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**RTCA Special Committee SC-209**  
**Transponder MOPS**  
**Meeting #6**

**DO-181D Section 1.4.3.6**  
**Proposed Breakdown of Level 2 transponders into Subclasses**

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**SUMMARY:**

This working paper presents a proposed breakdown of Level 2 Transponders into subclasses to meet today’s airspace requirements; and to add the SI Capability

## **INTRODUCTION:**

When the original Mode S transponder requirements were established, many various uplink and downlink services were envisioned which drove the requirements for data link transponders providing uplink Comm.-A and downlink Comm.-B services. But as today's airspace Mode S requirements have matured, the uses of the Mode-S Surveillance Services have evolved primarily into downlink transmission of aircraft parameters with virtually no use of the Mode-S Comm.-A/B uplink/downlink.

ICAO SARPS for global flight operations, the European Mode S mandate and the impending ADS-B equipage require the use of a Level 2 transponder operation. Obtaining the TSO/ETSO certification for Level 2 transponders requires full compliance to RTCA/DO-181C or Eurocae ED-73B MOPS including all Comm.-A and Comm.-B protocols. An Air Data Link Processor (ADLP) is needed to support Comm.-A and Comm.-B data link communications; yet, most of those services are without a defined application use, creating cost and effort to produce and certify these transponders, as well as the costs to certify the installation on the aircraft. Likewise, there are limited to no ADLP installations in the normal operation air space.

To provide today's services, Elementary Surveillance (ELS) and Enhanced Surveillance (EHS) require the use of Ground Initiated Comm.-B (GICB) protocols and Comm.-B Broadcast without the use of Directed Comm.-B and Air-Initiated Comm.-B (AICB) protocols or the use of any uplink protocols. Automatic Dependent Surveillance –Broadcast (ADS-B) Out transponder registers are loaded using GICB protocols; the addition of ADS-B protocol provides that service. For today's airspace requirements and for next 15 years, a Mode-S transponder essentially need only support the GICB protocols and ADS-B protocols, if desired. As such, there is no need for an ADLP function or Comm.-A/B capability.

## **PROPOSAL DISCUSSION:**

This paper proposes to break-down Level 2 transponders into sub-classes thus providing ability for transponder manufacturers and airlines to specify Level 2 transponders capabilities that are more in line with today's requirements without the burden of supporting protocols that are not in use today. This division of Level 2 into subclasses will yield benefits by reducing equipment design, testing and manufacturing costs; aircraft installations efforts; and certification costs to demonstrate compliance with requirements that are not relevant for specific applications.

This paper proposes the following additional Level designations:

- **Level 2A:**

To signify a full data link capable transponder, meeting all requirements of Section 2.2.19 of RTCA/DO-181. The Level 2A data link transponder requirements will cover legacy Level 2 transponders as well as any new data link transponder designs.

- **Level 2B:**

To signify a Level 2 transponder that supports GICB and Comm.-B Broadcast protocols only. Applications include ELS and EHS services and ADS-B Out.

A compliance matrix for each Level 2 sub-class shall detail the minimum requirements for each Level to aid the manufacturer in requirements definition, and meeting test and certification requirements. A draft of the Level 2 Compliance Matrix is provided at the end of the paper which will be ultimately placed in section 2.2. of the MOPs, e.g., RTCA Document No. DO-181D.

**Additions to MOPs Section 1.4:**

The following shall be added to section 1.4 (Mode S Transponder) of DO-181D as follows:

All Level 1, 2A and 2B transponders will have the same Common Package requirements containing:

- Error Protection
- Lockout /Multisite Lockout Protocols
- Acquisition squitter
- Flight Status and Vertical Status Protocols
- All-Call Reply Protocols
- Capability Reporting
- Interrogation Acceptance and Reply Coordination
- Data Handling and Interfaces

The transponder levels and capabilities can then be broken down in the following table:

Mode-S Transponder Level 2-A/B Requirements							
Functional Requirements	Transponder Levels <sup>1</sup>		Additional Capabilities <sup>3</sup>				
	2A	2B	CLINK	ELS	EHS	TCAS	ADS-B
Common Package	X	X					
GICB	X	X					
Comm.-B Broadcast	X	X					
Data Link Capability Report	X	X					
Flight ID	X	X					
Comm.-A	X						
Air-Initiated Comm.-B	X						
Multisite Message Protocols	X						
“SI” Codes <sup>2</sup>	X	X					
Crosslink (CLINK) (See RTCA DO-181D §2.2.19.1.17)			X				
Elementary Surveillance (ELS) (See RTCA DO-181D §2.2.24)				X			
Enhanced Surveillance (EHS) (See RTCA DO-181D §2.2.25)					X		
Comm.-U/V						X	
TCAS (See RTCA DO-181D §2.2.22)							
ADS-B Protocols (See RTCA DO-181D §2.2.23)							X
<b><u>Notes:</u></b>							
1. The shaded area represents the basic capabilities of Level 2A and 2B Transponders.							
2. Surveillance Identifier (“SI”) Codes are required by ICAO Annex 10, Volume IV, §2.1.5.1.7.1.							
3. Air Space managers may require these additional capabilities, depending on airspace requirements.							

The proposed changes to Section 1.4.3.2 of Do-181D, V0.5 are as follows:

### **1.4.3.2 Level 2 Transponders:**

The Level 2 Transponder supports all of the surveillance functions. It can also support:

- a. Bidirectional Air-to-Air information exchange
- b. Ground-to-Air data uplink, Comm.-A
- c. Air-to-Ground data downlink, Comm.-B
- d. Multisite message protocol
- e. Data Link capability reporting
- f. Aircraft Identification reporting
- g. ACAS Crosslink capability

**Level 2** Transponders support receipt and processing of long interrogations and the generation of long replies. The ground-air-ground data link capability comprises a multitude of services and can be implemented according to the number and kind of services available, depending on the mission requirements of the aircraft. Protocols provide a means of reporting to the ground the specifics of each individual installation.

#### **1.4.3.2.1:**

**Level 2** transponders will have the following additional capabilities as defined by their subclass designation. The subclasses will provide the following transponder capabilities:

- a. Ground-Initiated Comm-B (GICB) transponders will have the capabilities of §1.4.3.1 and those identified for **Level 2B**.
- b. **Level 2A** Data Link transponders will have the capabilities of §1.4.3.1 and §2.2.19.

Paragraph 1.4.3.6 of RTCA DO-181D, V0.5: Additional Features did not include references to the “SI” Capable transponder. This paper also proposes to add a subclass designation for a TCAS compatible transponder. The following additions to paragraph 1.4.3.6 are as follows:

#### **1.4.3.6 Additional Features:**

Some transponder installations will require additional features:

- Installations in large aircraft or co-installation with airborne collision avoidance systems may require the transponder to operate in the diversity mode, i.e., the use of two antennas, receivers and transmitting channels.
- Co-installation with TCAS II systems requires capability for long air-to-air formats.
- Co-installation with other L-band equipment may require an on-board mutual suppression system.
- Extended Squitter (ES) transponders will have the capabilities of §1.4.3.2, §1.4.3.3, §1.4.3.4 or §1.4.3.5 as well as those prescribed for extended squitter operation (See §2.2.23).
- Transponders with the ability to process “SI” codes will have the capabilities of §1.4.3.2 and also those prescribed for “SI” code operation
- TCAS Compatible transponders will have the capabilities of §1.4.3.2, §1.4.3.3, §1.4.3.4 or §1.4.3.5, and §2.2.22.

**Level 2 Subclass Compliance Matrix:**

<b>Mode-S Transponder Level 2 Subclass Compliance Matrix</b>			
<b>DO-181D Paragraph</b>	<b>DO-181D Requirement</b>	<b>Level 2B GICB Protocols ONLY</b>	<b>Level 2A Full Data Link</b>
2.2.19	Minimum Level 2 Transponder Description	X	X
2.2.19.1	Minimum Level 2 Transponder Requirements	X	X
2.2.19.1.1	Interrogation Acceptance protocol	(c) only	X
2.2.19.1.2	Error Protection	X	X
2.2.19.1.3	Information transfer	X	X
2.2.19.1.4	Interrogation Reply Coordination	X	X
2.2.19.1.5	Lockout Protocols	X	X
2.2.19.1.6	Flight and Vertical Status Protocols	X	X
2.2.19.1.7	Capability Report	X	X
2.2.19.1.8	Reply Content	X	X
2.2.19.1.9	UM Protocol		X
2.2.19.1.10	Comm.-A Protocol		X
2.2.19.1.11	Broadcast protocol		X
2.2.19.1.12	Comm.-B Protocol	GICB Only	X
2.2.19.1.12.1	Data Source Designators	X	X
2.2.19.1.12.2	Extended Data Source Designators	X	X
2.2.19.1.12.3	Ground-Initiated Comm.-B	X	X
2.2.19.1.12.4	Air-Initiated Comm.-B		X
2.2.19.1.12.4.1	Comm.-B Broadcast	X	X
2.2.19.1.12.5	Data Link Capability Report (DLCR)	X	X
2.2.19.1.12.6	Subfields in MB For DLCR (See Note 1)	X	X
2.2.19.1.12.7	Coding of DLCR (See Note 1)	X	X
2.2.19.1.12.8	Updating of DLCR	X	X
2.2.19.1.13	Air Identification Reporting and AIS Aircraft ID Subfield in MB	X	X
2.2.19.1.14	Linked Comm.-A Coding		X
2.2.19.1.15	Multisite Message protocol		X
2.2.19.1.16	Comm.-U/V Protocol	X	X
2.2.19.1.17	Data Handling and Interfaces	GICB Only	X
2.2.19.1.18	TCAS Crosslink protocol	X	X
2.2.19.2	The Multisite Message protocol		X
2.2.19.2.1	Multisite Data Formats		X
2.2.19.2.1.1	Subfields in SD	§ (c) LOS; § (d) RRS; § (f) only	X
2.2.19.2.1.2	Subfields in UM for Multisite Protocols		X
2.2.19.2.2	Multisite Common Protocols		X
2.2.19.2.2.1	Multisite timers		X
2.2.19.2.2.2	Interrogator Identity report		X
2.2.19.2.3	Multisite Comm.-B Protocol		X
2.2.19.2.3.1	Multisite Comm.-B reservation		X
2.2.19.2.3.2	Multisite Directed Comm.-B Transmissions		X
2.2.19.2.3.3	Multisite Comm.-B Closeout		X
2.2.19.2.3.4	Automatic Comm.-B Closeout		X
2.2.19.2.3.5	Significance of PC Command		X
2.2.22	TCAS Compatible Transponder	As Required or Needed	

Mode-S Transponder Level 2 Subclass Compliance Matrix			
DO-181D Paragraph	DO-181D Requirement	Level 2B GICB Protocols ONLY	Level 2A Full Data Link
2.2.23	Extended Squitter (ES) (See Note 2)	As Required or Needed	
2.2.24	Elementary Surveillance (ELS)	As Required or Needed	
2.2.25	Enhanced Surveillance (EHS)	As Required or Needed	
<b>Notes:</b>			
1. Paragraph should be eliminated – details now in Appendix B			
2. Except 2.2.23.3, Extended Squitter/Non-Transponder Devices Except 2.2.23.4, Extended Squitter/ Military Application			

**Other Changes needed for Establishing Subclasses:**

RTCA DO-181D Section 2.2.14.4.6 currently provide the following definition for the “CA” field:

***“CA Transponder Capability***

This 3-bit (6-8) downlink field is used in DF=11, the All-Call reply and acquisition squitter, and in DF=17, the Extended Squitter. The codes are:

Code	Description
0	signifies no communications capability (surveillance only), no ability to set CA code 7, either on the ground or airborne
1	Not used
2	Not used
3	Not used
4	signifies at least Comm-A and Comm-B capability, ability to set CA code 7, on the ground
5	signifies at least Comm-A and Comm-B capability, ability to set CA code 7, airborne
6	signifies at least Comm-A and Comm-B capability, ability to set CA code 7, either on the ground or airborne
7	signifies DR is NOT equal to ZERO, or FS equals 2, 3, 4 or 5, either on the ground or airborne (see §2.2.14.4.8 and §2.2.14.4.9)

When the conditions for CA code 7 are not satisfied, installations that have communications capability but do not have automatic means to set on-the-ground conditions **shall** use CA code 6. Aircraft with automatic on-the-ground determination **shall** use CA codes 4 and 5. Data link capability reports (see §**Error! Reference source not found.**) **shall** be available for CA codes 4, 5, 6 and 7.

**Note:** CA codes 1 to 3 were used by earlier Mode S transponders that did not use CA code 7. Transponders with these codes provide a data link capability report (see §**Error! Reference source not found.**). No data link transactions other than GICB extraction including aircraft identity, TCAS RA extraction, and downlink broadcast extraction, should be attempted with these transponders.”

Reclassification of the level 2 transponders into level 2A and 2B as discussed previously in this document results in the removal of the requirement for all level 2 transponders to support Comm.-A/B. Therefore, the code definitions provided in the table above should be changed to read as follows:

<b>Code</b>	<b>Description</b>
0	signifies no communications capability (surveillance only), no ability to set CA code 7, either on the ground or airborne
1	Not used
2	Not used
3	Not used
4	indicates the ability to set CA code 7, on the ground
5	indicates the ability to set CA code 7, airborne
6	indicates the ability to set CA code 7, either on the ground or airborne
7	signifies DR is NOT equal to ZERO, or FS equals 2, 3, 4 or 5, either on the ground or airborne (see §2.2.14.4.8 and §2.2.14.4.9)

**SUMMARY:**

During most of the history of the Mode-S transponder, need for a full level 2 transponder has been driven by the expectation of implementation of the Aeronautical Telecom Network (ATN) using an ADLP on the airborne side and an Ground Data Link Processor (GDLP) on the ground side. This need for full level 2 has significantly increased the complexity and cost to design and implement the rigorous Comm.-A and Comm.-B protocols necessary to be compliant with full level 2.

In more recent years, airspace needs have indicated that the ADLP function will probably not be needed. Therefore, level 3, 4, 5 and particularly full level 2 transponders should not be needed for many years to come, if ever. Introduction of the level 2B transponder as presented in this paper provides all necessary capabilities foreseen for the future airspace while still retaining definition of a level 2A (full level 2) transponder should it ever be needed.

Restructuring of the MOPs to allow level 2A and 2B transponders allows for rather simple updates to RTCA DO-181D, Eurocae ED-73B/C, and ICAO Annex 10 Volume IV without requiring extensive reorganization of these documents and thereby complicate certification and compliance issues.

**End of Document:**