.2.21.1.4, Figure 2-25:

**Make the same changes to Figure 2-25 that were made to Figure 2-20 in Paragraph 6.a of this document.**

## 7. Change section 2.2.19.1.12.1 to read as follows:

### 2.2.19.1.12.1 Data Source Designators

When Comm-B information to be transmitted resides in data sources that are part of the Mode S installation, the data sources **shall** be identified by the BDS code of §2.2.14.4.20.b. The interrogator uses the RR field of surveillance and Comm-A interrogations to designate the BDSl of the data source from which the reply should originate. BDS1 is represented by the last 4 bits (bits 10 – 13) of the received RR code (see §2.2.14.4.34).

If the DI code of the Comm-B requesting interrogation is not equal to 3 or 7, the BDS2 code of the desired reply source **shall** be "0."

If the "DI" code of the Comm-B requesting interrogation is 0, 3, or 7, the "SD" contains the "OVC" in accordance with §2.2.19.2.1.1.h. If the "OVC" is equal to "1", then the reply to the interrogation **shall** contain the "DP" (Data Parity) field in accordance with §2.2.14.4.12. If the "OVC" is equal to "0", then the reply to the interrogation **shall** contain the "AP" (see §2.2.14.4.4).

***Note:*** *The "RR" section number will change from 2.2.14.4.34 to 2.2.14.4.35 due to the addition of the DP field.*

## 8. Change section 2.2.19.1.12.2 to read as follows:

### 2.2.19.1.12.2 Extended Data Source Designators

The interrogator can request data to be read out from a source more specifically defined by both BDS1 and BDS2. The readout is initiated by transmitting, in addition to the BDS1 code in RR, the BDS2 code in the SD field. See §2.2.19.2.1.1 for definitions of subfields in SD.

For transponders that support the Overlay Command Capability, if the "DI" code of the Comm-B requesting interrogation is 0, 3, or 7, the "SD" contains the "OVC" in accordance with §2.2.19.2.1.1.h. If the "OVC" is equal to "1", then the reply to the interrogation **shall** contain the "DP" (Data Parity) field in accordance with §2.2.14.4.12. If the "OVC" is equal to "0", then the reply to the interrogation **shall** contain the "AP" (see §2.2.14.4.4).

## 9. Change section 2.2.19.1.12.6.2 to read as follows:

### 2.2.19.1.12.6.2 Coding of the Data Link Capability Report

BDS1: 1 = Data Link Report

BDS2: 0 = Basic Report

For AIS capability reporting in the Data Link Capability Report, see §2.2.24.

SCS: This 1-bit (bit 66) squitter capability subfield **shall** report the capability of the transponder to transmit Extended Squitter position reports. It **shall** be set to ONE if GICB Registers $05_{16}$ and $06_{16}$ have been updated within the last 10 ±1 seconds. Otherwise it **shall** be set to ZERO. The internal insertion of data by the transponder into these registers (altitude and surveillance status) **shall not** qualify as a register update for this purpose.

***Note:*** *GICB Registers $05_{16}$ and $06_{16}$ are used for the Extended Squitter airborne and surface position reports, respectively.*

SIC: This one bit (bit 67) SI capability subfield **shall** report the capability of the transponder to process SI codes. It **shall** be set to ONE for transponders with SI code capability. Otherwise it **shall** be set to ZERO.

OCC: This one bit (bit 47) Overlay Command Capability subfield shall report the capability of the transponder to include the Data Parity (see §2.2.14.4.12) downlink field when commanded by the interrogator (§2.2.19.2.1.1.h). It **shall** be set to ONE for transponders with Overlay Command Capability. Otherwise, it **shall** be set to ZERO.

Other bits are reserved for TCAS (see §2.2.22.1.2.2).

**10. In section 2.2.19.2.1.1:**

a. Add subparagraph 2.2.19.2.1.1.h directly after the Note 1 currently provided after subparagraph 2.2.19.2.1.1.g.

h. If the "DI" = 0, 3, or 7:

In addition to the requirements provided above, the "SD" shall contain the following:

"OVC": The 1-bit (bit 28) "Overlay Command" subfield in "SD" is used by the interrogator to command that the Data Parity ("DP") (see §2.2.14.4.12) be used in the resulting reply to the interrogation in accordance with §2.2.19.1.12.1 and §2.2.19.1.12.2.

b. Change the Note Header for ***Note 1*** directly after subparagraph 2.2.19.2.1.1.g to ***Note.***

The note is now a single note between subparagraphs 2.2.19.2.1.1.g and 2.2.19.2.1.1.h.

c. Change the Note Header for ***Note 2*** to ***Note*** as the note now follows subparagraph 2.2.19.2.1.1.h.

d. Change the Table Provided in the Note now following subparagraph 2.2.19.2.1.1.h (formerly Note 2) as shown in the following:

| Structure of SD, if: | Position | Number of Bits | Subfield |
|---|---|---|---|
| **DI=0** | 17 – 20 | 4 | IIS |
| | 21 – 27 | 7 | Not Assigned |
| | 28 | 1 | OVC |
| | 29-32 | 4 | Not Assigned |
| **DI=1** | 17 – 20 | 4 | IIS |
| | 21 – 22 | 2 | MBS |
| | 23 – 25 | 3 | MES |
| | 26 | 1 | LOS |
| | 27 – 28 | 2 | RSS |
| | 29 – 32 | 4 | TMS |
| **DI=2** | 17 – 20 | 4 | Not Assigned |
| | 21 – 23 | 3 | TCS |
| | 24 – 26 | 3 | RCS |
| | 27 – 28 | 2 | SAS |
| | 29 – 32 | 4 | Not Assigned |
| **DI=3** | 17 – 22 | 6 | SIS |
| | 23 | 1 | LSS |
| | 24 – 27 | 4 | RRS |
| | 28 | 1 | OVC |
| | 29 – 32 | 4 | Not Assigned |
| **DI=7** | 17 – 20 | 4 | IIS |
| | 21 – 24 | 4 | RRS |
| | 25 | 1 | Not Assigned |
| | 26 | 1 | LOS |
| | 27 | 1 | Not Assigned |
| | 28 | 1 | OVC |
| | 29 – 32 | 4 | TMS |

**11. In 2.5.3.a just after the table, revise the last sentence in the paragraph to require testing of AP and PI:**

The Error Protection Test (Procedure #1) is used to verify the correct operation of the error protection circuitry of the test equipment and the transponder. Its initial application is ~~recommended~~ required for AP and PI.

**12. In Appendix B, Table B-3-16, BDS 1,0 Data Link Capability Report**

**Assign Bit 15 as follows:**

15 Overlay Command Capability (OCC) (see 19)

**Then add new note 19 as follows:**

19) The Overlay Command Capability (OCC) shall be interpreted as follows:

0 = no Overlay Command Capability

1 = Overlay Command Capability

***Note:*** ***Equivalent changes will need to be made to the Data Link Capability Report definition in ICAO Doc. 9871.***

**END OF REQUIREMENTS CHANGES_Start of Test Procedure Changes:**

**12. Directly after the section heading for section 2.5.4.1, add the following subsection**

**2.5.4.1.1 Procedure #1: Error Protection, AP and PI Fields (**§2.2.18.2.1.c)

Leave the rest of the existing 2.5.4.1 Test Procedure in place as is.

Then, directly after the existing Test Procedure, add the following subsection and procedure:

**2.5.4.1.2 Procedure #1: Error Protection, DP Field (**§2.2.14.4.12, §2.2.18.2.1, and §2.2.19.1.12.6.2 )

**Verification of Transponder's Downlink Encoding Circuits for DP**

Interrogate the transponder to extract Register **$10_{16}$** with an interrogation having **"UF" = 4**, "PC" = 0, "RR" =20 (14 Hex), "DI" = 0, "IIS" = 0, and All remaining "SD" bits set to Zero.

Check the state of bit 47 ("MB" bit 15). If bit 47 is ZERO, then the transponder does not support the Data Parity (DP) field and the following steps "a" –through- "j" of this procedure do not need to be performed. If bit 47 is ONE, then perform the following steps "a" –through- 'j".

a. **Retain the test configuration used to perform Verification of the Transponder's Downlink Encoding Circuits for AP in section** §2.5.4.1.1.

b. Establish the conditions such that the following fields in "DF"=20 and "DF"=21 replies will be set to ALL ZERO:

"FS", "DR", "UM", "AC" in "DF"=20, and "ID" in "DF"=21

c. Establish the Discrete Address of the transponder as **5E 40 1A** Hex (e.g., set "AA" = **5E 40 1A** Hex).

d. Establish the conditions where the contents of Register $40_{16}$ and $5F_{16}$ are set to ALL ZERO.

e. Interrogate the transponder to extract Register **$40_{16}$** with an interrogation having **"UF" = 4**, "PC" = 0, "RR" =20 (14 Hex), "DI" = 0, "IIS" = 0, and All remaining "SD" bits set to Zero.

1. Verify that the transponder replies with a **"DF" = 20** reply **having "AP" = 96 C2 8E Hex**.
2. Repeat the interrogation with "DI" = 3 and verify the same results.
3. Repeat the interrogation with "DI" = 7 and verify the same results.

f. Interrogate the transponder to extract Register **$40_{16}$** with an interrogation having **"UF" = 5**, "PC" = 0, "RR" =20 (14 Hex), "DI" = 0, "IIS" = 0, and All remaining "SD" bits set to Zero.

1. Verify that the transponder replies with a **"DF" = 21** reply having **"AP" = 55 55 55 Hex**.
2. Repeat the interrogation with "DI" = 3 and verify the same results.
3. Repeat the interrogation with "DI" = 7 and verify the same results.

g. Interrogate the transponder to extract Register **$40_{16}$** with an interrogation having **"UF" = 4**, "PC" = 0, "RR" =20 (14 Hex), "DI" = 0, "IIS" = 0, **Bit 28 = 1 (e.g., "OVC" = 1)**, and All remaining "SD" bits equal to Zero.

1. Verify that the transponder replies with a **"DF" = 20** reply having **"DP" = D6 C2 8E Hex**.
2. Repeat the interrogation with "DI" = 3 and verify the same results
3. Repeat the interrogation with "DI" = 7 and verify the same results

h. Interrogate the transponder to extract Register **$40_{16}$** with an interrogation having **"UF" = 5**, "PC" = 0, "RR" =20 (14 Hex), "DI" = 0, "IIS" = 0, **Bit 28 = 1 (e.g., "OVC" = 1)**, and All remaining "SD" bits equal to Zero.

1. Verify that the transponder replies with a **"DF" = 21** reply having **"DP" = 15 55 55 Hex**.
2. Repeat the interrogation with "DI" = 3 and verify the same results.
3. Repeat the interrogation with "DI" = 7 and verify the same results.

i. Interrogate the transponder to extract Register **$5F_{16}$** with an interrogation having **"UF" = 4**, "PC" = 0, "RR" =21 (15 Hex), "DI" = 0, "IIS" = 0, "RRS" = F Hex, Bit 25 = 0, "LOS" = 0, Bit 27 = 0, **Bit 28 = 1 (e.g., "OVC" = 1)**, and All remaining "SD" bits set to 0.

1. Verify that the transponder replies with a **"DF" = 20** reply having **"DP" = C9 C2 8E Hex**.
2. Repeat the interrogation with "DI" = 3 and verify the same results.
3. Repeat the interrogation with "DI" = 7 and verify the same results.

j. Interrogate the transponder to extract Register **$5F_{16}$** with an interrogation having **"UF" = 5**, "PC" = 0, "RR" =21 (15 Hex), "DI" = 0, "IIS" = 0, "RRS" = F Hex,

Bit 25 = 0, "LOS" = 0, Bit 27 = 0, **Bit 28 = 1 (e.g., "OVC" = 1)**, and All remaining "SD" bits set to 0.

1. Verify that the transponder replies with a **"DF" = 21** reply having **"DP" = 0A 55 55 Hex**.
2. Repeat the interrogation with "DI" = 3 and verify the same results.
3. Repeat the interrogation with "DI" = 7 and verify the same results.

**END OF TEST PROCEDURE:**

## Part B: Proposed Changes to EUROCAE ED-73C/E:

~~**1. In section 1.4.2.2, insert an entry for the Overlay Command (OVC) as an optional feature after the entry for "SI" and insert a new entry into the table that follows:**~~

~~**Overlay Command Capability (OCC)** – transponders with the ability to overlay Register information over the parity in the reply when commanded by the interrogator, also have the capabilities of §3.30.~~

~~These additional features and corresponding identification codes are summarized in the following table:~~

| ~~Additional Features~~ | ~~ID Code~~ |
|---|---|
| ~~ACAS Compatibility~~ | ~~a~~ |
| ~~Antenna Diversity~~ | ~~d~~ |
| ~~Extended Squitter~~ | ~~e~~ |
| ~~Dataflash~~ | ~~f~~ |
| ~~Hijack Mode Capability~~ | ~~h~~ |
| ~~Elementary Surveillance (only)~~ | ~~l~~ |
| ~~Enhanced Surveillance (including Elementary Surveillance)~~ | ~~n~~ |
| ~~Overlay Command Capability~~ | ~~o~~ |
| ~~Surveillance Identifier Code (SI)~~ | ~~s~~ |

**2. In Figure 3-5, modify Table provided in Figure 3-5 by adding:**

a. the **"DP"** (Data Parity) subfield as shown in the following table.

b. the **"OVC"** (Overlay Command) subfield to the "SD" field as shown in the following table.

| | | BITS | | FORMATS | | REFERENCE PARAGRAPH (S) | |
|---|---|---|---|---|---|---|---|
| **FIELD** | **SUB FIELD** | **NO.** | **POSITION** | **UP** | **DOWN** | **CONTENT** | **PROTOCOL** |
| **DP** | | 24 | 89-112 | | X | 3.18.4.10 | 3.23.1.12.a |
| MB | | | | | | | |
| | **OCC** | 1 | 47 | | X | 3.23.1.12.e | 3.23.1.12.e |
| SD | | 16 | 17-32 | X | | 3.18.4.33 | 3.23.1.12.a, 3.23.2 |
| | MES | 3 | 23-25 (DI=1) | X | | 3.23.2.1 | 3.24.2.a, 3.25.2.a |
| | **OVC** | 1 | 28 (DI=0, 3, or 7) | X | | 3.23.2.1.a.(8) | 3.23.1.12.a |
| | RCS | 3 | 24-26 (DI=2) | X | | | |

## 3. Change Section 3.18.4.9 to read as follows:

### 3.18.4.9 Designator Identification DI

This three-bit (14 – 16) uplink field identifies the coding contained in the SD field in formats UF=4, 5, 20 and 21. The codes are:

| | | |
|---|---|---|
| 0 | = | SD contains IIS (paragraph 3.23.2.1.a), bits **21-27** and **29-32** are not assigned, and bit **28** contains the "OVC" (Overlay Control) (paragraph 3.23.2.1.a.(8)). |
| 1 | = | SD contains multisite II lockout and multisite data link protocol information (paragraph 3.23.2.1.a) |
| 2 | = | SD contains Extended Squitter control information (paragraph 3.23.2.1.a) |
| 3 | = | SD contains SI multisite lockout, broadcast and GICB control information (paragraph 3.23.2.1.a), and bit **28** contains the "OVC" (Overlay Control) (paragraph 3.23.2.1.a.(8)). |
| 4 - 6 | = | Signifies SD Not assigned |
| 7 | = | SD contains extended data readout request, multisite and communications control information (paragraphs 3.23.2.1.a and 3.23.1.12.a), and bit **28** contains the "OVC" (Overlay Control) (paragraph 3.23.2.1.a.(8)). |

## 4. Add new section 3.18.4.10 as follows to define the Data Parity downlink field.

### 3.18.4.10 DP Data Parity

This 24 bit (bits 89 – 112) downlink field contains the parity overlaid on a "Modified AA" field established by performing a modulo-2 summation (e.g., Exclusive-Or function) of the discrete address most significant 8 bits and BDS1, BDS2 where BDS1 and BDS2 are provided by the "RR" and "RRS" as specified in paragraph 3.23.1.12.a.

Example:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Discrete Address | = | AA AA AA Hex | = | 1010 | 1010 | 1010 | 1010 | 1010 | 1010 |
| BDS1, BDS2 | = | 5F 00 00 Hex | = | 0101 | 1111 | 0000 | 0000 | 0000 | 0000 |
| Discrete Address | ⊕ | BDS1, BDS2 Hex | = | 1111 | 0101 | 1010 | 1010 | 1010 | 1010 |
| "Modified AA" | = | F5 AA AA Hex | = | 1111 | 0101 | 1010 | 1010 | 1010 | 1010 |

where "⊕" prescribes modulo-2 addition

The resulting "Modified AA" field then represents the 24 bit sequence (a1,a2…a24) that **shall** be used to generate the DP field in accordance with 3.22.2.1.c.

***Note 1:*** *Effectively, the most significant 8 bits of the discrete Address (e.g., "AA" field) are first modulo-2 summed with the Register number of the register being provided in the reply. The result of that process is then used to generate the DP field.*

***Note 2:*** *When the interrogator receives the reply, the parity decoder will decode the received "DP" into an equivalent modified "AA". The interrogator can then modulo-2 sum the most significant 8 bits of this modified "AA" with the intended register BDS1, BDS2 with the result being the original "AA" used in the interrogation that requested the reply.*

## 5. In Figure 3-14, make the following changes:

**UPLINK FORMATS**

| Format # | UF | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 0000 | - 3 - | RL: 1 | - 4 - | AQ: 1 | DS: 8 | - 10 - | AP: 24 | . . . Short Special Surveillance |
| 4 | 0 0100 | PC: 3 | RR: 5 | | DI: 3 | SD: 16 | | AP: 24 | . . . Surveillance. Altitude Request |
| 5 | 0 0101 | PC: 3 | RR: 5 | | DI: 3 | SD: 16 | | AP: 24 | . . . Surveillance, Identity Request |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 11 | 0 1011 | PR: 4 | IC: 4 | CL: 3 | - 16 - | AP: 24 | . . . Mode S-Only All-Call | |
| 16 | 1 0000 | - 3 - | RL: 1 | - 4 - | AQ: 1 | - 18 - | MU: 56 | AP: 24 | . . . Long Special Surveillance |
| 20 | 1 0100 | PC: 3 | RR: 5 | DI: 3 | SD: 16 | MA: 56 | AP: 24 | . . . Comm-A, Altitude Request | |
| 21 | 1 0101 | PC: 3 | RR: 5 | DI: 3 | SD: 16 | MA: 56 | AP: 24 | . . . Comm-A, Identity Request | |

**DOWNLINK FORMATS**

| Format # | DF | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 0000 | VS: 1 | CC: 1 | - 1- | SL: 3 | - 2- | RI: 4 | - 2- | AC: 13 | AP: 24 | . . . Short Special Surveillance |
| 4 | 0 0100 | FS: 3 | DR: 5 | UM: 6 | AC: 13 | AP: 24 | . . . Surveillance. Altitude | | | |
| 5 | 0 0101 | FS: 3 | DR: 5 | UM: 6 | ID: 13 | AP: 24 | . . . Surveillance, Identity | | | |
| 11 | 0 1011 | CA: 3 | AA: 24 | PI: 24 | . . . All-Call Reply | | | | | |
| 16 | 1 0000 | VS: 1 | -2- | SL: 3 | - 2- | RI: 4 | -2- | AC: 13 | MV: 56 | AP: 24 | . . . Long Special Surveillance |
| 17 | 1 0001 | CA: 3 | AA: 24 | ME: 56 | PI: 24 | . . . Extended Squitter | | | | | |
| 20 | 1 0100 | FS: 3 | DR: 5 | UM: 6 | AC: 13 | MB: 56 | AP: 24<br>DP:24 | . . . Comm-B, Altitude<br>(see Note 4) | | | |
| 21 | 1 0101 | FS: 3 | DR: 5 | UM: 6 | ID: 13 | MB: 56 | AP: 24<br>DP:24 | . . . Comm-B, Identity<br>(see Note 4) | | | |

**FIGURE 3-14: SURVEILLANCE AND DATA LINKFORMATS SUPPORTED BY ALL TRANSPONDERS**

***NOTE 1:*** *Uplink and downlink formats 16 are used in ACAS applications and are optional.*

***NOTE 2:*** *The PC, RR, DI and SD fields do not apply to a Comm-A Broadcast Interrogation.*

***NOTE 3:*** *Downlink format 17 is only used for extended squitter and is optional.*

***NOTE 4:*** *The Data Parity (DP) (paragraph 3.18.4.10) is used if it has been commanded by the OVC (paragraph 3.23.2.1.a.(8)) in accordance with paragraph 3.23.1.12.a.*

## 6.a. In Figure 3-18:

**Make the same changes that were made to DO-181D/E Figure 2-20 in Paragraph 6.a in the DO-181D/E section of this document.**

## 6.b. In Figure 3-18A:

**Make the same changes that were made to DO-181D/E Figure 2-25 in Paragraph 6.b in the DO-181D/E section of this document.**

## 7. Change section 3.23.1.12.a to read as follows:

**3.23.1.12 Comm-B Protocol (Figure 3-18)**

Comm-B is the transmission of information from the aircraft to the ground and follows the general protocol as outlined in paragraph 3.2.g. Figure 3-18 is a flow chart containing the ground-initiated Comm-B readout, the procedures for air-initiated Comm-B transactions and the multisite procedures.

a. Comm-B data selector, BDS

The 8-bit BDS code shall determine the register whose contents shall be transferred in the MB field of the Comm-B reply. It shall be expressed in two groups of 4 bits each, BDS1 (most significant 4 bits) and BDS2 (least significant 4 bits).

(1) BDS1 Code

The BDS1 Code shall be as defined in the RR field of a surveillance or Comm-A interrogation.

(2) BDS2 Code

The BDS2 code shall be as defined in the RRS subfield of the SD field when DI=3 or 7. If no BDS2 code is specified (i.e., DI is not equal to 3 nor 7) it shall signify that BDS2 = 0.

If the "DI" code of the Comm-B requesting interrogation is 0, 3, or 7, the "SD" contains the "OVC" in accordance with paragraph 3.23.2.1.a.(8). If the "OVC" is equal to "1", then the reply to the interrogation **shall** contain the "DP" (Data Parity) field in accordance with paragraph 3.18.4.10. If the "OVC" is equal to "0", then the reply to the interrogation **shall** contain the "AP" (paragraph 3.18.4.3).

b. Ground-Initiated Comm-B

## 8. Change section 3.23.1.12.e.(1) to read as follows:

(1) Subfields in MB for data link capability report.

The subfields within the MB field of all data link capability reports shall be:

| | |
|---|---|
| BDS1 | A value of 1 shall be inserted in this 4-bit subfield (1-4 of the MB field) as a first part of Comm-B data selector (BDS) code. |
| BDS2 | A value of 0 shall be inserted in this 4-bit subfield (5-8 of the MB field) as a second part of Comm-B data selector (BDS) code. |
| SCS | This 1-bit (34 of the MB field) squitter capability subfield shall report the capability of the transponder to transmit extended squitter position reports. It shall be set to 1 if GICB registers 05 and 06 {HEX} have been updated within the last ten plus or minus one seconds. Otherwise, it shall be set to 0 |
| SIC | Surveillance Identifier (SI) code capability report. Transponders which process the SI codes (paragraph 3.18.4.34) shall report this capability by setting bit 35 of the MB field to 1 in the datalink capability report. Otherwise it shall be set to zero. |
| OCC | This one bit (bit 47) Overlay Command Capability subfield shall report the capability of the transponder to include the Data Parity (paragraph 3.18.4.10) downlink field when commanded by the interrogator. It **shall** be set to ONE for transponders with Data Parity capability. Otherwise, it **shall** be set to ZERO. |

**9. In section 3.23.2.1:**

a. Add subparagraph 3.23.2.1.a.(8) directly after the Note 1 currently provided after subparagraph 3.23.2.1.a.(7).

(8). If the "DI" = 0, 3, or 7:

In addition to the requirements provided above, the "SD" shall contain the following:

"OVC": The 1-bit (bit 28) "Overlay Command" subfield in "SD" is used by the interrogator to command that the Data Parity ("DP") (paragraph 3.18.4.10) be used in the resulting reply to the interrogation in accordance with paragraph 3.23.1.12.a.

b. Change the Note Header for ***Note 1*** directly after subparagraph 3.23.2.1.a.(7) to ***Note.***

The note is now a single note between subparagraphs 3.23.2.1.a.(7) and 3.23.2.1.a.(8).

c. Change ***Note 2*** which now follows 3.23.2.1.a.(8) to read as follows:

***NOTE:*** *Structure of SD if DI=0*

| Position | Number of bits | Subfield |
|---|---|---|
| 17-20 | 4 | IIS |
| 21-27 | 7 | Not Assigned |
| 28 | 1 | OVC |
| 29-32 | 4 | Not Assigned |

*Structure of SD if DI=1*

| Position | Number of bits | Subfield |
|---|---|---|
| 17-20 | 4 | IIS |
| 21-22 | 2 | MBS |
| 23-25 | 3 | MES |
| 26 | 1 | LOS |
| 27-28 | 2 | RSS |
| 29-32 | 4 | TMS |

*Structure of SD if DI=2*

| Position | Number of bits | Subfield |
|---|---|---|
| 17-20 | 4 | Not assigned |
| 21-23 | 3 | TCS |
| 24-26 | 3 | RCS |
| 27-28 | 2 | SAS |
| 29-32 | 4 | Not Assigned |

*Structure of SD if DI=3*

| Position | Number of bits | Subfield |
|---|---|---|
| 17-22 | 6 | SIS |
| 23 | 1 | LSS |
| 24-27 | 4 | RRS |
| 28 | 1 | OVC |
| 29-32 | 4 | Not Assigned |

*Structure of SD if DI=7*

| Position | Number of bits | Subfield |
|---|---|---|
| 17-20 | 4 | IIS |
| 21-24 | 4 | RRS |
| 25 | 1 | Not Assigned |
| 26 | 1 | LOS |
| 27 | 1 | Not Assigned |
| 28 | 1 | OVC |
| 29-32 | 4 | TMS |

**10. In 5.5.7.a just after the table, revise the last sentence in the paragraph to require testing of AP and PI:**

The Error Protection Test (Procedure #1) is used to verify the correct operation of the error protection circuitry of the test equipment and the transponder. Its initial application is ~~recommended~~ required for AP and PI.

**11. In Appendix B, Table B-3-16, BDS 1,0 Data Link Capability Report**

**Assign Bit 15 as follows:**

15 Overlay Command Capability (OCC) (see 19)

**Then add new note 19 as follows:**

19) The Overlay Command Capability (OCC) shall be interpreted as follows:

0 = no Overlay Command Capability

1 = Overlay Command Capability

***Note:*** ***Equivalent changes will need to be made to the Data Link Capability Report definition in ICAO Doc. 9871.***

**END OF REQUIREMENTS CHANGES_Start of Test Procedure Changes:**

**11. Make the following changes (shown in red font and yellow highlight) to section 5.5.8.1.**

**5.5.8.1 Procedure #1 - Error Protection (Paragraph 3.22.2.1)**

**5.5.8.1.1 Procedure #1: Error Protection, AP and PI Fields (Paragraph 3.22.2.1.c)**

The correct function of the two coding-parity processes in the transponder can be automatically verified by a hardware circuit in the test generator, designed according to Figure 3-9. The test set (signal generator/analyzer) carries out the correct encoding process. A transponder will recognize the correct address and will in turn correctly generate the AP and PI fields.

It is also possible to observe the function of the transponder's and test set's error protection circuits if the AP pattern resulting from known text and address is known. However, since the correct values of 24 bits must be verified from an oscilloscope presentation, the deciphering of the phase reversals in the uplink P6 or the relative pulse positions in the downlink becomes laborious.

Patterns for the AP field exist that are easily distinguished in an oscilloscope presentation. Combinations of text (the bit stream before the AP or PI fields) and address exist for which AP and PI consist of all ZEROs or of another easily recognizable and verifiable pattern. They are presented here.

### 5.5.8.1.1.1 Test Equipment

a. Test set capable of generating Mode S interrogations at a 0 dBm power level.

b. DPSK modulation detector. Use a simple diode detector for manual determination of the location of phase reversals when the Mode S signal test generator is using hard keying with amplitude drop.

***NOTE:*** *Such a method is only possible for test purposes as some transmitters can generate the phase reversal using IQ modulator with little or no amplitude drop.*

c. Wide-band oscilloscope (HP1710B, or equivalent).

### 5.5.8.1.1.2 Test Procedure

a. Verification of Transponder's Downlink Encoding Circuit for PI

At the transponder's address setting interface, set addresses shown in the following list, depending on the internal CA report:

(1) If CA=0, set AA to 03 13 D4 {HEX}.

(2) If CA=4, set AA to 03 2B E2 {HEX}.

(3) If CA=5, set AA to FC DF EB {HEX}.

(4) If CA=6, set AA to 03 37 F9 {HEX}.

(5) If CA=7, set AA to FC C3 F0 {HEX}.

Interrogate with the Mode A/C/S All-Call and verify that in the reply PI is all ZEROs by monitoring the detected transponder reply video on the oscilloscope.

***NOTE:*** *This test verifies the transponder's downlink encoder without relying on the correct operation of the Mode S test set.*

b. Verification of Test Set Error Protection Circuits

When the Mode S signal generator uses a hard keying method to generate phase reversal resulting in amplitude drop, the following method can be used to verify the Test Set Error Protection circuit.

Connect the diode detector and oscilloscope to the RF output of the test set and generate a signal strong enough to register on the oscilloscope. Synchronize with the test set interrogation rate and observe the shape of the resulting P6 pulse. The phase transitions within P6 will cause amplitude modulation that can be easily observed. The following combinations of texts and interrogation addresses AA will result in AP as shown:

UF=4, all fields = 0, AA = CO 51 F6 {HEX} : AP = all ZEROs.

UF=4, all fields = 0, AA = 3F AB F2 {HEX} : AP = AA AA AA {HEX}.

UF=20, all fields = 0, AA = AC C5 55 {HEX} : AP = all ZEROs.

UF=20, all fields = 0, AA = 53 3F 51 {HEX} : AP = AA AA AA {HEX}.

c. Verification of Transponder's Downlink Encoding Circuits for AP

Couple the modulation detector into the RF connection between the test set and transponder so that the transponder's reply waveform can be observed. Interrogate the transponder so that the following reply formats are generated and observe the reply pulses on the oscilloscope:

DF=5, all fields = 0, AA = 20 78 CE {HEX} : AP = all ZEROs.

DF=5, all fields = 0, AA = 75 2D 9B {HEX} : AP = 55 55 55 {HEX}.

DF=21, all fields = 0, AA = 0B 15 4F {HEX} : AP = all ZEROs.

DF=2l, all fields = 0, AA = 5E 40 1A {HEX} : AP = 55 55 55 {HEX}.

**5.5.8.1.2 Procedure #1: Error Protection, DP Field (Paragraph 3.18.4.10, 3.22.2.1.c, and 3.23.1.12.a)**

**5.5.8.1.2.1 Test Procedure**

**Verification of Transponder's Downlink Encoding Circuits for DP**

Interrogate the transponder to extract Register **$10_{16}$** with an interrogation having **"UF" = 4**, "PC" = 0, "RR" =20 (14 Hex), "DI" = 0, "IIS" = 0, and All remaining "SD" bits set to Zero.

Check the state of bit 47 ("MB" bit 15). If bit 47 is ZERO, then the transponder does not support the Data Parity (DP) field and the following steps "a" –through- "j" of this procedure do not need to be performed. If bit 47 is ONE, then perform the following steps "a" –through- "j".

**a. Retain the test configuration used to perform Verification of the Transponder's Downlink Encoding Circuits for AP in paragraph 5.5.8.1.1.**

b. Establish the conditions such that the following fields in "DF"=20 and "DF"=21 replies will be set to ALL ZERO:

"FS", "DR", "UM", "AC" in "DF"=20, and "ID" in "DF"=21

c. Establish the Discrete Address of the transponder as **5E 40 1A** Hex (e,g., set "AA" = **5E 40 1A** Hex).

d. Establish the conditions where the contents of Register $40_{16}$ and $5F_{16}$ are set to ALL ZERO.

e. Interrogate the transponder to extract Register **$40_{16}$** with an interrogation having **"UF" = 4**, "PC" = 0, "RR" =20 (14 Hex), "DI" = 0, "IIS" = 0, and All remaining "SD" bits set to Zero.

1. Verify that the transponder replies with a **"DF" = 20** reply **having "AP" = 96 C2 8E Hex**.
2. Repeat the interrogation with "DI" = 3 and verify the same results.
3. Repeat the interrogation with "DI" = 7 and verify the same results.

f. Interrogate the transponder to extract Register **$40_{16}$** with an interrogation having **"UF" = 5**, "PC" = 0, "RR" =20 (14 Hex), "DI" = 0, "IIS" = 0, and All remaining "SD" bits set to Zero.

1. Verify that the transponder replies with a **"DF" = 21** reply having **"AP" = 55 55 55 Hex**.
2. Repeat the interrogation with "DI" = 3 and verify the same results.
3. Repeat the interrogation with "DI" = 7 and verify the same results.

g. Interrogate the transponder to extract Register **$40_{16}$** with an interrogation having **"UF" = 4**, "PC" = 0, "RR" =20 (14 Hex), "DI" = 0, "IIS" = 0, **Bit 28 = 1 (e.g., "OVC" = 1)**, and All remaining "SD" bits equal to Zero.

1. Verify that the transponder replies with a **"DF" = 20** reply having **"DP" = D6 C2 8E Hex**.
2. Repeat the interrogation with "DI" = 3 and verify the same results.
3. Repeat the interrogation with "DI" = 7 and verify the same results.

h. Interrogate the transponder to extract Register **$40_{16}$** with an interrogation having **"UF" = 5**, "PC" = 0, "RR" =20 (14 Hex), "DI" = 0, "IIS" = 0, **Bit 28 = 1 (e.g., "OVC" = 1)**, and All remaining "SD" bits equal to Zero.

1. Verify that the transponder replies with a **"DF" = 21** reply having **"DP" = 15 55 55 Hex**.
2. Repeat the interrogation with "DI" = 3 and verify the same results.

3. Repeat the interrogation with “DI” = 7 and verify the same results.

i. Interrogate the transponder to extract Register **$5F_{16}$** with an interrogation having **“UF” = 4**, “PC” = 0, “RR” =21 (15 Hex), “DI” = 0, “IIS” = 0, “RRS” = F Hex, Bit 25 = 0, “LOS” = 0, Bit 27 = 0, **Bit 28 = 1 (e.g., “OVC” = 1)**, and All remaining “SD” bits set to 0.

1. Verify that the transponder replies with a **“DF” = 20** reply having **“DP” = C9 C2 8E Hex**.

2. Repeat the interrogation with “DI” = 3 and verify the same results.

3. Repeat the interrogation with “DI” = 7 and verify the same results.

j. Interrogate the transponder to extract Register **$5F_{16}$** with an interrogation having **“UF” = 5**, “PC” = 0, “RR” =21 (15 Hex), “DI” = 0, “IIS” = 0, “RRS” = F Hex, Bit 25 = 0, “LOS” = 0, Bit 27 = 0, **Bit 28 = 1 (e.g., “OVC” = 1)**, and All remaining “SD” bits set to 0.

1. Verify that the transponder replies with a **“DF” = 21** reply having **“DP” = 0A 55 55 Hex**.

2. Repeat the interrogation with “DI” = 3 and verify the same results.

3. Repeat the interrogation with “DI” = 7 and verify the same results.

**END OF TEST PROCEDURE:**