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4 – 6 December 2007

RTCA SC-209, Working Group #1, Meeting #4

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RTCA, Washington DC

Updated Elementary Surveillance, Enhanced Surveillance and Generic Requirements in RTCA DO-181D v1-1 section 2.2.24, 2.2.25, and 2.2.26

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SUMMARY

This Working Paper presents Updates to Elementary Surveillance, Enhanced Surveillance and Generic Requirements and is intended to align with WG49N13-XXRev_B, e.g.,

[(WG49N12-12) ELS and EHS in chapter 3 of ED73v10_rhs_x1B]

and

[RTCA DO-181D-v1-1_eric_rhs_x1B]

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MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR AIR TRAFFIC CONTROL RADAR BEACON SYSTEM/MODE SELECT (ATCRBS/MODE S) AIRBORNE EQUIPMENT

Draft
Version 1.1

RTCA/DO-181D
MM DD, YYYY
DO-181D supersedes DO-181C and all published changes thereto
Appendix B to DO-181D supercedes DO-218B

Prepared by SC-209

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FOREWORD

This document was prepared by RTCA Special Committee 209 (SC-209). It was approved by the RTCA Program Management Committee on MM DD, 2007, and supersedes RTCA/DO-181C, *Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/MODE S) Airborne Equipment*, issued June 12, 2001, and all published changes and errata. Appendix B of DO-181D supercedes RTCA/DO-218B.

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CHANGE HISTORY

Date / Version	Description
June 12, 2001/DO-181C	Document published as DO-181C, supplied by RTCA, without Change 1 and without Errata applied
Feb 14, 2006 / DO-181D v0.1	DO-181C with Errata applied presented during SC-209 Meeting #1 as WP01-05. Additional formatting in the process of being applied to bring the document into compliance with current RTCA standards.
May 2006, DO-181D v0.2	(1) Incorporation of changes to test procedures that were approved during Meeting #2 in WP02-05R1, where changes were highlighted in yellow. (2) All references to internal sections were hyperlinked to make future re-ordering of sections more automatic. (3) All Figures 2-4 through 2-32 were moved to the point of their first reference in the document (which actually caused the "List of Figures" to be in mixed ordering sequence). (4) Reduction in the entries in section §1.7 to just "Definitions of Key Acronyms and Terms," and creation of Appendix A for Acronymns and Definitions of Terms. (5) Re-ordering of entries in section §2.2.14.4 to be alphabetical, where moved section headings were highlighted in gray. (6) As directed by SC-209 during Meeting #2, implemented changes to test increments from 5 dB steps to one (1) dB steps. (7) Changed all occurrences of P1, P2, P3, P4, P5 and P6 to use subscripts to be consistent with the SARPs and DO-144A. (8) Re-oriented Table 2.2.16-1 90 degrees to be more readable.
June 2006, DO-181D-v0.3	(1). Implemented the suggested re-ordering of sections in §2.2 accomplished as per Working Paper WP02-06R1, where the sections that were moved have their section headings highlighted in gray.
July 2006, DO-181D-v0.4	(1) Began replacing all of the Figures with Visio produced figures. Some of the figures are actually produced using the MS-Word "Table" capability.
October 2006, DO-181D-v0.5	(1) The Minutes to Meeting #3 document several changes that were originally identified in WP02-05R1 that were modified during Meeting #3 and whose modifications were documented in the Minutes to Meeting #3 and in WP02-05R2. Those changes were implemented/reversed in this version. (2) Five Working Papers were presented during Meeting #4, including WP04-11, WP04-12R1, WP04-14R1, WP04-15R1 and WP04-16 in which changes were proposed and either agreed to be changed or agreed to leave as originally written. The changes which were agreed to be made in all five of these Working Papers were implemented into this version. (3) During Meeting #2 in Working Paper WP02-06R1 as part of the restructuring of section 2.2 in DO-181C, it was specified that §2.2.17.1.1 would be deleted. With further discussion in Meeting #4 on breaking down Level 2 transponders, it was agreed that this section should be restored into the draft MOPS document, which was accomplished in this version.
December 2006, DO-181D-v0.6	(1) Updated §2.2.13.3 with info on the MSP Channel header. (2) Added definition of MSP Channel Header into §2.2.14.4.24 and TMS field at §2.2.14.4.39. (3) SC-209 agreed upon changes associated with consolidated comments identified in WP05-05R1. (4) SC-209 agreed upon changes that are identified in WP05-12R1. (5) SC-209 agreed upon changes that are identified in WP05-07.
February 2007, DO-181D-v0.7	(1) As agreed to during the Joint Plenary Session with WG-49, updated §2.2.13.1.1 related to the handling of non-standard 24-bit addresses to match exactly that text in the available draft of ED-73C, §3.17.1. (2) Correction to Note #2 in Figure 2-19. (3) Addition of sections §1.8 and §1.9 to introduce Appendix B and C.
May 2007, DO-181D-v0.8	(1) Implement ModeS-WP01-08R1 to add to the Note under the RR Code table in §2.2.14.4.35. (2) Added requirements and test procedures for the CW Interference as specified in WP B5-10 according to Action Item 6-7.
July 2007 DO-181D-v0.9	(1) Integrated the ELS and EHS requirements and test procedures from ModeS-WP01-03R2 into the base document. (2) Correct numerous formatting issues throughout the document that resulted from integrating ELS/EHS.
August 2007 DO-181D-v1.0	(1) Standardize the use of Register XX_{16} instead of BDS Code X,X. (2) Designate section numbers for "Parts" of added ELS/EHS test procedures. (3) Redline changes from Tom Pagano with various introductory information.
Meeting #7, Aug 2007 DO-181D-v1.1	(1) Implement changes in WG49N11-05R1.

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2.2.24 Elementary Surveillance (ELS) Compliant Transponder

Elementary Surveillance has been defined as a functional capability necessary to support airspace operations in European airspace.

a. As a minimum, the transponder shall be a Level 2 transponder in accordance with §1.4.3.2 in order to support implementation of Elementary Surveillance functions.

b. The following subparagraphs summarize the functional aspects necessary to implement Elementary Surveillance.

Note: *The following subparagraphs do not declare actual requirements (e.g.* ***"shall"*** *statements). Such actual requirements are specified in subsequent subsections in order to establish traceability. The following subparagraphs are intended to introduce the Elementary Surveillance needs in order to improve understanding of the actual requirements provided in subsequent subsections.*

(1). Flight status reporting (FS) as described in §2.2.14.4.14. The Mode S transponder is capable of automatically acquiring the on-the-ground status as described in §2.2.18.2.7.

(2). Barometric pressure altitude reporting as described in §2.2.13.1.2.a.

(3). CA as specified in §2.2.14.4.6 and ??????? (ie. Greater than 3)

Commentary_RHS: **Could not find any reference regarding CA in section 3.23 other than in 3.23.1.7.; therefore, WG-49 need to verify if this is the correct intended reference and to provide cross reference to DO-181D if possible.**

(4). II and SI code as defined in section 3.21a and further details in §2.2.24.2.

Commentary_RHS: Section 3.21a??? makes no reference to II or SI. WG-49 needs to clarify reference. Section 2.2.24.2 is ok. Then update the above paragraph.

(5). Declaration of capability in register 10_{16} as described in §2.2.19.1.12.6.3 and further detailed in §2.2.24.3.

(6). Aircraft register 17_{16} as defined in §2.2.24.4.

(7). Aircraft registers 18_{16} {through $1C_{16}$} as defined in §2.2.24.5.

(8). Flight identification reporting in register 20_{16} as detailed in §2.2.19.1.13 and further detailed in. §2.2.24.6.

(9). As an option, Aircraft register 21_{16}.

c. In addition, the Mode S transponder must be capable of ACAS operation in accordance with all requirements defined in §2.2.22. In particular, the transponder reports ACAS capability and version in register 10_{16} as well as the RA Report in register 30_{16}.

Note: *For the remaining subsections of this section, servicing of a field or subfield in a register implies that valid data has been received at a sufficient rate to meet the update requirements specified for the given register in Appendix B.*

2.2.24.1 Ground Initiated Comm-B

Mode-S Transponders **shall** support extraction of Registers 10_{16}, 17_{16}, 18_{16} -through- $1C_{16}$, 20_{16} and 21_{16} **(Optional)** using the Ground Initiated Comm-B Protocols in accordance with §2.2.19.1.12.3.

Note: *In general, a level 2 ELS capable transponder replies to all GICB register extraction request (see §2.2.19.1.12.3). If the requested register is not serviced by the transponder, then the "MB" field of the transponder reply contains All ZERO's.*

2.2.24.2 Surveillance Identifier ("SI") Code Requirements

2.2.24.2.1 MOPS Requirements Relevant to "SI"

Mode-S Transponders support the requirements of the Surveillance Identifier ("SI") codes in accordance with the following sections of this document.

a. §2.2.14.4.11, "DI" Designator, Identification Field

b. §2.2.14.4.17, "II" Interrogator Identification Field

c. §2.2.14.4.30, "PI" Parity / Interrogator Identity

d. §2.2.14.4.36, "SD" Special Designator and "IIS", Subfield in "SD"

e. §2.2.14.4.9, "CL" Code Label

f. §2.2.14.4.15, "IC" Interrogator Code

g. §2.2.14.4.37, "SI" Surveillance Identifier

h. §2.2.18.2.1, Basic Mode-S Error Protection

i. §2.2.18.2.5, "Multisite Lockout Protocol"

j. §2.2.18.2.6, "Acquisition Squitter"

k. §2.2.23.1.1, "Extended Squitter Format (DF=17)"

l. §2.2.18.2.9, "All-Call Reply Protocol"

Note: *Item "k." in regards to Extended Squitter" is included herein since the "SI" field must be set to "0" in generating the "PI" field in accordance with §2.2.14.4.30. Therefore, if the transponder implements Extended Squitter, then subparagraph "k." applies.*

2.2.24.3 Declaration of Capability in Register 10_{16} – Data Link Capability Report

2.2.24.3.1 Purpose and Definition

Register 10_{16} **shall** be formatted as specified in Appendix B, Table B-3-16 and associated notes.

Note: *The following subsections detail the minimum requirements for servicing register 10_{16} in regards to Elementary Surveillance. Other fields in register 10_{16} that do not pertain to Elementary Surveillance need to be managed in accordance with the additional capabilities supported by the transponder.*

2.2.24.3.2 Data Requirements

2.2.24.3.2.1 Bit 1 –through- 8, BDS Code

Bits 1 –through- 8 of register 10_{16} **shall** be encoded with 10 HEX (0001 0000) (e.g., the BDS Register code).

Note: *The setting of the BDS code by the transponer ensures that a broadcast change of the capability report will contain the BDS code for all cases of data link failure (e.g., the loss of the transponder data link interface).*

2.2.24.3.2.2 Bit 17 –through- 23, Declaration of Mode-S Subnetwork Number

Bits 17 –through-- 23 of Register 10_{16} **shall** be encoded with the Mode-S Subnetwork Version Number in accordance with the following table:

Table 2.2.24.3.2.2: Mode S Subnetwork Version Number Encoding

Version Number	Year of ICAO Annex 10 Amendment	Edition of ICAO Doc. 9871	Comment
0	Mode S Subnetwork Not Available		
1	1996	-----	
2	1997	-----	
3	2002	-----	Annex 10, Amendment 77
4	2007	Edition 1	
5–127	Not Assigned		

To be consistent with Elementary and Enhance Surveillance requirements (e.g., this version of these MOPS), the Mode S Subnetwork Version Number **shall** be set to "3" or "higher".

2.2.24.3.2.3 Bit 25, Declaration of No Mode S Specific Services Capability

Bit 25 of Register 10_{16} **shall not** be set to "1" when reporting only Aircraft Identification in register 20_{16} when no other Mode S Specific Services are supported by the transponder.

Note: *When bit 25 is set to 1, it indicates that at least one Mode S specific service is supported other capability reports need to be checked in order to determine which registers are supported. Mode S Specific Service refers to the servicing of registers other than GICB services related to Registers 02_{16}, 03_{16}, 04_{16}, 10_{16}, 17_{16} -through- $1C_{16}$, 20_{16} and 30_{16}.*

2.2.24.3.2.4 Bit 23, Aircraft Identification Reporting Capability

Servicing of Register 20_{16} requires the updating of Register 10_{16} as follows:

a. Register 10_{16} (Data Link Capability Report) bit 33 **shall** be set to ONE (1) if the transponder is receiving any data from the Aircraft installation with which to service Register 20_{16} with Flight Identification or Aircraft Registration data as provided in the respective sections for each BDS register in the subsequent sections of this document.

   Note: *This requirement is not established by the transponder LRU own capability to service Register 20_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 20_{16}.*

a. Register 10_{16} (Data Link Capability Report) bit 33 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service Register 20_{16}.

Note: *When bit 33 of Register 10_{16} is changed, the change is broadcast as required in §2.2.19.12.3 and further defined in §2.24.4.*

2.2.24.3.2.5 Bit 35, Surveillance Identifier Code (SI)

Bit 35 of register 10_{16} shall be set to "1" to indicate that the transponder supports "SI" code capability.

Note: *"SI" code support is a mandatory requirement capability for all transponders.*

2.2.24.3.2.6 Bit 36, Common Usage GICB Capability Report

a. Register 10_{16} (Data Link Capability Report) bit 36 **shall** be toggled (i.e., changed from "0" to "1", or from "1" to "0") each time that the Common Usage GICB Capability Report (Register 17_{16}) is changed.

b. To avoid the generation of too many broadcast capability report changes, Register 17_{16} **shall** be sampled at approximately one minute intervals to check for changes that may require the toggling of bit 36 as discussed in subparagraph "a."

2.2.24.3.3 Minimum Update Interval

a. The minimum update interval at which Register 10_{16} **shall** be reloaded with valid data is ≤4.0 seconds.

Note: *Effectively, Register 10_{16} must be updated every 4.0 seconds or sooner.*

b. Register 10_{16} **shall** be updated within one second of the data changing and at least every four seconds thereafter.

c. If a particular data field in Register 10_{16} cannot be updated within 8.0 seconds (e.g., twice the specified minimum update interval of ≤4.0 seconds), then the data field **shall** be ZEROed.

2.2.24.3.4 Change Reporting

When register 10_{16} is changed, then the register **shall** be broadcast as described in §2.2.19.1.12.8.

2.2.24.4 Register 17_{16}, Common Usage GICB Capability Report

2.2.24.4.1 Purpose and Definition\

The format of register 17_{16} shall be formatted as specified in Appendix B table B-3-23 and associated notes.

Note: *The purpose of register 17_{16} is to indicate which registers are currently supported by the aircraft installation, i.e., currently contain data useable for operational use.*

Elementary Surveillance transponders manage the following bits of register 17_{16}:

a. Bit 7 to indicate servicing of Register 20_{16},

b. Bit 8 to indicate servicing of Optional Register 21_{16}.

2.2.24.4.2 Data Requirements

2.2.24.4.2.1 Required Servicing of Register 17_{16} Associated with Register 20_{16}

a. Register 17_{16} bit 7 **shall** be set to ONE (1) if the transponder is servicing either Aircraft Identification (also referred to as Flight Identification as specified in the Flight Plan) or Aircraft Registration data in the Aircraft installation.

Note: *This requirement is not established by the transponder LRU own capability to service Register 20_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 20_{16}.*

b. Register 17_{16} bit 7 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service Register 20_{16}.

2.2.24.4.2.2 Required Servicing of Register 17_{16} Associated with Optional Register 21_{16}

Note: *Elementary Surveillance does not require that Register 21_{16} be serviced. However, if Register 21_{16} is serviced, the following subparagraphs need to be complied with.*

a. Register 17_{16} bit 8 **shall** be set to ONE (1) if the transponder is receiving Aircraft Registration data in the Aircraft installation.

Note: *This requirement is not established by the transponder LRU own capability to service Register 21_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 21_{16}.*

b. Register 17_{16} bit 8 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service Register 21_{16}.

2.2.24.4.3 Register 17_{16} Change Reporting

Whenever the contents of Register 17_{16} change, bit 36 of Register 10_{16} shall be toggled as defined in §2.2.24.3.2.6.

2.2.24.5 Register 18_{16} –to- $1C_{16}$, Mode S Specific Services Capability Reports

2.2.24.5.1 Purpose and Definition

The Mode-S transponder **shall** format Register 18_{16} -through- $1C_{16}$ as defined in Appendix B, Table B-3-24 -through- Table B-3-28 and associated notes for Register 18_{16} -through- $1C_{16}$, respectively.

Note 1: *Registers 18_{16} to $1C_{16}$ are used to indicate the capability of the aircraft installation to provide data for each register i.e. the register or a part of the register is managed by the transponder and it is known that data can be received from the installation to fill this field.*

Note 2; *This is not established by the Transponder LRU own capability. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to service the corresponding register. Once this capability is established it remains set until powe- off of the transponder.*

Transponders that support Elementary Surveillance functions manage register 18_{16} as follows:

a. Register 18_{16} bit 41 to indicate that the installation has the capability to provide data in Register 10_{16}.

b. Register 18_{16} bit 34 to indicate that the installation has the capability to provide data in Register 17_{16}.

c. Register 18_{16} bit 33 to indicate that the installation has the capability to provide data in Register 18_{16}.

d. Register 18_{16} bit 25 to indicate that the installation has the capability to provide data in Register 20_{16}.

e. As an Option, Register 18_{16} bit 24 to indicate that the installation has the capability to provide data in Register 21_{16}.

Note 3: *Although not a function of Elementary Surveillance, Register 18_{16} bit 9 is set when the transponder is interfaced with TCAS to indicate that the ACAS Active Resolution Advisory Register 30_{16} is supported.*

Note 4: *Elementary Surveillance only requires that Register 18_{16} be serviced; Therefore, if no other transponder functions require the servicing of Register 19_{16} –through- $1C_{16}$, these registers will be set to ALL ZERO.*

2.2.24.5.2 Data Requirements

2.2.24.5.2.1 Required Servicing of Register 18_{16} Associated with Register 10_{16}

a. Register 18_{16} bit 41 **shall** be set to ONE (1) if the transponder is required to service any part of Register 10_{16}.

Note: *This requirement is not established by the Transponder LRU own capability to service Register 17_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data of which processing would result in the need to update Register 17_{16}.*

b. Once Register 18_{16} bit 41 has been set to ONE (1) during a particular power-on cycle, then it **shall** remain set to ONE (1) **until power-off** of the transponder.

2.2.24.5.2.2 Required Servicing of Register 18_{16} Associated with Register 17_{16}

a. Register 18_{16} bit 34 **shall** be set to ONE (1) if the transponder is required to service any part of Register 17_{16} as provided in §.

Note: *This requirement is not established by the Transponder LRU own capability to service Register 17_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data of which processing would result in the need to update Register 17_{16}.*

b. Once Register 18_{16} bit 34 has been set to ONE (1) during a particular power-on cycle, then it **shall** remain set to ONE (1) **until power-off** of the transponder.

c. Register 18_{16} bit 34 **shall** be set to ZERO (0) if the transponder receives no data from the Aircraft installation that could result in the need to service Register 17_{16} as provided in §2.2.24.4.

2.2.24.5.2.3 Required Servicing of Register 18_{16} Associated with Register 18_{16}

a. Register 18_{16} bit 33 **shall** be set to ONE (1) if the transponder is required to service any part of Register 18_{16}.

Note: *This requirement is not established by the Transponder LRU own capability to service Register 18_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data of which processing would result in the need to update Register 18_{16}.*

b. Once Register 18_{16} bit 33 has been set to ONE (1) during a particular power-on cycle, then it **shall** remain set to ONE (1) **until power-off** of the transponder.

c. Register 18_{16} bit 33 **shall** be set to ZERO (0) if the transponder receives no data from the Aircraft installation that could result in the need to service Register 18_{16}.

2.2.24.5.2.4 Required Servicing of Register 18_{16} Associated with Register 20_{16}

a. Register 18_{16} bit 25 **shall** be set to ONE (1) if the transponder has received either Aircraft Identification (also referred to as Flight Identification as specified in the Flight Plan) or Aircraft Registration data in the Aircraft Installation since the power-on of the transponder..

Note: *This requirement is not established by the Transponder LRU own capability to service Register 20_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 20_{16}.*

b. Once Register 18_{16} bit 25 has been set to ONE (1), then it **shall** remain set to ONE (1) **until power-off** of the transponder.

c. Register 18_{16} bit 25 **shall** be set to ZERO (0) if the transponder has received no data from the Aircraft installation that could be used to properly service Register 20_{16} **since power-on** of the transponder.

2.2.24.5.2.5 Required Servicing of Register 18_{16} Associated with optional Register 21_{16}

Note: *Elementary Surveillance does not require that Register 21_{16} be serviced. However, if Register 21_{16} is serviced, the following subparagraphs need to be complied with.*

a. Register 18_{16} bit 24 **shall** be set to ONE (1) if the transponder has received Aircraft Registration data in the Aircraft Installation **since power-on** of the transponder.

Note: *This requirement is not established by the Transponder LRU own capability to service Register 21_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 21_{16}.*

b. Once Register 18_{16} bit 24 has been set to ONE (1), then it **shall** remain set to ONE (1) **until power-off** of the transponder.

c. Register 18_{16} bit 24 shall be set to ZERO (0) if the transponder has received no data from the Aircraft installation that could be used to properly service Register 21_{16} **since power-on** of the transponder.

2.2.24.5.3 Minimum Update Interval of Register 18_{16} –to- $1C_{16}$

a. The minimum update interval at which Register 18_{16} (and/or Register 19_{16} –to- $1C_{16}$ if implemented) **shall** be reloaded with valid data is **5.0** seconds, i.e., Register 18_{16} (and/or Register 19_{16} –to- $1C_{16}$ if implemented) **shall** be updated at least once every **5.0** seconds.

b. The time between availability of data that causes a change in Register 18_{16} (and/or Register 19_{16} –to- $1C_{16}$ if implemented) and the time that the change is made to Register 18_{16} (and/or Register 19_{16} –to- $1C_{16}$ if implemented) **shall** be less than the minimum update interval specified as **5.0** seconds.

c. The setting of bits in Register 18_{16} –to- $1C_{16}$ is static. If a bit has been set to ONE (1) in one of these registers since power-on of the transponder, then the bit shall remain set to ONE (1) until power-off of the transponder.

2.2.24.6 Register 20_{16} -- Aircraft Identification and Data Sources

2.2.24.6.1 Purpose and Definition

The Mode-S transponder **shall** format Register 20_{16} as defined in Appendix B, Table B-3-32 and associated notes.

Note 1: *ICAO Annex 10, Volume IV requires that the aircraft identification to be used is that employed in the flight plan. When no flight plan is available, the registration marking is used if available, otherwise the aircraft identification is set to ALL ZERO's,*

Note 2: *On aircraft, it is possible to have access to data from an interface where the pilot can enter the data that is employed in the flight plan. This could be the telephony designator of the aircraft operating agency, followed by the flight identification or the registration marking of the aircraft. This piece of*

*information is considered as variable data and the transponder cannot know what is really entered by the pilot (depending on operational procedure). This piece of information is named "**Flight Identification**" within the rest of this section. In ARINC, it is normally provided via ARINC Labels 233 -through- 237 or by Label 360 for block transfer data.*

*In addition on some platforms it is also possible to receive another piece of data which is the registration marking (tail number). This is considered as a fixed data which does not vary during the flight. This piece of information can only be used when there is no data coming from the interface delivering the variable data. This is referenced as "**Aircraft Registration**´ within the rest of this section.*

2.2.24.6.2 Register 20_{16} -- Data Requirements

2.2.24.6.2.1 Data Selection Priority

Use of Flight Identification or Aircraft Registration Data in Register 20_{16} **shall** comply with the following guidelines:

Note: *Aircraft Registration Data may also be used in Register 08_{16} when Extended Squitter is implemented. As such, the requirements inferred below will also apply to Register 08_{16} when Extended Squitter is implemented.*

a. If Flight Identification data is available at anytime during unit operation, then flight identification data **shall** be inserted into the character subfields of Register 20_{16}.

Note: *Flight Identification data is normally provided via ARINC Labels 233 -through- 237 or by Label 360 for block transfer data. Available data means that the status of the data is not set to No Computed Data (NCD).*

b. If Flight Identification data is NOT available then Aircraft Registration, if available, **shall** be inserted into the character subfields of Register 20_{16}.

Note: *If the transponder has no input from the Aircraft installation that could be used to service Register 20_{16}, then the Register 20_{16} Character subfields are set to ZERO (0) and Register 10_{16} (Datal Link Capability Report) bit 33 is set to ZERO (0).*

c. If Flight Identification data has been entered into Register 20_{16} and then becomes NOT available, then the character subfields of the registers **shall** be set to all ZERO's.

d. In all of the above cases, encoding of the character subfields in Register 20_{16} **shall** conform to the following:

(1). All characters will be left justified prior to encoding the Character fields.

(2). Characters will be coded consecutively without intervening SPACE codes.

(3). Any unused character spaces at the end of the subfield should conatain a SPACE character code.

(4). Any extra characters **shall** be truncated.

2.2.24.6.3 Register 20_{16} – Flight Identification Update Rates

a. The minimum update interval at which Register 20_{16} **shall** be reloaded with valid data is **5.0** seconds.

Note: *Effectively, Register 20_{16} must be updated every **5.0** seconds or sooner.*

b. If Register 20_{16} cannot be updated within a **10.0** second timeframe (e.g., twice the specified minimum update interval of **5.0** seconds), then:

(1). The contents of of the character field of Register 20_{16} shall be set to ZERO (0).

(2). Bit 7 of Register 17_{16} **shall** be set to ZERO (0).

(3). Bit 33 of Register 10_{16} shall be set to ZERO (0). (see §2.2.24.3.2.4.)

(4). Bit 25 of Register 18_{16} **shall** not change state if Register 20_{16} has been properly serviced during the power-on cycle. If Register 20_{16} has not been properly serviced during the power-on cycle, then bit 25 of Register 18_{16} must be verified as being set to ZERO (0) (see §2.2.24.5.1 and §2.2.24.5.2.4).

c. The time between availability of data that causes a change in Register 20_{16} and the time that the change is made to Register 20_{16} **shall** be less than the minimum update interval specified as **5.0** seconds.

Note: *The time between establishing availability of data and the time of updating Register 20_{16} should be minimized (e.g., data latency should be minimized).*

2.2.24.6.4 Aircraft Identification Declaration of Capability

Aircraft Identification Capability of the tranponder shall be declared as provided in the following subsections.

2.2.24.6.4.1 In Register 10_{16} – Data Link Capability Report

Correct servicing of the character fields of Register 20_{16} **shall** be reported in Register 10_{16} via bit 33 as defined in §2.2.24.3.2.4.

2.2.24.6.4.2 In Register 17_{16} – Common Usage GICB Capability Report

Correct servicing of the character fields of Register 20_{16} **shall** be reported in Register 17_{16} via bit 33 as defined in §2.2.24.4.2.1.

2.2.24.6.4.3 In Register 18_{16} – Mode S Specific Services Capability Report

Correct servicing of the character fields of Register 20_{16} shall be reported in Register 18_{16} via bit 25 as defined in §2.2.24.5.2.4.

2.2.24.6.5 Flight Identification Change Reporting

If the aircraft identification reported in the "AIS" subfield is changed, then the transponder **shall** report the new aircraft identification in accordance with §2.2.19.1.13.e by use of the Comm-B Broadcast Message protocol (see §2.2.19.1.12.4.1).

2.2.24.7 Register 21_{16} – Aircraft Registration (Optional)

Note: *Elementary Surveillance does not require that Register 21_{16} be serviced. However, if Register 21_{16} is serviced, the following subparagraphs need to be complied with.*

2.2.24.7.1 Purpose and Defintion

The Mode-S transponder **shall** format Register 21_{16} as defined in Appendix B, Table B-3-33 and associated notes.

2.2.24.7.2 Register 21_{16} – Data Requirements

a. If valid Aircraft Registration data is available, then the data **shall** be used to fill the Characters in Register 21_{16}, "Aircraft and Airline Registration Markings" as shown in Appendix B, Table B-3-33.

Note: *Aircraft Registration data is normally provided via ARINC Labels 301 -through- 303 or by Label 360 for block transfer data. Available data means that the status of the data is not set to No Computed Data (NCD).*

b. There is currently no method to provide the transponder with ICAO Airline Registration marking. Therefore, bits 44 -through- 56 of Register 21_{16} **shall** be set to zero.

c. When Register 21_{16} is being serviced with Aircraft Registration data, then Register 21_{16} **shall** be available for GICB Extraction as per §2.2.24.1.

2.2.24.7.3 Register 21_{16} – Update Rates

a. The minimum update interval at which Register 21_{16} **shall** be reloaded with valid data is **15.0** seconds.

Note: *Register 21_{16} is updated every **15.0** seconds or sooner.*

b. If Register 21_{16} cannot be updated within a **30.0** second timeframe (e.g., twice the specified minimum update interval of **15.0** seconds), then the contents of Register 21_{16} **shall** be set to ZERO and:

(1). Bit 24 of Register 18_{16} **shall** not change state if Register 21_{16} has been properly serviced **since power-on** of the transponder. If Register 21_{16} has not been properly serviced **since power-on** of the transponder, then bit 24 of Register 18_{16} must be verified as being set to ZERO.

c. The time between availability of data that causes a change in Register 21_{16} and the time that the change is made to Register 21_{16} **shall** be less than the minimum update interval specified as 15.0 seconds.

Note: *The time between establishing availability of data and the time of updating Register 21_{16} should be minimized (e.g., data latency should be minimized).*

2.2.24.7.4 Register 21_{16} – Declaration of Capability

2.2.24.7.4.1 In Register 17_{16} – Common Usage GICB Capability Report

Correct servicing of at least one field in Register 21_{16} **shall** be reported in Register 17_{16} via bit 8 as defined in §2.2.24.4.2.2.

2.2.24.7.4.2 In Register 18_{16} –Mode S Specific Services Capability Report

Correct servicing of at least one field in Register 21_{16} **shall** be reported in Register 18_{16} via bit 24 as defined in §2.2.24.5.2.5.

2.2.25 Enhanced Surveillance (EHS) Compliant Transponder

This section contains requirements on Mode S transponders required to support EHS.

The Enhanced Surveillance application entails the use of eight Downlink Aircraft Parameters (DAPs) for initial implementation, as follows:

a. Magnetic Heading

b. Indicated Airspeed and/or Mach No.

c. Vertical Rate (climb/descend)

d. MCP/FCU Selected Altitude

e. Ground Speed

f. Roll Angle

g. Track Angle Rate (or True Airspeed if Track Angle Rate is not available)

h. True Track Angle

These DAPS are embedded in three transponder Registers (40_{16}, 50_{16}, and 60_{16}).

In addition to those three registers, the Enhanced Surveillance application uses a number of capability report registers to assess the real time ability of the aircraft to transmit DAPs. The format requirements related to the Enhanced Surveillance application for these capability registers are defined in §2.2.25.1 -through- §2.2.25.4.

The Enhanced Surveillance application presents the following benefits:

i. The provision of actual aircraft derived data, such as Magnetic Heading, Air Speed, Selected Altitude and Vertical Rate, enables controllers to reduce the radio telephony (RT) workload and better assess the separation situations.

j. EHS enables Monitoring Tools and Safety Nets, which work on actual data, to be implemented or improved (eg. Short Term Conflict Alert) which, in turn, will allow safety levels to be maintained or improved despite the increase in traffic levels.

Transponder capable of supporting EHS must:

k. support ELS as defined in §2.2.24.

l. at least be able to provide data in Registers 40_{16}, 50_{16}, and 60_{16}.

m. support capability reporting in CA and Register 10_{16} to $1F_{16}$.

Note 1: *Servicing register $5F_{16}$ is not mandatory.*

Note 2: *For the remaining subsections of this section, servicing of a field or subfield in a register implies that valid data has been received at a sufficient rate to meet the update requirements specified for the given register in Appendix B.*

2.2.25.1 Register 10_{16} – Data Link Capability Report

2.2.25.1.1 Purpose and Definition

Register 10_{16} shall be formatted as specified in Appendix B table B-3-16.

Note: *The following paragraphs detail the minimum requirement for Enhanced Surveillance. The other fields need to be managed according to the additional capabilities supported by the transponder.*

2.2.25.1.2 Data Requirements

2.2.25.1.2.1 Bits 1 –to- 8, BDS Code

Bits 1 –through- 8 of Register 10_{16} are defined in Elementary Surveillance (ELS) Compliant Transponder §2.2.24.3.2.1.

2.2.25.1.2.2 Bits 17 –to- 23, Mode S Subnetwork Version Number

Bit 17 –through- 23 (Mode S Subnetwork Version) of Register 10_{16} are defined in Elementary Surveillance (ELS) Compliant Transponder §2.2.24.3.2.2.

2.2.25.1.2.3 Bit 25, Mode S Specific Services Capability

a. Register 10_{16} (Data Link Capability Report) bit 25 **shall** be set to ONE (1) if the transponder is receiving any data from the Aircraft installation with which to service Registers $1D_{16}$ –through- $1F_{16}$, 40_{16}, 50_{16}, $5F_{16}$ (Optional) or 60_{16} (or other registers) as provided in the respective sections for each register in this document.

Note 1: *Registers $1D_{16}$ –through- $1F_{16}$ are included above in order to provide for possible declaration of capability to provide Dataflash or other Mode Specific Protocol capability.*

Note 2: *This requirement is not established by the transponder LRU own capability to service Registers $1D_{16}$ -through- $1F_{16}$, 40_{16}, 50_{16}, $5F_{16}$ **(Optional)** or 60_{16}.*

*Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Registers $1D_{16}$ -through- $1F_{16}$, 40_{16}, 50_{16}, $5F_{16}$ **(Optional)** or 60_{16}.*

b. Register 10_{16} (Data Link Capability Report) bit 25 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service either Registers $1D_{16}$ -through- $1F_{16}$, 40_{16}, 50_{16}, $5F_{16}$ (Optional), 60_{16} or any other registers other than 02_{16}, 03_{16}, 04_{16}, 10_{16}, 17_{16} –through- $1C_{16}$, 20_{16} and 30_{16}.

c. When bit 25 is set to ONE (1), it **shall** indicate that at least one Mode S Specific Service is supported.

Note: *Mode S Specific Service refers to the servicing of registers other than GICB services related to Registers 02_{16}, 03_{16}, 04_{16}, 10_{16}, 17_{16} -through- $1C_{16}$, 20_{16} and 30_{16}.*

2.2.25.1.2.4 Bit 25, Surveillance Identifier Code (SI)

Bit 35 of Register 10_{16} is set to ONE (1) as defined in Elementary Surveillance (ELS) Compliant Transponder §2.2.24.3.2.5.

2.2.25.1.2.5 Bit 36, Common Usage GICB Capability Report

Bit 36 of Register 10_{16} is managed as specified in Elementary Surveillance (ELS) Compliant Transponder §2.2.24.3.2.6.

2.2.25.1.3 Minimum Update Interval of Register 10_{16}

a. The minimum update interval at which Register 10_{16} **shall** be reloaded with valid data is **≤4.0** seconds.

Note: *Effectively, Register 10_{16} must be updated every 4.0 seconds or sooner.*

b. Register 10_{16} **shall** be updated within one second of the data changing and at least every four seconds thereafter.

c. If a particular data field in Register 10_{16} cannot be updated within **8.0** seconds (e.g., twice the specified minimum update interval of **≤4.0** seconds), then the status bit (if specified for that field) **shall** indicate that the data in that field is invalid and the data field **shall** be ZEROed.

2.2.25.1.4 Change Reporting

When register 10_{16} is changed, then the register **shall** be broadcast as described in §2.2.19.1.12.8.

2.2.25.2 Register 17_{16}—Common Usage GICB Capability Report

2.2.25.2.1 Register 17_{16} – Purpose and Definition

The Mode-S transponder **shall** format Register 17_{16} as defined in Appendix B, Table B-3-23 and associated notes.

The Elementary Surveillance (ELS) Compliant Transponder manages the following bits in Register 17_{16}.

a. Bit 7 to indicate servicing of Register 20_{16} Aircraft Identification as defined in Elementary Surveillance (ELS) Compliant Transponder §2.2.24.4.2.1.

b. Bit 8 to indicate servicing of Optional Register 21_{16} Aircraft Registration as defined in Elementary Surveillance (ELS) Compliant Transponder §2.2.24.4.2.2.

c. Bit 9 to indicate whether the aircraft installation is servicing any part of Register 40_{16} as defined in §2.2.25.4.2.2.

d. Bit 16 to indicate whether the aircraft installation is servicing any part of Register 50_{16} as defined in §2.2.25.4.2.2.

e. Bit 24 to indicate whether the aircraft installation is servicing any part of Register 60_{16} as defined in §2.2.25.4.2.2.

2.2.25.2.2 Enhanced Surveillance (EHS) Servicing Requirements

2.2.25.2.2.1 Required Servicing of Register 17_{16} Associated with Register 20_{16}

Refer to §2.2.24.4.2.1 where requirements have previously been provided for servicing Register 20_{16} as part of the Elementary Surveillance (ELS) Compliant Transponder.

2.2.25.2.2.2 Required Servicing of Register 17_{16} Associated with Optional Register 21_{16}

Refer to §2.2.24.4.2.2 where requirements have previously been provided for servicing Register 21_{16} as part of the Elementary Surveillance (ELS) Compliant Transponder.

2.2.25.2.2.3 Required Servicing of Register 17_{16} Associated with Register 40_{16}

a. Register 17_{16} bit 9 **shall** be set to ONE (1) if the transponder is servicing either MCP/FCU Selected Altitude, FMS Selected Altitude, Barometric Pressure Setting, FMS Vertical Mode (MCP/FCU Mode Bits), or Target Altitude Source data in Register 40_{16}.

Note 1: *This requirement is not established by the transponder LRU own capability to service Register 40_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 40_{16}.*

Note 2: *FMS Vertical Mode data refers to data used to establish bits 48 -through- 51 of Register 40_{16}.*

Note 3: *Target Altitude Source data refers to data used to establish bits 54 -through- 56 of Register 40_{16}.*

b. Register 17_{16} bit 9 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service Register 40_{16}.

2.2.25.2.2.4 Required Servicing of Register 17_{16} Associated with Register 50_{16}

a. Register 17_{16} bit 16 **shall** be set to ONE (1) if the transponder is servicing either Roll Angle, True Track Angle, Ground Speed, Track Angle Rate, or True Airspeed data in Register 50_{16}.

Note: *This requirement is not established by the transponder LRU own capability to service Register 50_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 50_{16}.*

b. Register 17_{16} bit 16 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service Register 50_{16}.

2.2.25.2.2.5 Required Servicing of Register 17_{16} Associated with Optional Register $5F_{16}$

Note: *Enhanced Surveillance does not require that Register $5F_{16}$ be serviced. However, servicing of Register $5F_{16}$ **is implicitly** required when servicing Register 40_{16} in ICAO Doc. 9871 and Appendix B. Therefore, **if** Register $5F_{16}$ is serviced, the following subparagraphs need to be complied with.*

a. Register 17_{16} bit 23 **shall** be set to ONE (1) if the transponder is receiving MCP/FCU Selected Altitude, FMS Selected Altitude, Barometric Pressure Setting, of FMS Vertical Mode (MCP/FCU Mode Bits) necessary to update Register 40_{16} (see §2.2.25.5) which then requires that Register $5F_{16}$ be updated in accordance with §2.2.25.7.

Note: *This requirement is not established by the transponder LRU own capability to service Register $5F_{16}$. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register $5F_{16}$.*

b. Register 17_{16} bit 23 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service Register $5F_{16}$.

2.2.25.2.2.6 Required Servicing of Register 17_{16} Associated with Register 60_{16}

a. Register 17_{16} bit 24 **shall** be set to ONE (1) if the transponder is servicing either Magnetic Heading, Indicated Airspeed, Mach, Barometric Altitude Rate, or Inertial Vertical Velocity data in Register 60_{16}.

Note: *This requirement is not established by the transponder LRU own capability to service Register 60_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 60_{16}.*

b. Register 17_{16} bit 24 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service Register 60_{16}.

2.2.25.2.2.7 Minimum Update Interval of Register 17_{16}

a. The minimum update interval at which Register 17_{16} **shall** be reloaded with valid data is **5.0** seconds.

Note: *Effectively, Register 17_{16} must be updated at least once every 5.0 seconds.*

b. The time between availability of data that causes a change in Register 17_{16} and the time that the change is made to Register 17_{16} **shall** be less than the minimum update interval specified as **5.0** seconds.

c. If a particular data field in Register 17_{16} cannot be updated within **10.0** seconds (e.g., twice the specified minimum update interval of **5.0** seconds), then the status bit (if specified for that field) **shall** indicate that the data in that field is invalid and the data field **shall** be ZEROed.

2.2.25.2.3 Change Reporting

When Register 17_{16} is changed, bit 36 of Register 10_{16} is to be toggled as defined in §2.2.24.3.2.6.

2.2.25.3 Register 18_{16} –through- $1C_{16}$ Mode S Specific Services GICB Capability

2.2.25.3.1 Purpose and Definition

The Mode-S transponder **shall** format Register 18_{16} -through- $1C_{16}$ as defined in Appendix B, Table B-3-24 -through- Table B-3-28 and associated notes for Register 18_{16} -through- $1C_{16}$, respectively.

Note 1: *Registers 18_{16} to $1C_{16}$ are used to indicate the capability of the aircraft installation to provide data for each register i.e. the register or a part of the register is managed by the transponder and it is known that data can be received from the installation to fill this field.*

Note 2; *This is not established by the Transponder LRU own capability. Rather, it is established by the Aircraft installation capability to provide the transponder*

with the appropriate data with which to service the corresponding register. Once this capability is established it remains set until power-off of the transponder.

Transponers that support Enhanced Surveillance (EHS) functions manage register 18_{16} as follows:

a. Register 18_{16} bit 41 to indicate that the installation has the capability to provide data in Register 10_{16}.

b. Register 18_{16} bit 34 to indicate that the installation has the capability to provide data in Register 17_{16}.

c. Register 18_{16} bit 33 to indicate that the installation has the capability to provide data in Register 18_{16}.

d. Register 18_{16} bit 32 to indicate that the installation has the capability to provide data in Register 19_{16}.

e. Register 18_{16} bit 25 to indicate that the installation has the capability to provide data in Register 20_{16}.

f. Register 18_{16} bit 24 to indicate that the installation has the capability to provide data in Register 21_{16} (Optional).

g. Register 19_{16} bit 49 to indicate that the installation has the capability to provide data in Register 40_{16}.

h. Register 19_{16} bit 33 to indicate that the installation has the capability to provide data in Register $5F_{16}$ **(Optional)**.

i. Register 19_{16} bit 18 to indicate that the installation has the capability to provide data in Register 60_{16}.

Note 3: *Although not a function of Elementary Surveillance, Register 18_{16} bit 9 is set when the transponder is interfaced with TCAS to indicate that the TCAS Active Resolution Advisory Register 30_{16} is supported.*

Note 4: *Combined Elementary and Enhanced Surveillance only require that Register 18_{16} and 19_{16} be serviced; Therefore, if no other transponder functions require the servicing of Register $1A_{16}$ –through- $1C_{16}$, these registers will be set to ALL ZERO.*

2.2.25.3.2 Enhanced Surveillance Capability Requirements

2.2.25.3.2.1 Required Servicing of Register 18_{16} Associated with Register 10_{16}

Refer to §2.2.24.5.2.1 where requirements have previously been provided for servicing Register 10_{16} as part of the Elementary Surveillance (ELS) Compliant Transponder.

2.2.25.3.2.2 Required Servicing of Register 18_{16} Associated with Register 17_{16}

Refer to §2.2.24.5.2.2 where requirements have previously been provided for servicing Register 17_{16} as part of the Elementary Surveillance (ELS) Compliant Transponder.

2.2.25.3.2.3 Required Servicing of Register 18_{16} Associated with Register 18_{16}

Refer to §2.2.24.5.2.3 where requirements have previously been provided for servicing Register 18_{16} as part of the Elementary Surveillance (ELS) Compliant Transponder.

2.2.25.3.2.4 Required Servicing of Register 18_{16} Associated with Register 19_{16}

a. Register 18_{16} bit 32 **shall** be set to ONE (1) if the transponder is required to service any part of Register 19_{16} as provided in §2.2.25.3.2.7 –through- §2.2.25.3.2.10.

Note: *This requirement is not established by the Transponder LRU own capability to service Register 19_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data of which processing would result in the need to update Register 19_{16}.*

b. Once Register 18_{16} bit 32 has been set to ONE (1) **since power-on** of the transponder, then it **shall** remain set to ONE (1) **until power-off** of the transponder.

c. Register 18_{16} bit 32 **shall** be set to ZERO (0) if the transponder receives no data from the Aircraft installation that could result in the need to service Register 19_{16} as provided in §2.2.25.3.2.6 -through- §2.2.25.3.2.9.

2.2.25.3.2.5 Required Servicing of Register 18_{16} Associated with Register 20_{16}

Refer to §2.2.24.5.2.4 where requirements have previously been provided for servicing Register 18_{16} as part of the Elementary Surveillance (ELS) Compliant Transponder.

2.2.25.3.2.6 Required Servicing of Register 18_{16} Associated with Register 21_{16} (Optional)

Refer to §2.2.24.5.2.5 where requirements have previously been provided for servicing Register 18_{16} as part of the Elementary Surveillance (ELS) Compliant Transponder.

2.2.25.3.2.7 Required Servicing of Register 19_{16} Associated with Register 40_{16}

a. Register 19_{16} bit 49 **shall** be set to ONE (1) if the transponder has received either MCP/FCU Selected Altitude, FMS Selected Altitude, Barometric Pressure Setting, FMS Vertical Mode (MCP/FCU Mode Bits), or Target Altitude Source data in the Aircraft Installation during the power-on cycle.

(Refer to Appendix B, Table B-3-64 for full definition of Register 40_{16}).

Note 1: *This requirement is not established by the Transponder LRU own capability to service Register 40_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 40_{16}.*

Note 2: *FMS Vertical Mode data refers to data used to establish bits 48 -through- 51 of Register 40_{16}.*

Note 3: *Target Altitude Source data refers to data used to establish bits 54 - through- 56 of Register 40_{16}.*

b. Once Register 19_{16} bit 49 has been set to ONE (1) **since power-on** of the transponder, then it **shall** remain set to ONE (1) **until power-off** of the transponder.

c. Register 19_{16} bit 49 **shall** be set to ZERO (0) if the transponder receives no data from the Aircraft installation that could be used to properly service Register 40_{16} during the power-on cycle.

2.2.25.3.2.8 Required Servicing of Register 19_{16} Associated with Register 50_{16}

a. Register 19_{16} bit 33 **shall** be set to ONE (1) if the transponder has received either Roll Angle, True Track Angle, Ground Speed, Track Angle Rate, or True Airspeed data in the Aircraft installation during the power-on cycle.

(Refer to Appendix B, Table B-3-80 for full definition of Register 50_{16})

Note: *This requirement is not established by the Transponder LRU own capability to service Register 50_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 50_{16}.*

b. Once Register 19_{16} bit 33 has been set to ONE (1) **since power-on** of the transponder, then it **shall** remain set to ONE (1) **until power-off** of the transponder.

c. Register 19_{16} bit 33 **shall** be set to ZERO (0) if the transponder receives no data from the Aircraft installation that could be used to properly service Register 50_{16} **since power-on** of the transponder.

2.2.25.3.2.9 Required Servicing of Register 19_{16} Associated with Optional Register $5F_{16}$

Note: *Enhanced Surveillance does not require that Register $5F_{16}$ be serviced. However, servicing of Register $5F_{16}$ **is implicitly** required when servicing Register 40_{16} in ICAO Doc. 9871 and Appendix B. Therefore, **if** Register $5F_{16}$ is serviced, the following subparagraphs need to be complied with.*

a. Register 19_{16} bit 18 **shall** be set to ONE (1) if the transponder is required to service any part of Register $5F_{16}$ as provided in §2.2.25.6.

Note: *This requirement is not established by the Transponder LRU own capability to service Register $5F_{16}$. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data of which processing would result in the need to update Register $5F_{16}$.*

b. Once Register 19_{16} bit 18 has been set to ONE (1) **since power-on** of the transponder, then it **shall** remain set to ONE (1) **until power-off** of the transponder.

c. Register 19_{16} bit 18 **shall** be set to ZERO (0) if the transponder receives no data from the Aircraft installation that could result in the need to service Register $5F_{16}$ as provided in §2.2.25.7.

2.2.25.3.2.10 Required Servicing of Register 19_{16} Associated with Register 60_{16}

a. Register 19_{16} bit 17 **shall** be set to ONE (1) if the transponder has received either Magnetic Heading, Indicated Airspeed, Mach, Barometric Altitude Rate, or Inertial Vertical Velocity data in the Aircraft installation during the power-on cycle.

(Refer to Appendix B, Table B-3-96 for full definition of Register 60_{16})

Note: *This requirement is not established by the Transponder LRU own capability to service Register 60_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 60_{16}.*

b. Once Register 19_{16} bit 17 has been set to ONE (1) **since power-on** of the transponder, then it **shall** remain set to ONE (1) **until power-off** of the transponder.

c. Register 19_{16} bit 17 **shall** be set to ZERO (0) if the transponder receives no data from the Aircraft installation that could be used to properly service Register 60_{16} **since power-on** of the transponder.

2.2.25.3.3 Minimum Update Interval of Registers 18_{16} to $1C_{16}$

a. The minimum update interval at which Register 18_{16} and/or Register 19_{16} **shall** be reloaded with valid data is **5.0** seconds.

Note: *Effectively, Register 18_{16} and/or Register 19_{16} are updated at least once every **5.0** seconds.*

b. The time between availability of data that causes a change in Register 18_{16} and/or Register 19_{16} and the time that the change is made to Register 18_{16} and/or Register 19_{16} **shall** be less than the minimum update interval specified as **5.0** seconds.

c. The setting of bits in Register 18_{16} –to- $1C_{16}$ is static. If a bit has been set to ONE (1) in one of these registers since power-on of the transponder, then the bit shall remain set to ONE (1) until power-off of the transponder.

2.2.25.4 Register $1D_{16}$ to $1F_{16}$ Mode S Specific Services MSP Capability

a. Register $1D_{16}$ to $1F_{16}$ shall be formatted as specified in Appendix B Table B-3-29 to B-3-31.

b. Although, servicing of Register $1D_{16}$ -through- $1F_{16}$ is not required by Enhanced Surveillance, the "MB" field of these registers shall be set to ALL ZEROs.

Note: *There is no formal requirement to implement data-flash however Mode S ground station may systematically extract register $1D_{16}$ to decide to extract a register using GICB protocol or using the data-flash application.*

2.2.25.5 Register 40_{16} – Selected Vertical Intention

2.2.25.5.1 Purpose and Definition

a) Transponders shall format Register **40_{16}** as defined in Appendix B, Table **B-3-64**.

b) The transponder **shall** comply with all constraints and requirements for servicing Register **40_{16}** that are provided with Table **B-3-64** in Appendix B.

2.2.25.5.2 Data Requirements

2.2.25.5.2.1 Selected Altitude from Altitude Control Panel

a. The transponder **shall** process Selected Altitude From Altitude Control Panel (Mode Control Panel/Flight Control Unit or equivalent equipment) data from on-board aircraft data sources as provided in Appendix B, Table B-3-64 of the Register 40_{16} definition table and format the data into bits 2 -through- 13 of the Register 40_{16} "MB" field as shown in that table.

b. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

c. Status Bit 1 **shall** be set to ONE (1) whenever valid data is available in bits 2 -through- 13.

d. Status Bit 1 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 2 -through- 13.

e. Bits 2 -through- 13 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.5.2.2 FMS Selected Altitude

a. The transponder **shall** process FMS Selected Altitude data from on-board aircraft data sources as provided in Appendix B, Table B-3-64 of the Register 40_{16} definition table and format the data into bits 15 -through- 26 of the Register 40_{16} "MB" field as shown in that table.

b. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

c. Status Bit 14 **shall** be set to ONE (1) whenever valid FMS Selected Altitude data is available in bits 15 -through- 26.

d. If FMS Selected Altitude data is not available for insertion into bits 15 -through- 26, Status Bit 14 **shall** be set to ZERO (0).

e. If FMS Selected Altitude data is not available for insertion into bits 15 -through- 26, bits 15 -through- 26 **shall** be set to ZERO (0).

2.2.25.5.2.3 Barometric Pressure Setting

a. The transponder **shall** process Barometric Pressure Setting data from on-board aircraft data sources as provided in Appendix B, Table B-3-64 of the Register 40_{16} definition table. Further processing of the input Barometric Pressure Setting data is needed as follows:

(1). Note that the Barometric Pressure Setting data received may be in BCD format and must be converted to Binary format prior to encoding data into

Register 40_{16}. Tentative information regarding BCD to Binary Conversion and final mapping of the data into Register 40_{16} is provided in the following Note:

Note: *Barometric Pressure Setting BCD –to- BINARY Conversion Method*
Consider an input of 1085.9 millibars in BCD data.

Multiply by 10 to give the BCD count of 0.1 increments needed to represent the input data.

Yields: 10859

10859/2	***=***	***5429***	***-***	***1***				
5429/2	***=***	***2714***	***-***	***1***				
2714/2	***=***	***1357***	***-***	***0***				
1357/2	***=***	***678***	***-***	***1***				
678/2	***=***	***339***	***-***	***0***				
339/2	***=***	***169***	***-***	***1***				
169/2	***=***	***84***	***-***	***1***				
84/2	***=***	***42***	***-***	***0***				
42/2	***=***	***21***	***-***	***0***				
21/2	***=***	***10***	***-***	***1***				
10/2	***=***	***5***	***-***	***0***				
5/2	***=***	***2***	***-***	***1***				
2/2	***=***	***1***	***-***	***0***				
½	***=***	***0***	***-***	***1***	***==***	***0010 1010 0110 1011 HEX***	***==***	***2A6B HEX*** ***==*** ***10859 Decimal***

Start:	***0001***	***0000***	***1000***	***0101***	***1001***		***10859***	***BCD***
Rotate R:	***0000***	***1000***	***0100***	***0010***	***1100***	***1***		
Add	***0000***	***1101***	***0000***	***0000***	***1101***			***Add "0D" Hex to each nibble that has the***
	0000	***0101***	***0100***	***0010***	***1001***		***05429***	***MSB of the nibble set to "1". Disregard the Carry***
Rotate R:	***0000***	***0010***	***1010***	***0001***	***0100***	***1***		
Add	***0000***	***0000***	***1101***	***0000***	***0000***			
	0000	***0010***	***0111***	***00001***	***0100***		***02714***	
Rotate R:	***0000***	***0001***	***0011***	***1000***	***1010***	***0***		
Add	***0000***	***0000***	***0000***	***1101***	***1101***			
	0000	***0001***	***0011***	***0101***	***0111***		***01357***	
Rotate R:	***0000***	***0000***	***1001***	***1010***	***1011***	***1***		
Add	***0000***	***0000***	***1101***	***1101***	***1101***			
	0000	***0000***	***0110***	***0111***	***1000***		***00678***	
Rotate R:	***0000***	***0000***	***0011***	***0011***	***1100***	***0***		
Add	***0000***	***0000***	***0000***	***0000***	***1101***			
	0000	***0000***	***0011***	***0011***	***1001***		***00339***	
Rotate R:	***0000***	***0000***	***0001***	***1001***	***1100***	***1***		
Add	***0000***	***0000***	***0000***	***1101***	***1101***			
	0000	***0000***	***0001***	***0110***	***1001***		***00169***	
Rotate R:	***0000***	***0000***	***0000***	***1011***	***0100***	***1***		
Add	***0000***	***0000***	***0000***	***1101***	***0000***			
	0000	***0000***	***0000***	***1000***	***0100***		***00084***	
Rotate R:	***0000***	***0000***	***0000***	***0100***	***0010***	***0***	***00042***	
Rotate R:	***0000***	***0000***	***0000***	***0010***	***0001***	***0***	***00021***	
Rotate R:	***0000***	***0000***	***0000***	***0001***	***0000***	***1***	***00010***	
Rotate R:	***0000***	***0000***	***0000***	***0000***	***1000***			
Add	***0000***	***0000***	***0000***	***0000***	***1101***			
	0000	***0000***	***0000***	***0000***	***0101***		***00005***	
Rotate R:	***0000***	***0000***	***0000***	***0000***	***0010***	***1***	***00002***	
Rotate R:	***0000***	***0000***	***0000***	***0000***	***00001***	***0***	***00001***	
Rotate R:	***0000***	***0000***	***0000***	***0000***	***0000***	***1***	***00000***	

Binary Equivalent == 0010 1010 0110 1011 = 2A6B Hex = 10859 Decimal

Next:

Establish Equivalent of 800.0 millibars having 0.1 resolution

Effectively, establish a count of 8000 millibars in binary: The value is 1F40 Hex

Establish 2's Complement of 1F40 Hex as E0C0 Hex.

Now, effectively subtract 8000 from the Binary Equivalent above as follows:

Binary Equivalent = 0010 1010 0110 101 = 2A6B Hex = 10859 Decimal

Add Neg. 800.0 mb = 1110 0000 1100 0000 = E0C0 Hex = -8000 millibars

Resultant Sum: = 0000 1011 0010 1011 = 0B2B Hex = 2859 Decimal

Map the Resultant Data into Bits 28 -through- 39 of Register 40_{16} as follows:

	MSB											**LSB**
Bit:	28	29	30	31	32	33	34	35	36	37	38	39
Data:	1	0	1	1	0	0	1	0	1	0	1	1

(2). Note that the encoding that is provided in Appendix B, Table B-3-64 Register 40_{16} for Barometric Pressure Setting represents the input Barometric Pressure Setting data MINUS 800 millibars (mb). See Appendix B, Table B-3-64, Register 40_{16} definition. Also, note that this 800 millibar correction has been taken into account in the BCD to BINARY conversion performed in the Note given in §2.2.25.5.2.3.a.(1).

b. The data loaded into the "MB" field **shall** be the Barometric Pressure Setting MINUS 800 millibars (mb) that has been converted to BINARY data in a manner that is consistent and equivalent with the BCD –to- BINARY conversion performed in the Note given in §2.2.25.5.2.3.a.(1).

c. Status Bit 27 **shall** be set to ONE (1) whenever valid data is available in bits 28 -through- 39, and the conditions given in §2.2.25.5.2.3.d are not applicable.

d. Status Bit 27 **shall** be set to ZERO (0) whenever:

(1). There is no valid data with which to fill bits 28 -through- 39.

(2). The input Barometric Pressure Setting data is less than 800 millibars (mb).

Note: *This would result in a negative Barometric Pressure Setting after subtracting 800 millibars (mb) and doing the BCD to BINARY conversion.*

(3). The input Barometric Pressure Setting data is greater than 1209.5 millibars (mb).

e. Bits 28 -through- 39 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.5.2.4 FMS Vertical Mode Bits

Note: *FMS Vertical Mode bits refer to bits 48 -through- 51 of Register 40_{16}.*

2.2.25.5.2.4.1 Status of MCP / FCU Mode Bits (Bit 48)

Bit 48 **shall** indicate whether the mode bits (49, 50, and 51) are actively being populated (e.g., set) in Register 40_{16} in accordance with the following table:

Table 2.2.25.5.2.4.1: Status of MCP/FCU Mode Bits (Bit 48) Encoding

Bit 48	Meaning
0	No Mode Information Provided
1	Mode Information Deliberately Provided

Essentially, if information is provided to the transponder to set either bit 49, 50, or 51 to either "0" or "1," then Bit 48 **shall** be set to ONE (1) Otherwise, Bit 48 **shall** be set to ZERO (0).

2.2.25.5.2.4.2 Vertical Navigation Mode (Bit 49)

a. The transponder **shall** accept information from an appropriate interface that indicates whether or not the Vertical Navigation Mode is active.

b. The transponder **shall** set Bit 49 in accordance with the following table:

Table 2.2.25.5.2.4.2: Vertical Navigation Mode (Bit 49) Encoding

Bit 49	Meaning
0	VNAV Not Active
1	VNAV Active

c. If appropriate information is not available to indicate whether or not the Vertical Navigation Mode is active, then the transponder **shall** set Bit 49 to ZERO (0).

2.2.25.5.2.4.3 Altitude Hold (Bit 50)

a. The transponder **shall** accept information from an appropriate interface that indicates whether or not the Altitude Hold Mode is active.

b. The transponder **shall** set Bit 50 in accordance with the following table:

Table 2.2.25.5.2.4.3: Altitude Hold Mode (Bit 50) Encoding

Bit 50	Meaning
0	Altitude Hold Not Active
1	Altitude Hold Active

c. If appropriate information is not available to indicate whether or not the Altitude Hold Mode is active, then the transponder **shall** set Bit 50 to ZERO (0).

2.2.25.5.2.4.4 Approach Mode (Bit 51)

a. The transponder **shall** accept information from an appropriate interface that indicates whether or not the Approach Mode is active.

b. The transponder **shall** set Bit 51 in accordance to the following:

Table 2.2.25.5.2.4.4: Approach Mode (Bit 51) Encoding

Bit 51	Meaning
0	Approach Mode Not Active
1	Approach Mode Active

c. If appropriate information is not available to indicate whether or not the Approach Mode is active, then the transponder **shall** set Bit 51 to ZERO (0).

2.2.25.5.2.5 Reserved Bits (52, 53)

Bits 52 and 53 of Register 40_{16} "MB" field **shall** be set to ZERO (0).

2.2.25.5.2.6 Target Altitude Bits

2.2.25.5.2.6.1 Status of Target Altitude Source Bits (Bit 54)

Bit 54 **shall** indicate whether the Target Altitude Source bits (55 and 56) are actively being populated (e.g., set) in Register 40_{16} in accordance with the following table:

Table 2.2.25.5.2.6.1: Status of Target Altitude Source Bits (Bit 54) Encoding

Bit 48	Meaning
0	No Source Information Provided
1	Source Information Deliberately Provided

Essentially, if information is provided to the transponder to set either bit 55 or 56 (or both) to either "0" or "1", then Bit 54 **shall** be set to ONE (1). Otherwise, Bit 54 **shall** be set to ZERO (0).

2.2.25.5.2.6.2 Target Altitude Source Bits (55, 56)

a. The transponder **shall** accept information from an appropriate interface that indicates the origin of the intended aircraft target altitude in accordance with the following table:

Table 2.2.25.5.2.6.2: Target Altitude Source (Bit 55, 56) Encoding

Bit 55, 56	Meaning
0 0	Unknown
0 1	Aircraft Altitude
1 0	FCU / MCP Selected Altitude
1 1	FMS Selected Altitude

b. Alternatively, the transponder may accept information from an appropriate interface or source and use such information to determine the encoding of bits 55, 56 in accordance with the table provided in §2.2.25.4.2.6.2.a.

c. If appropriate information is not available to establish the encoding given in either §2.2.25.4.2.6.2.a. or §2.2.24.4.2.6.2.b, then bits 55 and 56 of Register 40_{16} "MB" field **shall** be set to ZERO (0).

2.2.25.5.3 Minimum Update Interval of Register 40_{16}

a. The minimum update interval at which Register 40_{16} **shall** be reloaded with valid data is **1.0** second.

Note: *Register 40_{16} is updated at least once every **1.0** seconds.*

b. The time between availability of data that causes a change in Register 40_{16} and the time that the change is made to Register 40_{16} **shall** be less than the minimum update interval specified as **1.0** seconds.

c. If Altitude Control Panel (MCP /FCU) Selected Altitude in Register 40_{16} "MB" field bits 2 -through- 13 cannot be updated with valid data within **2.0** seconds (e.g., twice the specified minimum update interval of **1.0** seconds), then Status Bit 1 **shall** be set to ZERO (0) and bits 2 -through- 13 **shall** be set to ZERO (0).

d. If FMS Selected Altitude in Register 40_{16} "MB" field bits 15 -through- 26 cannot be updated with valid data within **2.0** seconds (e.g., twice the specified minimum update interval of **1.0** seconds), then Status Bit 14 **shall** be set to ZERO (0) and bits 15 -through- 26 **shall** be set to ZERO (0).

e. If Barometric Pressure Setting in Register 40_{16} "MB" field bits 28 -through- 39 cannot be updated with valid data within **2.0** seconds (e.g., twice the specified minimum update interval of **1.0** seconds) then Status Bit 27 **shall** be set to ZERO (0) and bits 28 -through- 39 **shall** be set to ZERO (0).

f. If the FMS Vertical Mode Bits in Register 40_{16} "MB" field bits 48 -through- 51 cannot be updated with valid data within **2.0** seconds (e.g., twice the specified minimum update interval of **1.0** seconds), then bits 48 -through- 51 **shall** be set to ZERO (0).

g. If the Target Altitude Bits in Register 40_{16} "MB" field bits 54 -through- 56 cannot be updated with valid data within **2.0** seconds (e.g., twice the specified minimum update interval of **1.0** seconds), then bits 54 -through- 56 **shall** be set to ZERO (0).

2.2.25.6 Register 50_{16} – Track and Turn Report

2.2.25.6.1 Purpose and Introduction

a. Transponders shall format Register 50_{16} as defined in Appendix B, Table B-3-80.

b. The transponder **shall** comply with all constraints and requirements for servicing Register 50_{16} that are provided in Appendix B, Table B-3-80.

2.2.25.6.2 Register 50_{16} – Data Requirements

2.2.25.6.2.1 Roll Angle

a. The transponder **shall** process Roll Angle data from on-board aircraft data sources as provided in Appendix B, Table B-3-80 of the Register 50_{16} definition table and format the data into bits 2 -through- 11 of the Register 50_{16} "MB" field as shown in that table.

b. Bits 2 –through- 11 shall be encoded using two's complement coding.

c. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

d. Status Bit 1 **shall** be set to ONE (1) whenever valid data is available in bits 2 -through- 11.

e. Status Bit 1 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 2 -through- 11.

f. Bits 2 –through- 11 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.6.2.2 True Track Angle

a. The transponder **shall** process True Track Angle data from on-board aircraft data sources as provided in Appendix B, Table B-3-80 of the Register 50_{16} definition table and format the data into bits 13 -through- 23 of the Register 50_{16} "MB" field as shown in that table.

b. Bits 13 –through- 23 shall be encoded using two's complement coding.

c. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

d. Status Bit 12 **shall** be set to ONE (1) whenever valid data is available in bits 13 -through- 23.

e. Status Bit 12 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 13 -through- 23.

f. Bits 13 -through- 23 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.6.2.3 Ground Speed

a. The transponder **shall** process Ground Speed data from on-board aircraft data sources as provided in Appendix B, Table B-3-80 of the Register 50_{16} definition table and format the data into bits 25 -through- 34 of the Register 50_{16} "MB" field as shown in that table.

b. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

c. Status Bit 24 **shall** be set to ONE (1) whenever valid data is available in bits 25 -through- 34.

d. Status Bit 24 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 25 -through- 34.

e. Bits 25 –through- 34 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.6.2.4 Track Angle Rate

a. The transponder **shall** process Track Angle Rate data from on-board aircraft data sources as provided in Appendix B, Table B-3-80 of the Register 50_{16} definition table and format the data into bits 36 -through- 45 of the Register 50_{16} "MB" field as shown in that table.

b. Bits 36 –through- 45 shall be encoded using two's complement coding.

c. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

d. Status Bit 35 **shall** be set to ONE (1) whenever valid data is available in bits 36 -through- 45.

e. Status Bit 35 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 36 -through- 45.

f. Bits 36 -through- 45 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.6.2.5 True Airspeed (TAS)

a. The transponder **shall** process True Airspeed (TAS) data from on-board aircraft data sources as provided in Appendix B, Table B-3-80 of the Register 50_{16} definition table and format the data into bits 47 -through- 56 of the Register 50_{16} "MB" field as shown in that table.

b. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

c. Status Bit 46 **shall** be set to ONE (1) whenever valid data is available in bits 47 -through- 56.

d. Status Bit 46 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 47 -through- 56.

e. Bits 47 –through- 56 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.6.3 Minimum Update Interval of Register 50_{16}

a. The minimum update interval at which Register 50_{16} **shall** be reloaded with valid data is **1.3** seconds.

Note: *Register 50_{16} **is** updated at least once every **1.3** seconds.*

b. The time between availability of data that causes a change in Register 50_{16} and the time that the change is made to Register 50_{16} **shall** be less than the minimum update interval specified as 1.3 seconds.

c. If Roll Angle data in Register 50_{16} "MB" field bits 2 -through- 11 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified minimum update interval of 1.3 seconds) then Status Bit 1 **shall** be set to ZERO (0) and bits 2 -through- 11 **shall** be set to ZERO (0).

d. If True Track Angle data in Register 50_{16} "MB" field bits 13 -through- 23 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified minimum update interval of 1.3 seconds), then Status Bit 12 **shall** be set to ZERO (0) and bits 13 -through- 23 **shall** be set to ZERO (0).

e. If Ground Speed data in Register 50_{16} "MB" field bits 25 -through- 34 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified minimum update interval of 1.3 seconds) then Status Bit 24 **shall** be set to ZERO (0) and bits 25 -through- 34 **shall** be set to ZERO (0).

f. If Track Angle Rate data in Register 50_{16} "MB" field bits 36 -through- 45 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified minimum update interval of 1.3 seconds) then Status Bit 35 **shall** be set to ZERO (0) and bits 36 -through- 45 **shall** be set to ZERO (0).

g. If True Airspeed (TAS) data in Register 50_{16} "MB" field bits 47 -through- 56 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified minimum update interval of 1.3 seconds) then Status Bit 46 **shall** be set to ZERO (0) and bits 47 -through- 56 **shall** be set to ZERO (0).

2.2.25.7 Register $5F_{16}$ – Quasi-Static Parameter Monitoring (Optional)

Note: *Enhanced Surveillance does not require that Register $5F_{16}$ be serviced. However, servicing of Register $5F_{16}$ **is implicitly** required when servicing Register 40_{16} in ICAO Doc. 9871 and Appendix B. Therefore, **if** Register $5F_{16}$ is serviced, the following subparagraphs need to be complied with.*

2.2.25.7.1 Purpose and Definition

a. Transponders shall format Register $5F_{16}$ as defined in Appendix B, Table B-3-80.

b. The transponder **shall** comply with all constraints and requirements for servicing Register $5F_{16}$ that are provided in Appendix B, Table B-3-95.

2.2.25.7.2 Enhanced Surveillance Servicing Requirements Associated with Register $5F_{16}$

2.2.25.7.2.1 Due to MCP / FCU Selected Altitude

a. Register $5F_{16}$ bits 1 – 2 **shall** be set to "00" whenever MCP / FCU Selected Altitude data is not available to set bits 1 -through- 13 of Register 40_{16}.

b. Whenever a change is detected in the MCP / FCU Selected Altitude data used to set bits 1 -through- 13 of Register 40_{16}, the Register $5F_{16}$ bits 1 – 2 **shall** be incremented by one.

Note 1: *Effectively, the decimal count is as follows: 1, 2, 3, -- 1, 2, 3, etc.*

Note 2: *The binary equivalent setting bits 1,2 is as follows: 01, 10, 11, -- 01, 10, 11, etc.*

2.2.25.7.2.2 Due to FMS Selected Altitude

a. Register $5F_{16}$ bits 23 – 24 **shall** be set to "00" whenever FMS Selected Altitude data is not available to set bits 14 -through- 26 of Register 40_{16}.

b. Whenever a change is detected in the FMS Selected Altitude data used to set bits 14 -through- 26 of Register 40_{16}, the Register $5F_{16}$ bits 23 – 24 **shall** be incremented by one.

Note 1: *Effectively, the decimal count is as follows: 1, 2, 3, -- 1, 2, 3, etc.*

Note 2: *The binary equivalent setting bits 23 – 24 is as follows: 01, 10, 11, -- 01, 10, 11, etc.*

2.2.25.7.2.3 Due to Barometric Pressure Setting

a. Register $5F_{16}$ bits 25 – 26 **shall** be set to "00" whenever Barometric Pressure Setting data is not available to set bits 27 -through- 39 of Register 40_{16}.

b. Whenever a change is detected in the Barometric Pressure Setting data used to set bits 27 -through- 39 of Register 4016, the Register $5F_{16}$ bits 25 – 26 **shall** be incremented by one.

Note 1: *Effectively, the decimal count is as follows: 1, 2, 3, -- 1, 2, 3, etc.*

Note 2: *The binary equivalent setting bits 25 – 26 is as follows: 01, 10, 11, -- 01, 10, 11, etc.*

2.2.25.7.2.4 Due to FMS Vertical Mode

a. Register $5F_{16}$ bits 17 – 18 **shall** be set to "00" whenever Barometric Pressure Setting data is not available to set bits 48 -through- 51 of Register 40_{16}.

b. Whenever a change is detected in the FMS Vertical Mode data used to set bits 48 -through- 51 of Register 40_{16}, the Register $5F_{16}$ bits 17 – 18 **shall** be incremented by one.

Note 1: *Effectively, the decimal count is as follows: 1, 2, 3, -- 1, 2, 3, etc.*

Note 2: *The binary equivalent setting bits 17 – 18 is as follows: 01, 10, 11, -- 01, 10, 11, etc.*

2.2.25.7.2.5 Other Register $5F_{16}$ Bits

Register $5F_{16}$ bits 3 -through- 16, 19 -through- 22, and 27 -through- 56 **shall** be set to ZERO (0) until such time that the respective parameters identified in Appendix B, Table B-3-95 are being monitored.

2.2.25.7.3 Minimum Update Interval of Register $5F_{16}$

a. The minimum update interval at which Register $5F_{16}$ **shall** be reloaded with valid data is **0.5** seconds.

Note: *Register $5F_{16}$ is updated at least once every **0.5** seconds.*

b. The time between availability of data that causes a change in Register $5F_{16}$ and the time that the change is made to Register $5F_{16}$ **shall** be less than the minimum update interval specified as **0.5** seconds.

c. If a particular data field in Register $5F_{16}$ cannot be updated within 1.0 seconds (e.g., twice the specified minimum update interval of 0.5. seconds, then the data field **shall** be ZEROed (i.e., binary "00")

2.2.25.8 Register 60_{16} – Heading and Speed Report

2.2.25.8.1 Purpose and Definition

a. Transponders shall format Register 60_{16} as defined in Appendix B, Table B-3-96.

b. The transponder **shall** comply with all constraints and requirements for servicing Register 60_{16} that are provided in Appendix B, Table B-3-96.

2.2.25.8.2 Data Requirements

2.2.25.8.2.1 Magnetic Heading

a. The transponder **shall** process Magnetic Heading data from on-board aircraft data sources as provided in Appendix B, Table B-3-96 of the Register 60_{16} definition table and format the data into bits 2 -through- 12 of the Register 60_{16} "MB" field as shown in that table.

b. Bits 2 –through- 12 shall be encoded using two's complement coding.

c. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

d. Status Bit 1 **shall** be set to ONE (1) whenever valid data is available in bits 2 -through- 12.

e. Status Bit 1 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 2 -through- 12.

f. Bits 2 -through- 12 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.8.2.2 Indicated Airspeed

a. The transponder **shall** process Indicated Airspeed data from on-board aircraft data sources as provided in Appendix B, Table B-3-96 of the Register 60_{16} definition table and format the data into bits 14 -through- 23 of the Register 60_{16} "MB" field as shown in that table.

b. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

c. Status Bit 13 **shall** be set to ONE (1) whenever valid data is available in bits 14 -through- 23.

d. Status Bit 13 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 14 -through- 23.

e. Bits 14 -through- 23 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.8.2.3 Mach

a. The transponder **shall** process Mach data from on-board aircraft data sources as provided in Appendix B, Table B-3-96 of the Register 60_{16} definition table and format the data into bits 25 -through- 34 of the Register 60_{16} "MB" field as shown in that table.

b. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

c. Status Bit 24 **shall** be set to ONE (1) whenever valid data is available in bits 25 -through- 34.

d. Status Bit 24 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 25 -through- 34.

e. Bits 25 -through- 34 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.8.2.4 Barometric Altitude Rate

a. The transponder **shall** process Barometric Altitude Rate data from on-board aircraft data sources as provided in Appendix B, Table B-3-96 of the Register 60_{16} definition table and format the data into bits 36 -through- 45 of the Register 60_{16} "MB" field as shown in that table.

b. Bits 36 –through- 45 shall be encoded using two's complement coding.

c. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

d. Status Bit 35 **shall** be set to ONE (1) whenever valid data is available in bits 36 -through- 45.

e. Status Bit 35 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 36 -through- 45.

f. Bits 36 -through- 45 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.8.2.5 Inertial Vertical Velocity

a. The transponder **shall** process Inertial Vertical Rate data from on-board aircraft data sources as provided in Appendix B, Table B-3-96 of the Register 60_16 definition table and format the data into bits 47 -through- 56 of the Register 60_{16} "MB" field as shown in that table.

b. Bits 47 –through- 56 shall be encoded using two's complement coding.

c. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

d. Status Bit 46 **shall** be set to ONE (1) whenever valid data is available in bits 47 -through- 56.

e. Status Bit 46 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 47 -through- 56.

f. Bits 47 -through- 56 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.8.3 Minimum Update Interval of Register 60_{16}

a. The minimum update interval at which Register 60_{16} **shall** be reloaded with valid data is **1.0** second.

*Note: Register 60_{16} is updated at least once every **1.0** second.*

b. The time between availability of data that causes a change in Register 60_{16} and the time that the change is made to Register 60_{16} **shall** be less than the minimum update interval specified as **1.0** seconds.

c. If Magnetic Heading data in Register 60_{16} "MB" field bits 2 -through- 12 cannot be updated with valid data within **2.0** seconds (e.g., twice the specified minimum update interval of **1.0** seconds) then Status Bit 1 **shall** be set to ZERO (0) and bits 2 -through- 12 **shall** be set to ZERO (0).

d. If Indicated Airspeed data in Register 60_{16} "MB" field bits 14 -through- 23 cannot be updated with valid data within **2.0** seconds (e.g., twice the specified minimum update interval of **1.0** seconds) then Status Bit 13 **shall** be set to ZERO (0) and bits 14 -through- 23 **shall** be set to ZERO (0).

e. If Mach data in Register 60_{16} "MB" field bits 25 -through- 34 cannot be updated with valid data within **2.0** seconds (e.g., twice the specified minimum update interval of **1.0** seconds) then Status Bit 24 **shall** be set to ZERO (0) and bits 25 -through- 34 **shall** be set to ZERO (0).

f. If Barometric Altitude Rate data in Register 60_{16} "MB" field bits 36 -through- 45 cannot be updated with valid data within **2.0** seconds (e.g., twice the specified minimum update interval of **1.0** seconds) then Status Bit 35 **shall** be set to ZERO (0) and bits 36 -through- 45 **shall** be set to ZERO (0).

g. If Inertial Vertical Rate data in Register 60_{16} "MB" field bits 47 -through- 56 cannot be updated with valid data within **2.0** seconds (e.g., twice the specified minimum update interval of **1.0** seconds) then Status Bit 46 **shall** be set to ZERO (0) and bits 47 -through- 56 **shall** be set to ZERO (0).

2.2.26 Generic Register XX_{16} Requirements

The following subsections provide generic requirements that shall be verified when transponders implement registers that have not been defined in detail in this document.

Note: *In the following subsections,* ***"ddd"*** *means the decimal equivalent* ***to*** XX_{16}. *For instance, for* 40_{16}, ***"ddd"*** = 64_{10} = 64.

2.2.26.1 Purpose and Definition

a) Transponders **shall** format Register $\mathbf{XX_{16}}$ as defined in Appendix B, Table **B-3-ddd**.

b) The transponder **shall** comply with all constraints and requirements for servicing Register $\mathbf{XX_{16}}$ that are provided with Table **B-3-ddd** in Appendix B.

2.2.26.2 Data Requirement

2.2.26.2.1 Data Field "y"

a. The transponder **shall** process data from on-board aircraft data sources as provided in Appendix B, Table B-3-**ddd** of Register $\mathbf{XX_{16}}$ definition table and format the data into field **"y"** of the Register $\mathbf{XX_{16}}$ "MB" field as shown in that table.

b. Field **"y"** shall be encoded using two's complement coding if it is a signed arithmetic field unless otherwise specified.

c. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±1/2 LSB.

d. Status Bit of field **"y" shall** be set to ONE (1) whenever valid and up to date data (data not older than twice the maximum update interval specified in Table B-2-1 in Appendix B) is available in field **"y"**.

e. Status Bit b0 **shall** be set to ZERO (0) whenever there is no valid and up to date data with which to fill field **"y"**.

Note 1: *On an ARINC platform, when data is available in BCD and in binary, transponders will preferably use binary data rather than BCD data.*

Note 2: *When multiple sources of data are available for a given field "y", transponders will use the data source that is being used to manage the aircraft profile or the source selected by the flight crew. This general convention applies unless the highest integrity data is desired as in Automatic Dependent Surveillance – Broadcast (ADS-B). In such cases, the highest integrity source will be used for data.*

2.2.26.3 Update Rate

a. The minimum update interval at which a data field in a register **shall** be reloaded with valid data is defined for each register in Table B-1 in Appendix B.

b. The transponder **shall** load valid data into the related transponder register as soon as it becomes available at the Mode S Specific Services entity.

c. The time between availability of data that causes a change in a data-field of a register and the time that the change is made to the register **shall** be less than the minimum update interval specified in Table B-1 in Appendix B.

d. If a data-field field cannot be updated with valid data within twice the specified minimum update interval defined for the register or 2 seconds (whichever is the greater), then Status Bit (if specified) of the field **shall** be set to **"0"** (INVALID) and that data field shall be zeroed**.**

2.2.26.4 Service Reporting

a. The transponder **shall** report Mode-S Specific Services Capability Reports (installation capability) in transponder registers 18_{16} to $1C_{16}$.

b. The transponder **shall** update the common usage GICB Capability Report (transponder register 17_{16}) while periodically checking the availability of the related data.

c. The transponder **shall** promptly update the Data Link Capability Report (transponder register 10_{16} bit 25 and bit 36 and broadcast register 10_{16} in case of change in register 10_{16}.

END OF ELS/EHS/GENERIC___RHS