ESC-TR-2006-082

Project Report
ATC-334

Guidance Material for Mode S-Specific Protocol Application Avionics

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4 June 2007

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Prepared for the Department of the Air Force under Contract FA8721-05-0002.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE
4 June 2007

2. REPORT TYPE
Project Report

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE

Guidance Material for Mode S-Specific Protocol Application Avionics

5a. CONTRACT NUMBER
FA8721-05-C-0002

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Robert D. Grappel and Randall T. Wiken

5d. PROJECT NUMBER
1564

5e. TASK NUMBER
1

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES)

MIT Lincoln Laboratory
244 Wood Street
Lexington, MA 02420-9108

8. PERFORMING ORGANIZATION REPORT NUMBER

PR-ATC-334

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Department of the Air Force, ESC
5 Eglin Street
Hanscom AFB, MA 01731

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
ESC-TR-2006-082

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

This ATC report presents guidance material for the use of the "Ground-Initiated Comm. B" (GICB) register set contained in a Mode S transponder. The guidance material is intended to provide assistance for implementers of Mode S avionics installations. A common summary of the requirements and specifications for Mode S GICB transponder register data link applications is developed. While this ATC report focuses primarily on the "Elementary Surveillance" (ELS), "Enhanced Surveillance" (EHS), and "Automatic Dependent Surveillance–Broadcast" (ADS-B) applications, guidance information is also provided for general transponder configuration and architecture of other Mode S functions employing the GICB register set.

Although the information contained in this ATC report is drawn from a number of approved national and international standards, it is not intended to replace or supersede those standards documents. In the event of a conflict or contradiction between this ATC report and any approved standards (see references 1 through 6), the approved standard takes precedence and the reader is encouraged to contact the authors of this document. Reference 4 is the most-recent and complete specification for the Mode S register contents. For ease of reference, the relevant Mode S register images have been duplicated in Appendix A of this ATC report.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT Unclassified	**b. ABSTRACT** Unclassified	**c. THIS PAGE** Unclassified	Same as report	104	**19b. TELEPHONE NUMBER** *(include area code)*

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

Massachusetts Institute of Technology
Lincoln Laboratory

Guidance Material for Mode S-Specific Protocol Application Avionics

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Group 42

Project Report ATC-334

4 June 2007

Lexington Massachusetts

EXECUTIVE SUMMARY

This ATC report discusses the three main applications of the Mode S-Specific Protocols (MSP) that are currently being fitted to aircraft and ground systems worldwide and are being considered for future military and civilian functions. It also seeks to provide a common summary of the requirements and specifications for the Mode S avionics employed in these applications. The three MSP applications described in this ATC report are:

- ELS Elementary Surveillance;
- EHS Enhanced Surveillance; and
- ADS-B Automatic Dependent Surveillance Broadcast ADS-B (implemented in Mode S as 1090 MHz "Extended Squitter" (ES)).

Elementary Surveillance

ELS support is required by the European Mode S mandate. Support of ELS consists primarily of populating and maintaining four Mode S transponder registers:

- 10_{16} Data Link Capability Report;
- 17_{16} Common-Usage Ground-Initiated Comm B (GICB) Capability Report;
- 20_{16} Aircraft Identification Register; and
- 30_{16} Airborne Collision Avoidance System (ACAS) Resolution Advisory (RA).

The first two of these registers form the basis for the transponder configuration, register extraction, and fault-detection protocols used by all MSP applications. There are several other registers used to configure a Mode S transponder for varying levels of data link applications, but the two basic transponder registers (10_{16} and 17_{16}) are sufficient for the application set described in this ATC report. The later two of the ELS-required transponder registers provide the aircraft flight identification (20_{16}) and information about the state of the onboard ACAS equipment (30_{16}). The definition, specification, and content of the ELS application data is well defined and quite mature.

It should be noted that the European ELS mandate also includes the requirement to support the Mode S Surveillance Identifier (SI) code protocol. The SI protocol provides for additional interrogator codes and therefore supports a higher level of overlapping coverage by multiple Mode S ground sensors. This is seen as an immediate need in European airspace. The only impact of the use of SI codes discussed in this ATC report is the setting of the SI bit in the Data Link Capability Report (register 10_{16}).

Enhanced Surveillance

EHS support is required by the European Mode S mandate. Support of EHS consists of populating and maintaining three Mode S transponder registers beyond those required for ELS:

40_{16} Selected Vertical Intention;

50_{16} Track and Turn Report; and

60_{16} Heading and Speed Report.

These Mode S registers are intended to support improved ATC systems where knowledge of the aircraft's intended flight path can be used to supplement surveillance tracking. The data fields in these registers are simply a reformatting of values expected to already exist in the aircraft on its ARINC 429 data buses or equivalent information from data buses on aircraft not equipped with ARINC buses. The register definitions provide a status bit for each data field. A particular avionics suite may provide a subset of the data available from its onboard flight management system or other avionics. Register 40_{16} is the most complex of the EHS register set, since it uses a wide variety of data sources. Different aircraft configurations (e.g., Boeing versus Airbus) may need to set the data fields in this register differently, depending on the particular data sources and pilot control inputs available in the particular avionics.

It should be noted that the definition of the contents of register 40_{16} has been redefined from an earlier version that sought to provide 3-dimensional intent information in a single register. The current register 40_{16} definition has been limited to vertical intent only as this is the data with the most immediate ATC application.

Automatic Dependent Surveillance – Broadcast

The specification of the Mode S ADS-B (1090 MHz Extended Squitter) application is by far the most complex of the MSP applications described in this ATC report; its description occupies nearly half the pages. One reason for this complexity is simply the number of registers defined for this application. There are six "basic" 1090 MHz ES ADS-B registers (five more "event-driven" ADS-B registers will be discussed later):

05_{16} ES Airborne Position;

06_{16} ES Surface Position;

07_{16} ES Status;

08_{16} ES Identification and Type;

09_{16} ES Airborne Velocity; and

$0A_{16}$ ES Event-Driven Information.

Note that the 1090 MHz ES ADS-B application separates position from velocity data in the airborne case. This is done because there are not enough bits in a given Mode S transponder register to fully encode both position and velocity in three dimensions. A separate register is defined for the surface case that incorporates both position and velocity fields. The ADS-B “aircraft identification and type” register (08_{16}) parallels the aircraft identification register (20_{16}) defined for the ELS application. The rationale for this apparent duplication of data is that ELS registers are extracted through an interrogation by an external Mode S interrogator, while ADS-B registers are spontaneously broadcast (squittered). No interrogation is required to receive the ADS-B data. In addition, register (08_{16}) also contains aircraft type information that is not contained in register (20_{16}).

A second reason for the complexity of the Mode S ADS-B definition is that two different versions of the specification are currently being maintained. The original specification (termed “Version 0”) is given in Radio Technical Commission for Aeronautics (RTCA) DO-260 originally published in 2000. A newer specification (termed “Version 1”) is given in RTCA DO-260A originally published in 2003. The Version 1 formats are fully compatible with the Version 0 formats, in that a receiver built to either standard can correctly receive and process ADS-B messages generated by transmitting equipment built to either standard. Version 1 differs from Version 0 in two areas: (a) its specification of the ADS-B “event-driven” transponder register set, and (b) how available avionics surveillance accuracy is specified.

The five Mode S 1090 MHz ES ADS-B “event-driven” transponder registers extend the basic set of broadcast data to include slowly changing values or rare events that need not be continuously broadcast. As was the case for aircraft identification, this broadcast mechanism parallels the operation of other Mode S transponder registers whose contents are obtained by interrogation/extraction. The 1090 MHz ES ADS-B “event-driven” register set is:

- 61_{16} ES Emergency Priority Status;
- 62_{16} Current Trajectory Change Point in Version 0, reserved for target state and status information in Version 1;
- 63_{16} Next Trajectory Change Point in Version 0, not used in Version 1;
- 64_{16} Aircraft Operational Coordination Message in Version 0, not used in Version 1; and
- 65_{16} ES Aircraft Operational Status.

The ES Emergency Priority Status data in register 61_{16} parallels that in ELS register 30_{16}, and the aircraft’s emergency state may also be obtained via direct Mode S surveillance. The data in registers 62_{16} and 63_{16} was defined to provide long-term aircraft intent information for potential conflict detection and resolution algorithms to be supported via 1090 ES. Again, this data is equivalent to that defined in other registers whose contents may be obtained via direct Mode S interrogation/extraction. Support for registers 62_{16} and 63_{16} was removed from the Version 1 definition of 1090 MHz ES ADS-B. Register 64_{16} was envisaged to support various “paired” aircraft applications (formation flying). It is also no longer supported in Version 1. The definition of register 65_{16} has been greatly expanded in Version 1 to support various potential airborne and surface operations.

As was indicated above, there are a number of registers and data fields defined for the 1090 MHz ES ADS-B application that parallel data available elsewhere in the Mode S transponder registers. The 1090 ES ADS-B broadcast (squitter) protocol is seen by its designers to operate independently from applications employing Mode S interrogation/extraction (e.g., ELS and EHS). Also, it is seen that the set of 1090 ES ADS-B supported applications is quite fluid and undergoing change. The requirements for support of ADS-B applications beyond the "basic" set (position, velocity, and identification) are not yet completely firm.

Also, the Version 0 and Version 1 definitions of 1090 MHz ES ADS-B differ in how the available avionics surveillance accuracy is specified. Version 0 avionics use a "navigation uncertainty category" (NUC), while Version 1 avionics provide a "navigation accuracy category" (NAC), a "navigational integrity category" (NIC), and a "surveillance integrity level" (SIL). Version 1 also re-defines the usage and contents of the "event-driven" register set.

ELS/EHS/ADS-B Summary

In summary, the Mode S ELS and EHS applications as required by the European mandate are mature and stable. Equipping for these Mode S applications is relatively straightforward. The source of data for the ELS and EHS registers is largely the aircraft's ARINC-429 buses or equivalent information from data buses on aircraft not equipped with ARINC buses. The task of populating the required Mode S registers is primarily a reformatting process.

The case of the Mode S 1090 MHz ES ADS-B application is somewhat different from the ELS and EHS applications. The 1090 MHz ES ADS-B application is more complex than ELS and EHS. This additional complexity arises from several areas:

- The 1090 MHz ADS-B application requires more Mode S transponder register definitions than ELS and EHS;
- There are two application specification versions for 1090 MHz ES ADS-B; and
- The data formatting and control protocols required for 1090 MHz ES ADS-B are more complex than those used in ELS and EHS.

There is no current equipage mandate for 1090 MHz ES ADS-B systems. There is a prototype ADS-B implementation in Alaska (project Capstone) using the Universal Access Transceiver (UAT). An operational ADS-B surveillance system using 1090 MHz ES exclusively (conforming to the specification in [6]) is currently being installed in Australia. Some air-to-air usage of 1090 MHz ES messages to augment TCAS is also underway. The operational concepts for ADS-B applications are less stable than those for ELS and EHS, and these operational concepts are likely to evolve as they mature.

PREFACE

This ATC report is the result of research and development sponsored by the United States Air Force (USAF) 853rd Electronic Systems Group at Hanscom Air Force Base, MA. The authors have prepared this report to assist the USAF in the task of equipping their aircraft with appropriate Mode S avionics to support the European mandate for “Elementary Surveillance” (ELS) and “Enhanced Surveillance” (EHS) applications.

The authors wish to acknowledge the many writers and reviewers who prepared references 1 through 6, from which this ATC report derives much of its material. The authors would like to thank the reviewers who provided many significant comments and corrections on drafts of this ATC report, with special thanks to Bill Thedford, Eric Potier, Mikael Ponnau, Bob Saffell, Dieter Kunze, Richard Bush, Vincent Orlando, Ann Drumm, Val Heinz, and Garrett Harris. Finally, the authors acknowledge the input from the “European Organisation for Civil Aviation Equipment” (EUROCAE) “Mode S Enhanced Surveillance” Working Group 49 who provided valuable comments on this text.

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1. INTRODUCTION

This ATC report presents guidance material for the use of the "Ground-Initiated Comm. B" (GICB) transponder register set within a Mode S avionics installation. The intent of this ATC report is to reduce the effect of complexity in various implementations of Mode S transponder applications resulting from the number of documentation sources and revisions that have occurred over time. This ATC report combines information from several sources, including references 1 through 6) into a single and organized entity. It focuses on the "Elementary Surveillance" (ELS), "Enhanced Surveillance" (EHS), and "Automatic Dependent Surveillance–Broadcast" (ADS-B, also called 1090 MHz Extended Squitter when implemented in Mode S) applications, as well as support of military surveillance functions. The information in this ATC report will also help in the development of other Mode S data link applications.

Section 2 of this ATC report discusses the configuration settings in the aircraft Mode S transponder and avionics required to support Mode S data link applications such as ELS, EHS, and ADS-B. Section 3 goes on to describe the protocols employed by Mode S data link applications to determine the avionics configuration and to deal with changes in configuration due to equipment failures. Section 4 describes the additional Mode S transponder register support required for the ELS application. Section 5 describes the additional registers required for the EHS application. Section 6 describes the additional registers and associated protocols required for the Mode S 1090 MHz Extended Squitter (ADS-B) application. Finally, Section 7 describes the additional registers used to support military surveillance applications.

Although the information provided in this ATC report is drawn from several approved national and international standards, it is not intended to replace or supersede those standards. Rather, this report is meant to provide guidance for system implementers. In the event of a conflict or contradiction between this document and any approved standards (see references 1 through 6), the approved standards take precedence and the reader is encouraged to contact the authors of this report. Reference 4 is the most-recent and complete specification for the Mode S register contents. For ease of reference, the relevant Mode S register images have been duplicated in Appendix A of this document.

Note: This document contains many references to Mode S transponder registers. Following international documentation standards, they are listed as hexadecimal numbers. In this document, register numbers are stated as hexadecimal values (subscript 16). (Note: Some international standards use a comma-notation to represent hexadecimal transponder register numbers without requiring subscripts.) Also, there are many references to ARINC 429 labels, which are expressed herein in octal (subscript 8).

Figure 1-1 illustrates the organization and basic data flows for the subset of the registers used in the ELS, EHS, ADS-B, and military applications.

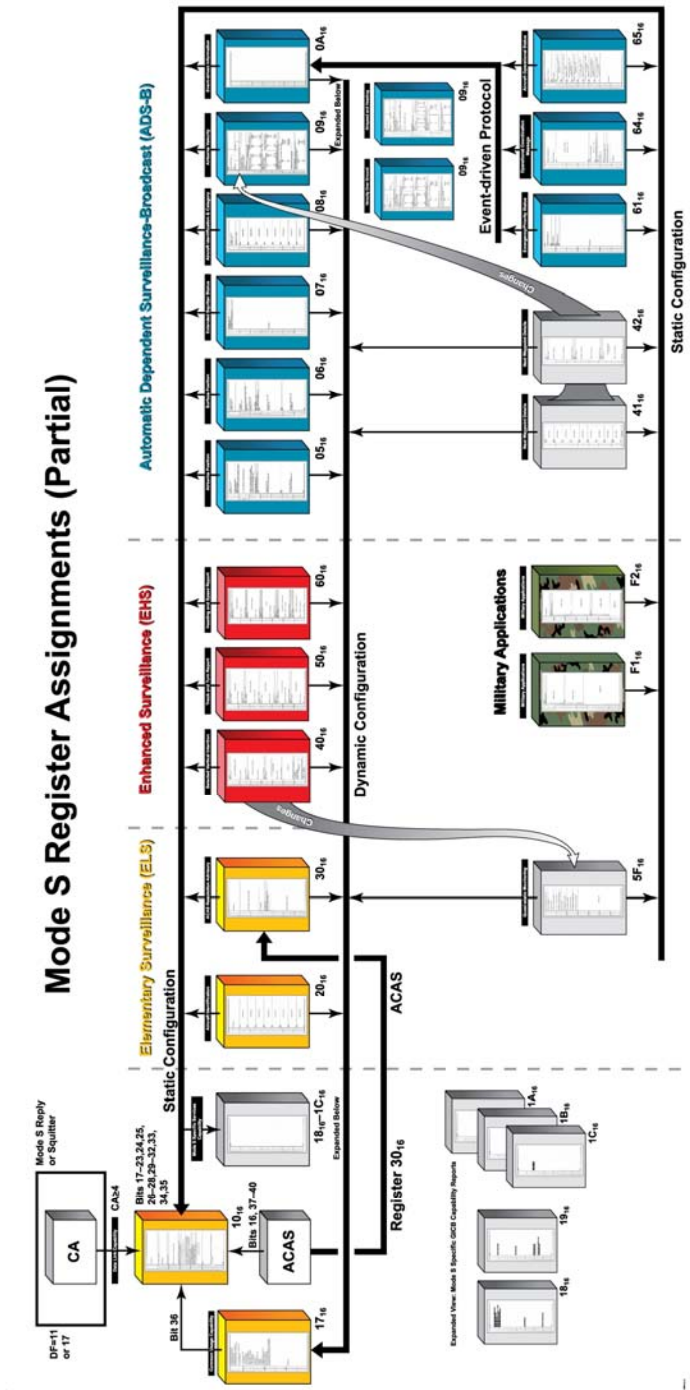

Figure 1-1. Mode S Register Assignments for ELS, EHS, and ADS-B.

Figure 1-1 illustrates the organization and basic data flows for the subset of the registers used in the ELS, EHS, ADS-B, and military applications. Color-coding is used to group the registers by application: ELS (yellow), EHS (red), ADS-B (blue), and military (green). Registers shown in gray are indirectly involved with these applications, but are not directly called out by the application specification. The figure employs thick arrows to denote the transponder static and dynamic configuration data flows and the ADS-B event-driven protocol.

2. AVIONICS CONFIGURATION SETTINGS

This section describes the various registers used to specify the configuration of the Mode S avionics with respect to the various Mode S applications (e.g., ELS, EHS, and ADS-B) that might be installed on the aircraft. Two sets of these registers (the Mode S-Specific services GICB capability reports and the "Mode S-Specific Protocol" [MSP] capability reports) are static and simply indicate the airborne configuration. Two other configuration registers (the common usage GICB capability report and the data link capability report) combine static configuration information with dynamic status information on the timeliness of data within certain other registers. Combined with the "configuration and failure protocols" described in Section 3 below, these registers allow the sensor extracting data from the transponder to ascertain which data values are valid in the transponder's registers.

2.1 MODE S-SPECIFIC SERVICES GICB CAPABILITY REPORTS (REGS. 18_{16}...$1C_{16}$)

Registers 18_{16} though $1C_{16}$ are used to specify which of the 255 possible registers are actually implemented in the particular avionics configuration. (Register number zero is reserved.) Note that these capability bits indicate only that the avionics are configured to be able to load the indicated register – these bits do not indicate whether the register is, in fact, being loaded in a timely manner. The indication of timely data is performed for "important" register applications via the "common usage capability report" register 17_{16} (see Section 2.3 below). If there is no bit assigned in register 17_{16} for the particular register of interest, then a status bit (or bits) within the particular register itself must to be tested to determine if the register is being loaded appropriately.

The installed capability for registers is indicated by setting the appropriate bit corresponding to the given register in the GICB Capability Report register as indicated in Table 2-1. The bit position numbering for each register capability bit starts with the least significant bit (LSB, bit 56) of each register. The 25 most-significant bits in register $1C_{16}$ are not used.

TABLE 2-1
Register Configuration Bit Assignments in Mode S-Specific Services GICB Capability Reports

First GICB	Last GICB	Capability Register
01_{16}	38_{16}	18_{16}
39_{16}	70_{16}	19_{16}
71_{16}	$A8_{16}$	$1A_{16}$
$A9_{16}$	$E0_{16}$	$1B_{16}$
$E1_{16}$	FF_{16}	$1C_{16}$

2.2 MODE S-SPECIFIC SERVICES MSP CAPABILITY REPORTS (REGS. $1D_{16}..1F_{16}$)

Registers $1D_{16}$ through $1F_{16}$ contain bits that indicate which (if any) of the 63 uplink and the 63 downlink MSP channels are supported by the particular avionics installation. (Note: These functions are not required for the support of ELS, EHS, or ADS-B 1090 Squitter). Example MSP functions include the "Traffic Information Service" [TIS uplink channel 2] and ACAS sensitivity control [uplink channel 5].) The bits in the Mode S-Specific services MSP capability report registers simply indicate the avionics configuration, not whether the particular MSP functions are currently operational.

Within each of the Mode S-Specific services MSP capability reports, the high-order 28 bits of each register are used to specify the configuration state of uplink MSP channels, while the low-order 28 bits of each register are used to indicate the configuration state of the corresponding downlink MSP channels. Register $1D_{16}$ indicates the configuration status of MSP channels 1 through 28 (uplink and downlink). Register $1E_{16}$ indicates the configuration status of MSP channels 29 through 56. Register $1F_{16}$ indicates the configuration status of MSP channels 57 through 63. The remaining bits in register $1F_{16}$ are unused.

2.3 COMMON USAGE GICB CAPABILITY REPORT (REG. 17_{16})

Register 17_{16} contains a series of bit flags that indicate the status of a subset of the Mode S transponder's registers expected to be the most likely to be implemented. All of the registers involved with the ELS, EHS, and ADS-B applications of Mode S have bit flags assigned in this register. These bit flags partly parallel the similar bit flags in the Mode S-Specific Services GICB Capability Reports – they cannot be set unless the avionics configuration supports the particular register. Providing a single capability register for all the "commonly used" registers allows a sensor to obtain all the configuration information it needs for a given aircraft with a single GICB register extraction – instead of having to pick bits from multiple registers in the range 18_{16} through $1C_{16}$ for each register that is of interest to the sensor.

Unlike the bit flags in the Mode S-Specific Services GICB Capability Report registers, the bit flags in the "common usage" GICB capability report are not a static indication of whether the particular register is installed in the aircraft's avionics. Rather, the bit flags in register 17_{16} are dynamic – if set, they indicate that the particular register has been updated in a timely manner and contains valid data. All registers having bit flags in register 17_{16} are continually monitored at a rate consistent with the update rate required for the individual register. The bit flag is set to '1' by the transponder only if valid data is being input to that register at the required rate.

The bit flag in register 17_{16} for a given register is set to '1' if at least one data field in that register is receiving valid data at the required rate. The data field status bits in the given register itself indicate which of the data items in the register are current and valid. Each of the EHS registers contain several data items, therefore to ensure compliance with the European mandates it is important to verify that each field status bit is set, and then verify that the bits in each of the data fields are set to some non-zero value. For completeness, a final check should compare the values in those data fields with an independent surveillance source, such as radar, to verify that the values are correctly reporting the aircraft's state.

There is a bit in the "data link capability report" (see Section 2.4 below) combined with an avionics protocol (see Section 3.0 below) that is used to signal changes in the contents of register 17_{16} (indicating loss or recovery of timely data in one or more registers being supported in the avionics). The sensor will, in absence of avionics failures, only have to extract the contents of register 17_{16} once.

2.4 DATA LINK CAPABILITY REPORT (REG. 10_{16})

The Data Link Capability Report (Reg. 10_{16}) is the root source of configuration and operational status information for the Mode S avionics system. Register 10_{16} contains subfields that describe the capabilities and operational status of the Mode S transponder itself, its support for Mode S data link applications (e.g., ACAS, ADS-B, etc.) and its support for the Mode S sub network of the Aeronautical Telecommunications Network (ATN). This section discusses primarily those subfields of the Data Link Capability Report register that are pertinent to the ELS, EHS, and ADS-B applications. See [3] and [4] for a complete definition of the contents of this register.

The first eight bits of register 10_{16} contain the fixed value "10_{16}" – used to identify the Data Link Capability Report when it is broadcast via the air-initiated Comm-B protocol. A Mode S transponder broadcasts the contents of register 10_{16} whenever its contents change (indicating some sort of change and/or failure or recovery mode in the Mode S avionics). Bit 24 of register 10_{16} is used to indicate whether the Mode S transponder can support the "enhanced protocol" of Mode S – the ability to perform extended length message (ELM) transactions with more than one sensor simultaneously. Bit 35 of register 10_{16} is used to indicate whether the Mode S transponder can support the "surveillance identifier" (SI) code extension to the Mode S link protocols. Bits 26 through 28 of register 10_{16} are used to indicate the rate at which the Mode S transponder can perform uplink ELM transactions. Bits 29 through 32 of register 10_{16} are used to indicate the rate at which the Mode S transponder can perform downlink ELM transactions. All of these static configuration settings are functions of the Mode S transponder capabilities. (Note: The ELS, EHS, and ADS-B Mode S data link applications of Mode S do not employ ELM transactions [either uplink or downlink] or the "enhanced protocol.")

Bit 25 of register 10_{16} is used to indicate whether the Mode S avionics are configured with any Mode S-Specific service applications. These applications include extraction of any registers excepting 02_{16} through 04_{16}, 10_{16}, 17_{16} through $1C_{16}$, 20_{16}, and 30_{16}. They also include any MSP applications as discussed in Section 2.2 above. This is a static bit indicating the avionics configuration.

Bit 33 of register 10_{16} is used to indicate whether the Mode S avionics are configured to support the extraction of aircraft identification (Reg. 20_{16}). If this bit is set statically, it mirrors bit 25 of register 18_{16}. However, it is preferable to set this bit dynamically to mirror bit 7 of register 17_{16} (which indicates that the aircraft identification is currently valid). Section 4.1 describes the contents of register 20_{16}.

Bit 34 of register 10_{16} is used to indicate whether the Mode S avionics are configured to support ADS-B squitter applications. Bit 34 is set if both the airborne and surface position registers (05_{16} and 06_{16}) have been updated within the last ten seconds. Hence, the setting of bit 34 is dynamic and equivalent to the "and" of bits 1 and 2 of register 17_{16} (bits 1 and 2 indicate the configuration of registers 05_{16} and 06_{16} respectively). Section 6 describes the ADS-B squitter register contents.

Bit 36 of register 10_{16} is used to indicate whether the contents of the common usage capability register 17_{16} (see Section 2.3 above) have changed. Such a change indicates some sort of failure or recovery mode in the Mode S avionics. Bit 36 is toggled each time the content of register 17_{16} changes. By changing the value of bit 36 in register 10_{16}, a downlink of the data link capability report (via the air-initiated Comm B broadcast protocol) is generated – sensors do not need to poll the register contents to detect failures or recovery events in the Mode S avionics. To avoid generation of too many broadcasts of the data link capability report, register 17_{16} is sampled at a 1-minute rate to detect changes. A further discussion of the protocols for extracting and monitoring the configuration and failure status of an aircraft's Mode S avionics is given in Section 3.0 below.

Bits 16 and 37 through 40 of register 10_{16} are used as bit flags to indicate the status of an ACAS application that might be installed as part of the aircraft's Mode S avionics. Table 2-2 defines the use of these ACAS bit flags.

TABLE 2-2

ACAS Configuration Bits in Data Link Capability Register (10_{16})

Bit No.	Usage
16	0 ➔ ACAS failed or in standby 1 ➔ ACAS operational
37	0 ➔ ACAS II 1 ➔ ACAS III (reserved)
38	0 ➔ ACAS generating TAs only 1 ➔ ACAS generating TAs and RAs
39	0 ➔ no ACAS onboard 1 ➔ ACAS onboard
40	Reserved for ACAS

Bits 17 through 23 of register 10_{16} are used to denote the documentation version of International Civil Aviation Organization (ICAO) standards [3] and [4] used to encode the register contents in the aircraft's Mode S avionics. The register definitions must be consistent with one document version, although only a subset of the documents' features need be installed. The version number should be set to a non-zero value if any Mode S-Specific services are used in the avionics (i.e., if bit 25 of register 10_{16} is set). Table 2-3 defines the coding of the version number field.

Bits 41 through 56 of register 10_{16} are used to indicate the support status of each of the 16 "Data Terminal Equipment" (DTE) sub-addresses in the Mode S subnetwork of the "Aeronautical Telecommunications Network (ATN). This functionality is not used by any of the currently defined Mode S applications (i.e., ELS, EHS, ADS-B).

TABLE 2-3

Version Number Coding in the Mode S Data Link Capability Register (10_{16})

Coding	Year of Annex 10 Amendment [3]	Edition of ICAO Doc 9871 [4]
0	Mode S subnetwork not available	
1	1996	Not applicable
2	1998	Not applicable
3	2002	Not applicable
4	2007	Edition 1
5...127	Unassigned	

2.5 TRANSPONDER AND ACAS TYPE / PART NUMBER / SOFTWARE REVISION (REGS. $E3_{16}$, $E4_{16}$, $E5_{16}$, $E6_{16}$)

The recent issue of the Mode S GICB register formats [4] includes a set of four registers that are used to specify the type and software revision of the Mode S transponder and ACAS unit (if any) on board the aircraft. Registers $E3_{16}$ and $E4_{16}$ refer to the transponder itself, while registers $E5_{16}$ and $E6_{16}$ refer to the ACAS unit. The first register of each pair refers to the part number or type specification of the equipment, while the second register of each pair refers to the software revision hosted in the equipment. (Note: for operational reasons, some military installations may not populate these registers.)

The format of all four registers is the same. The first bit in the register format is a status flag that indicates the validity of the data in the register. The next two bits in the register form a format type code value. The format type code value '0' indicates that the remainder of the register uses the "part number" (P/N) format – a decimal digit string. The format type code value '1' indicates that the remainder of the register uses the Mode S character format. Type codes '2' and '3' are reserved.

If the format of the register is P/N, then the part number is expressed as a string of up to 12 "binary-coded decimal" (BCD) digits. This is the recommended format for the expression of these registers. If the part number (revision number) is not available, then the first eight characters of the commercial name are encoded in the register using the Mode S character string format. As described in Section 4.1 below (and in [1]), the Mode S character format uses 6 bits for each character. Letters 'A' through 'Z' are encoded using values 1 through 26. Digits '0' through '9' are encoded using values 48 through 57. The space character is encoded as value 32. All other encoding values are undefined. For either P/N or character format, the last five bits of the register format are reserved.

3. CONFIGURATION AND FAILURE PROTOCOLS

The first processing step for any Mode S data link application is to obtain the transponder capability (CA) value from the aircraft. The 3-bit CA field is found in the “Mode S All-Call Reply and Acquisition Squitter” (DF=11) and the “Extended Squitter” (DF=17) downlinks. If CA=0, then this transponder is surveillance-only and supports no data link functions at all. If CA=1, 2, or 3, then this transponder is using an earlier form of the Mode S protocol. These Mode S transponders support only GICB extraction of the aircraft’s data link capability (Reg. 10_{16}), aircraft identity (Reg. 20_{16}), ACAS RA (Reg. 30_{16}), and air-initiated Comm B broadcast. Values of CA greater than or equal to 4 indicate that the Mode S transponder is fully capable of at least 56-bit short uplink and downlink message transfer. These Mode S transponders can support the ELS, EHS, ADS-B, and other data link functions (given that their avionics load the appropriate registers, etc.). The Mode S transponder CA value should be stored in the data link application as part of the aircraft “state.” (See [1] for a full description of the transponder capability values.)

Given that the Mode S transponder’s CA value is 4 or greater, the second processing step for any Mode S data link application is to extract the transponder’s Mode S data link capability report (Reg. 10_{16}) as described in Section 2.4 above. The contents of this register should be stored in the data link application as part of the aircraft “state.” Bits in this register indicate the support of such Mode S data link functions as aircraft identification, ADS-B, ACAS, etc. The Mode S-Specific services capability bit indicates whether the avionics installation supports further data link functions. If this bit is set, the Mode S data link application would next extract the common-usage capability register (17_{16}) as described in Section 2.3 above. The contents of this register would also be stored as part of the aircraft “state.”

The processing protocol described in this section so far is sufficient initialization for basic data link applications such as ELS, EHS, and ADS-B, since all their status and configuration information is available from registers 10_{16} and 17_{16}. Other Mode S data link applications (e.g., Traffic Information Service [TIS]) might need to extract one or more of the Mode S-Specific services GICB capability reports (see Section 2.1 above) or one or more of the Mode S-Specific services MSP capability reports (see Section 2.2 above) to determine whether the aircraft’s avionics support the particular Mode S data link application. The additional capability register contents also become part of the aircraft “state” in the application.

This completes the initialization processing for Mode S data link applications. The application should subsequently monitor any air-initiated Comm B broadcast messages received from the particular aircraft in order to detect any changes in the aircraft’s configuration status. Any changes in the contents of any of the registers 10_{16}, 20_{16}, or 30_{16} triggers a downlink message via the air-initiated Comm B broadcast protocol including the updated register contents. The Mode S data link application should update the aircraft’s “state” values with the new ones. The changed state might result in discontinuance (or reinstatement) of certain Mode S data link functions. A change in the value of the common-usage GICB report bit in the data link capability report (Reg. 10_{16}) would cause the application to re-extract the contents of the common-usage GICB capability report (Reg. 17_{16}). (Note: Mode S transponder air-initiated Comm B broadcast messages are held active in the transponder for 18 seconds after the triggering event. Any Mode S sensor can extract the broadcast information.)

4. ELEMENTARY SURVEILLANCE (ELS) TRANSPONDER REGISTERS

The “Elementary Surveillance” application (ELS) includes registers 10_{16}, and 17_{16}, and 18_{16} through $1C_{16}$ as discussed in Sections 2 and 3 above. In addition, ELS includes the “aircraft identification” register (20_{16}) and the “ACAS resolution advisory” register (30_{16}) for aircraft equipped with ACAS. This section provides guidance on the contents and operation of registers 20_{16} and 30_{16}.

4.1 AIRCRAFT IDENTIFICATION (REG. 20_{16})

The intent of this register is to provide a means for applications to correlate surveillance data (containing the Mode S address and the Mode 3/A code) with the flight plan (containing the aircraft identification). The aircraft identification register contains an 8-character text string that is to be set equal to the flight plan identification (if one is available) – otherwise, it should be set to the aircraft’s registration marking. The text string should be left justified in the register. No intervening “space” codes should be included in the text string. Any unused characters at the end of the text string should be set to the “space” code.

A 6-bit character encoding is employed which incorporates upper-case letters, decimal digits, and a space character. The encoding is described in [1] and [4]. Letters ‘A’ through ‘Z’ are encoded using values 1 through 26. Digits ‘0’ through ‘9’ are encoded using values 48 through 57. The space character is encoded as value 32. All other encoding values are undefined. The input text string could come from ARINC words $233\text{-}236_8$ (Flight Identification), $301\text{-}303_8$ (Aircraft Identification), or 360_8 (Flight Number).

Note that receiving applications will detect any changes in or loss of the contents of this register via an air-initiated Comm B broadcast message from the Mode S transponder. This broadcast downlink message occurs within 2 seconds of the change in or loss of the data in GICB register 20_{16}.

4.2 ACAS RESOLUTION ADVISORY (REG. 30_{16})

The format of the ACAS Resolution Advisory Register content is defined in [3] and [4]. This register allows external systems (such as a ground Mode S sensor) to extract the current state of an ACAS system’s resolution advisory display(s). The structure of the ACAS resolution advisory’s 56 bits is illustrated in Table 4-1.

TABLE 4-1

Field Definitions for ACAS Resolution Advisory Transponder Register (30_{16})

Field Name	Number of Bits
BDS	8
ARA	14
RAC	4
RAT	1
MTI	1
TTI	2
TID	26

The "Comm-B Data Selector" (BDS) field is set to 30_{16} to denote the ACAS resolution advisory when this data is broadcast. (An air-initiated Comm B broadcast downlink is generated whenever the register contents change.) The "Active RAs" (ARA) field indicates the characteristics of the RA (if any) generated by ACAS. The coding of the ARA field is described below. The "RAs Active" (RAC) field is composed of four bit flags indicating the current state of active RA complements received by ACAS from other aircraft. The RAC field coding is shown in Table 4-2.

TABLE 4-2

Bit Definitions in RAC Field of ACAS Resolution Advisory Register (30_{16})

Bit in RAC Field	Meaning if Set
1	Do not pass below
2	Do not pass above
3	Do not turn left
4	Do not turn right

The "RA terminated" (RAT) bit is cleared (set to "0") if the ACAS RA in the ARA field is active. The RAT bit is set to "1" to indicate that the RA has been terminated. The "multiple threat indicator" (MTI) bit is set to "1" if two or more simultaneous threats are being processed by the ACAS. The MTI bit is cleared when there is a single threat or if there is no current threat, depending on the coding of the high-order bit of the ARA field. The "threat type indicator" (TTI) field defines the type of data in the "threat identity data" (TID) field that follows it. The coding of the TTI field is described in Table 4-3.

TABLE 4-3

TTI Coding Definitions for the ACAS Resolution Advisory Register (30_{16})

TTI Coding	Meaning
0	No identity data in TID
1	TID contains Mode S address
2	TID contains altitude, range, and bearing
3	Not assigned

If the TTI field value is ‘1,’ the TID field contains the 24-bit Mode S address of the threat (when the threat is Mode S equipped). The low-order 2 bits of the TID field are cleared. If the TTI field value is ‘2,’ the TID field is subdivided into three subfields as illustrated in Table 4-4. Note: If there are multiple threats, the TID field contains data for the most-recently declared threat.

TABLE 4-4

TID Field Coding of the ACAS Resolution Advisory Register when TTI=2

TID Subfield	Number of Bits	Coding
Altitude	13	Mode C altitude code of threat. Bit ordering is C1 A1 C2 A2 C4 A4 0 B1 D1 B2 D2 B4 D4
Range	7	0 ➔ no range estimate available 1 ➔ range < 0.05 Nmi. 2…126 ➔ (range – 1) / 10 Nmi. 127 ➔ range > 12.55 Nmi.
Bearing	6	0 ➔ no bearing estimate available 1...60 ➔ bearing in 6 degree increments 61...63 ➔ not assigned

The ARA field is a set of bit flags that can take on two sets of defined values, depending on the value of its high-order bit and the value of the separate MTI bit field. If the high-order bit of the ARA field is cleared, this indicates that there is more than one threat and the RA is intended to provide separation below some and above others (if MTI=1), or no RA has been generated (if MTI=0). If the high-order bit of the ARA field is set, this indicates that there is only one threat or the RA is intended to provide separation in the same direction for all the threats. The internal definitions for the remaining bit flags in the ARA field (when ARA bit 1=1) are illustrated in Tables 4-5 and 4-6.

TABLE 4-5

Internal Coding of ARA Field When ARA Bit 1=1

Bit Number in ARA Nield	Definition (when ARA bit 1=1)
2	0 ➔ RA is preventive 1 ➔ RA is corrective
3	0 ➔ upward sense RA 1 ➔ downward sense RA
4	0 ➔ not increased rate 1 ➔ increased rate
5	0 ➔ RA is not a sense reversal 1 ➔ RA is a sense reversal
6	0 ➔ not altitude crossing 1 ➔ altitude crossing
7	0 ➔ RA is vertical speed limit 1 ➔RA is positive
8...14	Reserved for ACAS III

The internal definitions for the remaining bit flags in the ARA field (when ARA bit 1=0 and MTI=1) are illustrated in the Table 4-6.

TABLE 4-6

Internal Coding of ARA Field When ARA Bit 1=0 and MTI=1

Bit Number in ARA Field	Definition (when ARA bit 1=0 and MTI=1)
2	0 ➔ RA does not require upward correction 1 ➔ RA requires upward correction
3	0 ➔ RA does not require positive climb 1 ➔ RA requires positive climb
4	0 ➔ RA does not require downward correction 1 ➔ RA requires downward correction
5	0 ➔ RA does not require positive descent 1 ➔ RA requires positive descent
6	0 ➔ RA does not require altitude crossing 1 ➔ RA requires altitude crossing
7	0 ➔ RA is not a sense reversal 1 ➔RA is a sense reversal
8...14	Reserved for ACAS III

5. ENHANCED SURVEILLANCE (EHS) TRANSPONDER REGISTERS

This section discusses the three registers (40_{16}, 50_{16}, and 60_{16}) that make up the "Enhanced Surveillance" (EHS) function. (See reference 4 for the complete definition of these registers.) Whenever possible, the data value entered into the register should come from the sources in actual control of the aircraft. If the value of any data parameter received from the avionics data source exceeds the allowable range for the particular register format, the maximum allowable data value (with the appropriate sign) is encoded in the register. The least-significant bit for each encoded data value should be obtained via rounding. If any data value is not available in the aircraft's avionics, then all bits in the register value for that data should be cleared.

Within this section, the ARINC 429 word that provides the required data value is given in the accompanying tables. In some cases there is a choice of applicable ARINC 429 words for a data value – there may be a choice of ARINC 429 formats (binary or BCD), etc. Note: Alternative data bus standards such as IEEE 1553B (used by some military aircraft) have equivalent mechanisms to transfer the required information. The details of the data transfer may vary from aircraft to aircraft.

In addition to the EHS registers (40_{16}, 50_{16}, and 60_{16}), an additional register is used to provide Mode S applications a means to monitor changes in flight parameters that do not change frequently in normal flight (i.e., are expected to stay constant for 5 minutes or more at a time). An application can determine whether one or more of these flight parameters has changed by a single extraction of the "quasi-static parameter monitoring" register $5F_{16}$.

5.1 SELECTED VERTICAL INTENTION (REG. 40_{16})

The selected vertical intention report (Reg. 40_{16}) contains five data subfields, each incorporating their own independent status bit. The maximum acceptable update interval for any of the data subfields in this transponder register is 1 second. In general, if data updates are missing for a time no longer than twice the specified maximum update interval or 2 seconds (whichever is greater), then the status bit for this data item (if specified for the given field) must indicate that the data is invalid and the subfield in the register itself should be filled with zeroes. The update interval for each data subfield in the register should be sufficient to ensure that the maximum latency of each data value is not exceeded. (Note: If all five of the status fields in the register are simultaneously cleared, then the register itself is no longer valid. Its corresponding bit in the Mode S common usage capability register [17_{16}] should be cleared.)

The purpose of the data in register 40_{16} is to provide access to information about the aircraft's intentions with respect to altitude changes during flight. This information could improve the effectiveness of conflict-probe applications and could provide an aid to air-traffic controllers in maintaining vertical separation among aircraft.

This register is the most complicated of the EHS register set (40_{16}, 50_{16}, and 60_{16}) with respect to the variety and complexity of data sources that must feed into the register's data fields. Different avionics configurations must deal with this register in different ways. See reference 4 for examples of the logic required to populate this register using typical Airbus and Boeing Mode S avionics installations.

The first data subfield in register 40_{16} is the selected MCP/FCU Selected Altitude. This is the value that the flight crew have dialed into the autopilot flight control unit / mode control panel or altitude alerter, and is, if the autopilot is engaged and a number of other conditions are met, the altitude at which the aircraft will resume level flight (or has already leveled off) at the completion of the current maneuvers. The source of this data is the aircraft's Mode Control Panel (MCP) or Flight Control Unit (FCU). The selected altitude field supports a "read-back" function so that ground surveillance applications can determine what the pilot has loaded into the aircraft's altitude control avionics. Note that changes in the MCP/FCU Selected Altitude are reflected in a change to bits 1 and 2 of the Quasi-Static Parameter Monitor (Reg. $5F_{16}$) described in Section 5.4 below.

The second data subfield in this register is the FMS selected altitude from the aircraft's Flight Management System (FMS). In ARINC avionics architectures, these data may be obtained from ARINC 429 label 102 (binary) or 025 (BCD).

The third data subfield in this register is the barometric pressure setting minus 800 millibars. This data value may be obtained from ARINC 429 label 234_8.

The fourth data subfield in this register is a set of four bit flags that indicate the Mode Status of the MCP/FCU. The first bit (bit 48) is the status bit used to indicate whether altitude mode information is being actively provided. The second bit is set to indicate VNAV mode (e.g., ARINC 429 label 272_8), the third bit is set to indicate APPROACH mode (e.g., ARINC 429 label 273_8), and the fourth bit is set to indicate ALT HOLD mode (e.g., ARINC 429 label 272_8). Note that changes in the Mode Status are reflected in a change to bits 17 and 18 of the Quasi-Static Parameter Monitor (Reg. $5F_{16}$) described in Section 5.4 below. Also, if there is no means in the avionics to determine the altitude mode, bits 48 through 51 should be cleared to zero.

The fifth data subfield (bits 54-56) in this register specifies which of the first two data fields in this register or the current aircraft altitude should be used to determine the short-term intent value at which the aircraft will level off. The status bit for this field (bit 54) indicates whether such altitude mode information is currently provided. Table 5-1 describes the coding for the 2-bit target altitude source value (bits 55-56). Note: if the aircraft's avionics are not able to determine the source of target altitude data (see [4] for the appropriate avionics logic), then the source field is to be cleared as well as its respective status bit. Also, note that changes in the FMS Selected Altitude are reflected in a change to bits 23 and 24 of the Quasi-Static Parameter Monitor (Reg. $5F_{16}$) described in Section 5.4 below.

TABLE 5-1

Coding for the Altitude Source Field in the Selected Vertical Intent (Reg. 40_{16})

Target Altitude Source Coding (Bits 55-56)	Description
0	Unknown
1	Aircraft altitude
2	FCU/MCP selected altitude
3	FMS selected altitude

5.2 TRACK AND TURN REPORT (REG. 50_{16})

The Track and Turn Report (Reg. 50_{16}) contains five data subfields, each incorporating their own independent status bit. The purpose of this register is to aid conflict probe and long-term air traffic control functions in maintaining accurate aircraft horizontal track positions and velocities. The maximum acceptable update interval for any of the data subfields in this transponder register is 1 second. In general, if data updates are missing for a time no longer than twice the specified maximum update interval or 2 seconds (whichever is greater), then the status bit for this data item (if specified for the given field) must indicate that the data is invalid and the subfield in the register itself should be filled with zeroes. The update interval for each data subfield in the register should be sufficient to ensure that the maximum latency of each data value is not exceeded. Note: If all of the five status fields in the register are simultaneously cleared, then the register itself is no longer valid. Its corresponding bit in the common usage capability register (Reg. 17_{16}) should be cleared – which triggers a change in the data link capability register (Reg. 10_{16}) and a downlink message is then sent via the air-initiated Comm B broadcast protocol. Table 5-2 lists the data subfields in register 50_{16}.

TABLE 5-2

Data Subfields in the Track and Turn Report (Reg. 50_{16})

Data Field	LSB	Range	ARINC 429 Word (octal)
Roll angle	45/256 degrees	–90...90 degrees	325
True Track angle	90/512 degrees	–180...180 degrees	313 (binary) 013 (BCD) 103 (GNSS[1] – binary)
Ground Speed	2 knots	0...2046 knots	312 (binary) 012 (BCD) 112 (GNSS – binary)
Track Angle Rate	1/32 degree/second	–16...16 degree/second	335 (see note below)
True Airspeed	2 knots	0...2046 knots	210 (binary) 230 (BCD)

<u>Note:</u> For ARINC General Aviation Manufacturers Association (GAMA) avionics configurations, ARINC 429 label 335_8 is not used for the true track angle rate but for another parameter. For this particular ARINC configuration, the true track angle rate field in the Track and Turn Register should be cleared. Applications could infer the track angle rate from the true airspeed and roll angle values.

[1] Global Navigation Satellite System

5.3 HEADING AND SPEED REPORT (REG. 60_{16})

The Heading and Speed Report (Reg. 60_{16}) contains five data subfields, each incorporating its own independent status bit. The purpose of this register (like register 50_{16} described in Section 5.2 above) is to aid conflict probe and long-term air traffic control functions in maintaining accurate aircraft horizontal track positions and velocities. The maximum acceptable update interval for any of the data subfields in this transponder register is 1 second. In general, if data updates are missing for a time no longer than twice the specified maximum update interval or 2 seconds (whichever is greater), then the status bit for this data item (if specified for the given field) must indicate that the data is invalid and the field in the register itself should be filled with zeroes. The update interval for each data subfield in the register should be sufficient to ensure that the maximum latency of each data value is not exceeded. Note: if all the five status fields in the register are simultaneously cleared, then the register itself is no longer valid. Its corresponding bit in the common usage capability register (17_{16}) should be cleared – which triggers a change in the data link capability register (10_{16}) and a broadcast message with the new contents of register 10_{16} via the air-initiated Comm B downlink protocol. Table 5-3 lists the data subfields in register 60_{16}.

TABLE 5-3

Data Subfields in the Heading and Speed Report (Reg. 60_{16})

Data Value	LSB	Range	ARINC 429 Word (octal)
Magnetic Heading	90/512 degrees	–180...180 degrees	320 (binary) 014 (BCD)
Indicated Airspeed	1 knot	0...1023 knots	206 (computed airspeed)
Mach	0.004 Mach	0...4.09 Mach	205
Barometric Altitude Rate	32 feet/minute	–6,384...16,352 feet/minute	212
Inertial Vertical Velocity	32 feet/minute	–6,384...16,352 feet/minute	365

5.4 QUASI-STATIC PARAMETER MONITORING (REG. $5F_{16}$)

The "Quasi-Static Parameter Monitoring" register is provided to permit monitoring of changes in parameters that do not normally change very frequently (those expected to be stable for 5 minutes or more) by extracting a single register. This register contains 28 two-bit subfields that indicate whether their respective flight parameter has changed its value. A subfield value of 00 binary indicates that there is no valid data available for the particular monitored parameter. If valid data is available for the particular monitored parameter, then the subfield value cycles through binary values 01, 10, and 11 each time there is a change in the monitored parameter. A change in any of the subfields in the quasi-static parameter monitoring register ($5F_{16}$) triggers a change in bit 23 of the common usage capability register (17_{16}) – which, in turn, triggers a change in the data link capability register (10_{16}) and a downlink broadcast message with the new contents of register 10_{16} via the air-initiated Comm B protocol. Table 5-4 lists the data subfields in register $5F_{16}$ and the register that contains the parameter being monitored by that data field. Note that some of the monitored parameters (e.g., those which used to indicate horizontal intent) do not currently have defined register locations. Some of this is due to changes in the register assignments over time. These subfields in register $5F_{16}$ are reserved for future parameter monitoring applications.

TABLE 5-4

Data Subfields in the Quasi-Static Parameter Monitoring Register ($5F_{16}$)

Bits in Register $5F_{16}$	Monitored Parameter	Register(s) Containing Parameter
1,2	MCP/FCU Selected Altitude	40_{16}
3,4	Reserved (was Selected Heading)	—
5,6	Reserved (was Selected Speed)	—
7,8	Reserved (was Selected Mach Number)	—
9,10	Reserved (was Selected Altitude Rate)	—
11,12	Reserved (was Selected Flight Path Angle)	—
13,14	Next Waypoint	41_{16}, 42_{16}, 43_{16}
15,16	Reserved (was FMS Horizontal Mode)	—
17,18	FMS Vertical Mode	40_{16}
19,20	VHF Channel Report	48_{16}
21,22	Meteorological Hazards	45_{16}
23,24	FMS Selected Altitude	40_{16}
25,26	Barometric Pressure (minus 800 mb)	40_{16}
27...56	Reserved	—

6. 1090 EXTENDED SQUITTER (MODE S ADS-B)

This section discusses the registers and protocols used for Mode S Extended Squitter applications. A “squitter” is a spontaneous broadcast transmission by the Mode S transponder on the 1090 MHz frequency not initiated by an interrogation on 1030 MHz. Mode S support of “automatic dependent surveillance–broadcast” (ADS-B) is provided by means of squitters. Registers 05_{16} through $0A_{16}$ (plus 61_{16} to 65_{16}) are used by the extended squitter protocols. Note that registers 05_{16} through $0A_{16}$ have a matching capability bit in the common-usage capability register 17_{16} (see Section 2.3 above). See references [4], [5], and [6] for the complete definition of the Mode S ADS-B application.

There are two defined standards for Mode S extended squitter applications. The initial standard [5] is termed “Version 0.” Using these message formats, ADS-B surveillance quality is reported in terms of the “Navigation Uncertainty Category” (NUC), which can be an indication of either the accuracy or the integrity of the navigation data used by ADS-B. However, there is no indication provided as to whether the NUC value is based on integrity or accuracy.

The revised ADS-B standard [6] is termed “Version 1.” The Version 1 formats overcome the limits of Version 0 by reporting separately the “Navigation Accuracy Category” (NAC), the “Navigation Integrity Category” (NIC), and the “Surveillance Integrity Level” (SIL). The Version 1 formats are fully compatible with the Version 0 formats, in that a receiver built to either standard can correctly receive and process ADS-B messages generated by transmitting equipment built to either standard. Sections 6.1 through 6.6 of this paper cover Version 0 formats, indicating where Version 1 formats differ. Section 6.7 of this paper covers the Version 1-specific format revisions. Note: Reference 4 covers both Version 0 and Version 1.

There are 32 types of Mode S extended squitter messages denoted by a 5-bit format type code. Each squitter message begins with the 5-bit format type code. Table 6-1 describes the various format type codes, their related squitter formats, and the section in this paper that discusses the particular squitter type. (The “navigational uncertainty category in position” [NUC_P] is defined in [4] and [5]. It is a measure of the integrity and accuracy of the navigational data available from the aircraft’s avionics, both horizontally and vertically.) Note that Version 0 ADS-B uses NUC, while Version 1 formats use NIC, NAC, and SIL. See Section 6.7.1 of this paper for the format type coding used in Version 1.

TABLE 6-1

Mode S Extended Squitter Format Type Codes (Version 0)

Format Type Code	Description	Altitude Type	Section Reference	NUC_P
0	No position information	Barometric or none	6.1	0
1	Identification (Category D)	N.A.	6.4	--
2	Identification (Category C)	N.A.	6.4	--
3	Identification (Category B)	N.A.	6.4	--
4	Identification (Category A)	N.A.	6.4	--
5	Surface Position	N.A.	6.2	9
6	Surface Position	N.A.	6.2	8
7	Surface Position	N.A.	6.2	7
8	Surface Position	N.A.	6.2	6
9	Airborne Position	Barometric	6.1	9
10	Airborne Position	Barometric	6.1	8
11	Airborne Position	Barometric	6.1	7
12	Airborne Position	Barometric	6.1	6
13	Airborne Position	Barometric	6.1	5
14	Airborne Position	Barometric	6.1	4
15	Airborne Position	Barometric	6.1	3
16	Airborne Position	Barometric	6.1	2
17	Airborne Position	Barometric	6.1	1
18	Airborne Position	Barometric	6.1	0
19	Airborne Velocity	Either	6.5	--
20	Airborne Position	GNSS	6.1	9
21	Airborne Position	GNSS	6.1	8
22	Airborne Position	GNSS	6.1	Reserved
23	Reserved for testing			
24	Reserved for surface system status			
25	Reserved			
26	Reserved			
27	Reserved			
28	Extended Squitter Aircraft Status		6.6.1	—
29	Was Current/Next Trajectory Change Point in Version 0 [5] – proposed re-definition for Target State and Status [4]		6.6.2 6.7.4	—
30	Aircraft Operational Coordination in Version 0 [5], no longer used in Version 1 [6]		6.6.3	—
31	Aircraft Operational Status		6.6.4	—

Table 6-2 describes the NUC_P values for the case of barometric altitudes. The NUC_P categories are based on the "Horizontal Protection Limit" (HPL) and the "95% containment radius" (denoted "μ") for horizontal position error. The values of HPL and μ would be obtained from the avionics sources of aircraft position. If GNSS-derived altitudes are being used, an additional measure of the 95% containment radius for vertical position error would be factored into the determination of NUC_P. See [4] and [5] for a complete definition of the NUC_P values.

TABLE 6-2

Values of NUC_P for Mode S ES with Barometric Altitudes (Version 0)

NUC_P	HPL	95% Containment Radius On Horizontal Position Error μ
0	HPL ≥ 37.04 km (20 nm)	18.52 km (10.0 nm) ≤ μ
1	18.52 km (10 nm) ≤ HPL< 37.04 km (20 nm)	9.26 km (5.0 nm) ≤ μ < 18.52 km (10.0 nm)
2	3.704 km (2.0 nm) ≤ HPL< 18.52 km (10 nm)	1.852 km (1.0 nm) ≤ μ < 9.26 km (5.0 nm)
3	1852 m (1.0 nm) ≤ HPL< 3704 m (2.0 nm)	926 m (0.5 nm) ≤ μ < 1852 m (1.0 nm)
4	926 m (0.5 nm) ≤ HPL< 1852 m (1.0 nm)	463 m (0.25 NM) ≤ μ < 926 m (0.5 NM)
5	370.4 m (0.2 nm) ≤ HPL< 926 m (0.5 nm)	185.2 m (0.1 nm) ≤ μ < 463 m (0.25 nm)
6	185.2 m (0.1 nm) ≤ HPL < 370.4 m (0.2 nm)	92.6 m (0.05 nm) ≤ μ < 185.2 m (0.1 nm)
7	25 m ≤ HPL < 185.2 m (0.1 nm)	10 m ≤ μ < 92.6 m (0.05 nm)
8	7.5 m ≤ HPL < 25 m	3 m ≤ μ < 10 m
9	HPL < 7.5 m	μ < 3 m

6.1 MODE S EXTENDED SQUITTER AIRBORNE POSITION (REG. 05_{16})

The Mode S extended squitter airborne position register is used to update the current aircraft position for Mode S ADS-B. Note that airborne velocity is provided via another register (see Section 6.5 below). Also, note that the position and velocity for aircraft on the ground (as well as surface vehicles and fixed squitter installations) utilize another register (see Section 6.2 below). The extended squitter airborne position register is nominally broadcast (squittered) twice per second.

The format type code field value in the first five bits of the Mode S extended squitter airborne position register is used to denote the source of altitude information being used as well as the NUC_P value for Version 0 (see Section 6.0 above) for the source of horizontal positional data. Format type code values 9 through 18 denote NUC_P values ranging from 9 (most precise) to 0 (least precise) with barometric altitude data. Format type code values 20 through 22 denote GNSS-derived altitudes with NUC_P values 9, 8, and 0 with GNSS height above ellipsoid (HAE) rather than barometric altitude. (Since GNSS is providing the altitude data, it is assumed to be providing the horizontal position data as well.) The format type code field is based on the NIC value for Version 1 (see Section 6.7).

The next two bits in the airborne position register denote the Mode 3/A identity code emergency and other special conditions. Table 6-3 defines the coding for the "surveillance status" field. Note that the emergency condition (value=1) takes priority over the other cases. Codes 1 and 2 take precedence over code 3.

TABLE 6-3

Mode S Extended Squitter Airborne Position Surveillance Status Field Coding

Value	Description
0	No emergency or other Mode 3/A code information
1	Permanent alert (emergency code)
2	Temporary alert (change of Mode 3/A code other than emergency)
3	Special Position Indicator (SPI) condition

Bit 8 in the Airborne Position Register indicates whether the transponder has diversity transmitting antennas (1) or not (0). The next twelve bits in the Airborne Position Register contain the altitude information, either barometric or GNSS-derived. Bit 21 of the Airborne Position Register indicates whether the position information has been synchronized to the UTC time (1) or not (0). Time synchronization is only relevant for the top NUC_P levels (format type codes 9, 10, 20, and 21).

The position information in the Airborne Position Register (API) is compressed and encoded, using the Mode S "Compact Position Reporting" (CPR) algorithm. (See [4] and [6] for a full definition of the CPR algorithm, as well as the assignment of ARINC 429 data words to the register data fields.) Bit 22 of the Airborne Position Register holds the CPR format bit – CPR uses differing encodings for even and odd-second data in order to provide globally unambiguous latitude and longitude values. The CPR-encoded latitude and longitude fields each occupy 17 bits.

Broadcast of the airborne position message is not initiated when there is no horizontal (latitude/longitude) data available in the avionics (due to equipment failure or configuration). If broadcast has been initiated, but horizontal data becomes unavailable and altitude information is still available, then the airborne position is sent with a format type code of zero and barometric altitude in its data field. If neither horizontal nor altitude data is available in the avionics, then the entire register (all 56 bits) should be cleared to zero – indicating the loss of information (and broadcast of this message will be terminated in 60 seconds). This failure would be echoed by clearing bit 1 of register $17_{16,}$ which would in turn cause bit 34 of register 10_{16} to be cleared. Further, downlink of the new contents of register 10_{16} would be generated via the air-initiated Comm B broadcast protocol.

6.2 MODE S EXTENDED SQUITTER SURFACE POSITION (REG. 06_{16})

The Mode S Extended Squitter Surface Position Register is used to update the aircraft (or surface vehicle/fixed device) position and velocity. Note that, unlike the airborne case, a single register is used for both position and velocity on the surface. (This is possible because there is no need to encode altitude in a surface position.) The surface position register is transmitted (squittered) twice per second if the aircraft/vehicle is in motion (> 10 meters in any 30-second interval or about 0.65 knots). If the aircraft/vehicle is stationary, the squitter rate may be reduced to once every 5 seconds. (See Section 6.3 where the extended squitter status register is described.)

The format type code field value in the first five bits of the surface position register is used to denote the "navigational uncertainty category for position" (NUC_P) value for the source of positional data in Version 0 (see Section 6.0). Format type code values 5 through 8 denote NUC_P values ranging from 9 to 6. NUC_P values less than 6 are not precise enough to provide surface position data. (See the table in Section 6.0 above for a description of the NUC_P values.) The format type codes are based on NIC values for Version 1 (see Section 6.7).

The next seven bits of the surface position register form the "movement" field. This data field encodes the aircraft or vehicle ground speed in a non-linear scaling. See [4] for the definition of this speed scaling. Bit 13 of the surface position register provides the validity status of the ground track field contained in bits 14 through 20 of this register. This 7-bit field encodes the ground track angle (if valid) from 0 to 360 degrees in 128 steps. The ground track angle is referenced to true north for Version 0. It may be referenced either to true north or magnetic north for Version 1, depending on the value of the "horizontal reference direction" (HRD) bit in the Version 1 aircraft operational status message (see Section 6.7.3). If a source of aircraft/vehicle heading is not available, the ground track angle may be substituted so long as the heading status bit (bit 13) is cleared whenever the aircraft/vehicle's speed is too low for a reliable estimate of heading to be made.

The remainder of the surface position register encodes the surface position latitude and longitude using the CPR algorithm in the same way as the extended squitter airborne position (see Section 6.1 above). Note that CPR uses a slightly different encoding for surface positions than it does for airborne positions – surface positions are more precise but have a more-limited range. (See [4], and [6] for a full definition of the CPR algorithm, as well as the assignment of ARINC 429 words to the register data fields.)

If surveillance data becomes unavailable in the avionics (after surface squitter initiation), then the entire register (all 56 bits) should be cleared to zero – indicating the loss of information and broadcast of this message will be terminated in 60 seconds. The short identity squitter will be broadcast if no other squitter is available. This failure would be echoed by clearing bit 2 of register 17_{16} which would in turn cause bit 34 of register 10_{16} to be cleared. Further, a downlink of the new contents of register 10_{16} would be generated via the air-initiated Comm B broadcast protocol.

6.3 MODE S EXTENDED SQUITTER STATUS (REG. 07_{16})

The Extended Squitter Status Register provides information about the current squitter rate selected by the avionics and also whether the source of altitude information currently being employed is barometric or GNSS-derived. Extracting this register allows an application to determine if the target transponder is squittering surface position at a lowered rate (to reduce the usage of the Mode S 1090 MHz channel for slow-moving vehicles). The lowered surface squitter rate may be selected when the aircraft (or vehicle) is moving less than 10 meters during any 30-second interval (about 0.65 knots). The squitter rate will revert to high as soon as the aircraft/vehicle has moved more than 10 meters since the low rate was selected. The automatically selected squitter rate (for transponder-based implementations) may be over-ridden by commands from ground control.

TABLE 6-4

Surface Squitter Rate Encodings for the Extended Squitter Status Register 07_{16}

Encoding	Description
0	No capability to determine surface squitter rate
1	High surface squitter rate selected
2	Low surface squitter rate selected
3	Reserved

The third bit of this register indicates use of barometric altitudes (if cleared to 0) or the use of GNSS-derived altitudes (if set to 1). All the remaining bits in the register are reserved for future use.

Note that this register was originally intended for use in avionics systems where the formatting of transponder contents is done in a device external to the Mode S transponder. This register serves as an interface between the transponder and the external register formatting function.

6.4 EXTENDED SQUITTER AIRCRAFT IDENTIFICATION AND CATEGORY (REG. 08_{16})

The Mode S transponder Extended Squitter Aircraft Identification and Category Register provides information about the type of vehicle and its identification. The contents of this register are broadcast every 5 seconds if the aircraft/vehicle is in motion (> 10 meters in any 30-second interval or about 0.65 knots). If the aircraft/vehicle is stationary, the squitter rate may be reduced to once every 10 seconds. (See Section 6.3 where the extended squitter status register is described.)

The aircraft identification information text string in this register is similar to that provided in the transponder aircraft identification register (Reg. 20_{16}) described in Section 4.1 above. See [4] for the assignment of ARINC 429 data words to the data fields in this register. The input text string could come from ARINC 429 data words $233\text{-}236_8$ (Flight Identification), $301\text{-}303_8$ (Aircraft Identification), or 360_8 (Flight Number).

As was described in Section 6.0 above, there are four type code values (1...4) that are assigned to this register, depending on the category of the aircraft or vehicle carrying the squitter transmitter. Category A (type code 4) applies to standard types of aircraft. Category B (type code 3) applies to non-standard air vehicles. Category C (type code 2) applies to surface vehicles and fixed installations. Category D is currently unassigned. For each category, a 3-bit “category coding” value further defines the type of aircraft, vehicle, etc. Table 6-5 defines the values for the 3-bit vehicle category field in this register.

TABLE 6-5

Vehicle Category Coding Values in the Extended Squitter Register 08_{16}

Value	Category A Standard Aircraft	Category B Non-standard Aircraft	Category C Surface Vehicles
0	No data	No data	No data
1	Light (<15,000 lbs.)	Glider/sailplane	Emergency vehicle
2	Medium (<75,000 lbs.)	Lighter-than-air	Service vehicle
3	Heavy (<300,000 lbs.)	Parachute/skydiver	Fixed or tethered obstruction
4	High-vortex	Ultralight/Hang glider	Reserved (Version 0) Cluster obstacle (Version 1
5	Very heavy (>300,000 lbs.)	Reserved	Reserved (Version 0) Line obstacle (Version 1)
6	High performance (>5g) and high speed (> 400 knots)	Unmanned air vehicle	Reserved
7	Rotorcraft	Spacecraft	Reserved

The remaining 48 bits of this register contain an 8-character text string that identifies the particular aircraft, vehicle, or other Mode S installation. The text string is encoded using a 6-bit character set (upper-case letters and decimal digits) in the same manner as the aircraft identification register (Reg. 20_{16}) described in Section 4.1 above.

6.5 MODE S EXTENDED SQUITTER AIRBORNE VELOCITY (REG. 09_{16})

The Mode S Extended Squitter Airborne Velocity register provides the velocity counterpart to the airborne position register 05_{16} (see Section 6.1 above). The extended squitter airborne velocity register is spontaneously broadcast (squittered) twice per second.

Beyond the format type code of 19 decimal in the first five bits, the airborne velocity register also incorporates a 3-bit "subtype" encoding to further subdivide the types of velocity encoding in use. Table 6-6 describes the subtype encoding values currently defined. Note that horizontal velocity can be expressed in two coordinate systems: Cartesian (east-west and north-south components of ground speed), and Polar (magnetic heading and airspeed). The Cartesian coordinate system is preferred – the polar encoding should only be used if the avionics cannot determine the ground speed components. Within each coordinate system, the speeds can be expressed in either the "normal" range (speed ≤ 1000 knots) or "supersonic" (speed > 1000 knots).

TABLE 6-6

Extended Squitter Airborne Velocity Register Subtype Encodings

Encoding	Velocity	Type
0	Reserved	
1	Cartesian (Ground Speed)	Normal
2		Supersonic
3	Polar (Airspeed, Heading)	Normal
4		Supersonic
5	Reserved	
6	Reserved	
7	Reserved	

Bit 9 of the airborne velocity register is set if a change in aircraft "intent" information has occurred. Aircraft intent is indicated by the contents of registers 40_{16} through 42_{16}. (Reg. 43_{16} is not included in the "intent" register set because it contains dynamic data and is always changing.) Having the intent flag in a squitter allows the receiving application to know when it is necessary to extract the aircraft intent registers in order to obtain the new information. Bit 9 of the airborne velocity register is set 4 seconds after the update to one or more of the aircraft intent registers and is maintained for 18 seconds thereafter.

Bit 10 of the airborne velocity register is set if the squitter avionics are configured to support ADS-B based conflict detection or other higher-level ADS-B applications. Bits 11 through 13 of the extended squitter airborne velocity register contain the "navigational uncertainty category for rate" (NUC_R) encoding for velocity in Version 0. Bits 11 through 13 contain the "navigational accuracy category for velocity" (NAC_V) in Version 1 (see Section 6.7). Table 6-7 contains the definitions for NUC_R.

TABLE 6-7

NUC_R Encodings in the Extended Squitter Airborne Velocity Register (Vers. 0)

NUC_R	Horizontal Velocity Error (95% containment)	Vertical Velocity Error (95% containment)
0	Unknown	Unknown
1	< 10 meters/second	< 50 feet/second
2	< 3 meters/second	< 15 feet/second
3	< 1 meters/second	< 5 feet/second
4	< 0.3 meters/second	< 1.5 feet/second

Bit 36 of the airborne velocity register is set if the vertical velocity value is derived from barometric altimetry. It is cleared if the vertical velocity value is derived from GNSS. Bit 37 is the vertical velocity sign bit (0=upward, 1=downward). Bits 38 through 46 of the airborne velocity register form the 9-bit vertical velocity field. Vertical velocity is expressed in units of feet per minute. The LSB for this field is 64 feet/minute. The value 0 in this field is reserved to indicate the lack of vertical velocity information – level flight is indicated by the value "1."

Bits 47 and 48 of the airborne velocity register are reserved for a future indication of aircraft maneuvering (left or right turn). Such an indicator would be used to improve the tracking of aircraft via ADS-B since true maneuvers could be immediately differentiated from data error.

The remainder of the airborne velocity register contains the difference between barometric altitude and GNSS-derived altitude (if both sources of data are available). Bit 49 of the extended squitter airborne velocity register indicates the sign of this difference (0=GNSS > Barometric, 1=GNSS < Barometric). Bits 50 through 56 of the extended squitter airborne velocity register contain the magnitude of the altitude difference in units of feet. The LSB for this field is 25 feet. As was the case for the vertical velocity field, the value 0 in this field is reserved to indicate the lack of data (either or both sources of altitude data unavailable). The value 1 in this field indicates no altitude difference.

6.5.1 Cartesian (Ground Speed) Encoding

If the subtype encoding in bits 6-8 of the Mode S extended squitter airborne velocity register is 1 or 2, then the horizontal velocity field encoding in bits 14 through 35 of the extended squitter airborne velocity register incorporates two 10-bit ground speed components (east/west and north/south), each with their respective sign bit (0=east or north). The field value 0 is reserved to indicate the lack of data – the encodings of ground speed begin with 1. The speed components are given in units of knots. If the subtype encoding is 1 (normal speed range), the LSB for this field is 1 knot. If the subtype encoding is 2 (supersonic speed range), the LSB for this field is 4 knots.

6.5.2 Polar (Heading and Airspeed) Encoding

If the subtype encoding in bits 6-8 of the airborne velocity register is 3 or 4, then the horizontal velocity field encoding in bits 14 through 35 of the airborne velocity register incorporates a magnetic heading component and an airspeed component. Bit 14 is a status bit for magnetic heading – it is set if magnetic heading data is available. The 10-bit magnetic heading value ranges from 0 to 360 degrees and is measured clockwise from magnetic north. Bit 25 indicates the type of airspeed data (0=indicated airspeed while 1=true airspeed). Bits 26 through 35 hold the airspeed field. The field value 0 is reserved to indicate the lack of data – the encodings of airspeed begin with 1. The airspeed is given in units of knots. If the subtype is 3 (normal speed range), the LSB for this field is 1 knot. If the subtype is 4 (supersonic speed range), the LSB for this field is 4 knots.

6.6 MODE S EXTENDED SQUITTER EVENT-DRIVEN INFORMATION (REG. $0A_{16}$)

The Mode S Extended Squitter "Event-Driven protocol" provides a mechanism to generate Mode S squitters (spontaneous broadcasts of selected register contents) when particular events occur in the avionics rather than with a periodic schedule like the other squitters. Loading the extended squitter event-driven information register ($0A_{16}$) causes the Mode S transponder to generate a single squitter transmission containing the register contents. The Mode S transponder generates the event-driven squitter with minimal delay following the event that loaded register $0A_{16}$ (interleaving the event-driven squitter among the periodic squitters). If multiple "events" occur very close together in time, the squitters are queued in the transponder up to a maximum of two event-driven squitters per second.

The avionics do not directly load register $0A_{16}$. The event-driven protocol is actually driven by loading one or more of the registers in the range 61_{16} through $6F_{16}$ (assuming that these registers are supported by the avionics). When a register in the range 61_{16}-$6F_{16}$ is loaded, the value is transferred into register $0A_{16}$ automatically. Loading register 61_{16} ("Emergency/Priority Status") takes precedence over the other "events" and would be squittered first – events involving registers 62_{16}-$6F_{16}$ employ a round-robin scheduling algorithm.

Currently, only the contents of registers 61_{16} through 65_{16} are defined. Table 6-8 lists the event-driven registers with their respective extended squitter format type code values. Note that registers 62_{16} and 63_{16} in the Version 0 specification [5] share the squitter format type code value 29 – these squitters were to be differentiated by the next bit in their contents. The Version 1 specification [6] has removed these two register definitions from the ADS-B application because no support was generated for their operational use. They are now available for reassignment to other functions. See [4]–[6] for a complete description of the contents of these registers. See [4] for the assignment of ARINC words to the data fields in these registers.

TABLE 6-8

Event-Driven Protocol GICB Registers and Type Codes

GICB	Type Code	Description
61_{16}	28	Emergency conditions in Version 0. Shared with ACAS RA broadcast in Version 1.
62_{16}	29	Current trajectory change point in Version 0. Reserved for the Target State and Status message in Version 1.
63_{16}	29	Next trajectory change point in Version 0. Reserved in Version 1.
64_{16}	30	Aircraft operational coordination message
65_{16}	31	Aircraft operational status message

6.6.1 Emergency/ACAS RA (Reg. 61_{16})

Register 61_{16} (type code 28) is used to indicate emergency conditions on board the aircraft and to send this indication to the ground via the Mode S squitter event-driven protocol. This register is transmitted every 0.8 seconds. Note that some of the emergency conditions are triggered via the setting of the Mode 3/A transponder code to a particular value. In Version 1, this register is also used to indicate the generation of ACAS resolution advisories (RAs). A 3-bit "sub-type" value follows the type code. Sub-type=1 is used for emergency conditions, while sub-type=2 (in Version 1) is used to indicate ACAS RA data. If the sub-type=1 (emergency), then a 3-bit data field indicates the type of emergency condition as defined in Table 6-9 (and the remaining 45 bits in the register are reserved). Note: termination of the emergency condition may be detected by reading the surveillance status field in the Mode S extended squitter airborne position data (Reg. 05_{16}), described in Section 6.1 above.

TABLE 6-9

Register 61_{16} Emergency Code Definitions

Emergency Code Value	Meaning	Transponder Mode 3/A Code Setting (octal)
0	No emergency	—
1	General emergency	7700_8
2	Lifeguard/Medical	—
3	Minimum fuel	—
4	No communications	7600_8
5	Unlawful interference	7500_8
6	Downed aircraft	—
7	Reserved	—

For Version 1 equipment, sub-type=2 is used to indicate that register 61_{16} contains ACAS RA data as described for register 30_{16} in Section 4.2 above. The only difference in the data format is that the first eight bits of register 30_{16} contain the value 30_{16} while the first eight bits of register 61_{16} contain type code=28 (in the first five bits) and the sub-type value 2 in the next three bits. Note: ACAS RA data (sub-type=2) takes priority over emergency data (sub-type=1) if both conditions occur simultaneously.

6.6.2 Aircraft Operational Status Message (Reg. 65_{16})

The intent of the Aircraft Operational Status Message (Reg. 65_{16}) is to provide the current capability class and operational mode of ATC-related applications on board the aircraft via the Mode S squitter event-driven protocol. Register 65_{16} data is to be transmitted every 1.7 seconds in Version 0. The first five bits of the register contains the format type code value of 31. The next 3 bits form a sub-type field. Only the sub-type 0 is defined in Version 0. Version 0 subdivides the next 32 bits into eight 4-bit fields covering such things as enroute operations/status, terminal operations/status, approach/landing operations/status, and surface operations/status. The remaining 32 bits are reserved. However, Version 0 of register 65_{16} [5] only defines the first 4-bit field (enroute operations) as shown in Table 6-10. “Enroute Operations” in Version 0 is used to indicate the operational state of ACAS and “cockpit display of traffic information” (CDTI) avionics on board the aircraft. “ACAS operational” refers to a TCAS II unit operating in the TA/RA mode. All the other fields in the aircraft operational status message (Reg. 65_{16}) were simply left “reserved.” Register 65_{16} gets a more complete definition in Version 1 (see Section 6.7.3 below).

TABLE 6-10

Version 0 Aircraft "Enroute Operations" Coding (Reg. 65_{16})

Value	ACAS	CDTI
0	Operational or unknown	Not operational or unknown
1	Operational or unknown	Operational
2	Not operational	Not operational or unknown
3	Not operational	Operational
4...15	Reserved	Reserved

6.7 VERSION 1 MODE S ADS-B SQUITTER CHANGES

As was discussed in Section 6.0 above, the main difference between Version 0 [5] and Version 1 [6] of the Mode S ADS-B squitter format specification is that the Version 0 formats employed a "navigation uncertainty category" (NUC) while the Version 1 formats overcome the limits of Version 0 by reporting separately the "navigation accuracy category" (NAC), the "navigation integrity category" (NIC), and the "surveillance integrity level" (SIL). Version 1 differences from Version 0 fall into several areas:

(1) format type encoding uses NIC instead of NUC (see Section 6.7.1);

(2) use of NAC instead of NUC for velocity (Section 6.7.2);

(3) a full definition of the aircraft operational status format message (Section 6.7.3); and

(4) redefinition of the contents of register 62_{16} (Section 6.7.4).

6.7.1 Version 1 ADS-B Format Type Encoding

Table 6-11 defines the ADS-B format type coding for Version 1. It closely parallels the equivalent table for Version 0 given in Section 6.0 above, except for the substitution of NIC values for NUC values. Note that the NIC value expressed by the format type code is sometimes modified by the "NIC Supplement" bit in the aircraft operational status message (Reg. 65_{16}) described further in Section 6.7.3 below.

TABLE 6-11

Mode S Extended Squitter Format Type Codes (Version 1)

Format Type Code	Description	Altitude Type	Section Reference	NIC	NIC Supp.
0	No position information	Barometric or none	6.1	0	—
1	Identification (Category D)	N.A.	6.4	—	—
2	Identification (Category C)	N.A.	6.4	—	—
3	Identification (Category B)	N.A.	6.4	—	—
4	Identification (Category A)	N.A.	6.4	—	—
5	Surface Position	N.A.	6.2	11	0
6	Surface Position	N.A.	6.2	10	0
7	Surface Position	N.A.	6.2	9,8	1,0
8	Surface Position	N.A.	6.2	0	0
9	Airborne Position	Barometric	6.1	11	0
10	Airborne Position	Barometric	6.1	10	0
11	Airborne Position	Barometric	6.1	9,8	1,0
12	Airborne Position	Barometric	6.1	7	0
13	Airborne Position	Barometric	6.1	6	1,0
14	Airborne Position	Barometric	6.1	5	0
15	Airborne Position	Barometric	6.1	4	0
16	Airborne Position	Barometric	6.1	3,2	1,0
17	Airborne Position	Barometric	6.1	1	0
18	Airborne Position	Barometric	6.1	0	0
19	Airborne Velocity	Either	6.5	—	—
20	Airborne Position	GNSS	6.1	11	0
21	Airborne Position	GNSS	6.1	10	0
22	Airborne Position	GNSS	6.1	0	0
23	Reserved for testing				
24	Reserved for surface system status				
25	Reserved				
26	Reserved				
27	Reserved				
28	Extended Squitter Aircraft Status/ACAS RA		6.6.1	—	—
29	Reserved for Target State and Status in Version 1		6.6.2 / 6.7.4	—	—
30	No longer used in Version 1		6.6.3	—	—
31	Aircraft Operational Status		6.7.3	—	—

Note: Table 6-12 describes the NIC values for barometric altitude cases. GNSS altitude cases may report only NIC=0, 10, or 11. The NIC categories are based on the 95% "radius of containment" for horizontal navigational error (R_C, also termed the "horizontal protection limit" [HPL] or "horizontal integrity limit" [HIL]). The value of R_C, HPL, or HIL (ARINC Label 130_8) is obtained from the avionics sources of aircraft position. High values of NIC also require a "vertical protection limit" (VPL) measurement. See [4] and [6] for a complete definition of NIC.

TABLE 6-12

Values of NIC for Mode S Extended Squitter (Version 1)

NIC	R_C (HPL, HIL)	VPL
0	$R_C \geq 20$ nmi	—
1	$8 \leq R_C < 20$ nmi	—
2	$4 \leq R_C < 8$ nmi	—
3	$2 \leq R_C < 4$ nmi	—
4	$1 \leq R_C < 2$ nmi	—
5	$0.5 \leq R_C < 1$ nmi	—
6	$0.2 \leq R_C < 0.5$ nmi	—
7	$0.1 \leq R_C < 0.2$ nmi	—
8	75 meters $\leq R_C < 0.1$ nmi	—
9	$25 \leq R_C < 75$ meters	VPL < 112 meters
10	$7.5 \leq R_C < 25$ meters	VPL < 37.5 meters
11	$R_C < 7.5$ meters	VPL < 11 meters

6.7.2 Version 1 NAC Encoding for Velocity

The airborne velocity register 09_{16} described in Section 6.5 above contains the value of the "navigational accuracy parameter for velocity" (NAC_V) in Version 1 rather than the value of NUC_R as in Version 0. Table 6-13 gives the definition for NAC_V when the avionics data source provides the 95% accuracy figure of merit for horizontal velocity ($HFOM_R$) and vertical velocity ($VFOM_R$). The tests indicated in the table are to be applied in the order shown, from most stringent to least stringent. The full definition of NAC_V is given in [4] and [6].

Table 6-13

Values of NAC_V for Airborne Velocity Register 09_{16} (Version 1)

NAC_V	$HFOM_R$ (meters/second)		$VFOM_R$ (feet/second)
4	$HFOM_R < 0.3$	AND	$VFOM_R < 1.5$
3	$HFOM_R < 1$	AND	$VFOM_R < 5$
2	$HFOM_R < 3$	AND	$VFOM_R < 15$
1	$HFOM_R < 10$	AND	$VFOM_R < 50$
0	$HFOM_R$ unknown or ≥ 10	OR	$VFOM_R$ unknown or ≥ 50

6.7.3 Version 1 Format for Aircraft Operational Status (Reg. 65_{16})

The Aircraft Operational Status Message (Reg. 65_{16}) has been greatly extended in the Version 1 format. (Section 6.6.4 above described the Version 0 format of this message/register.) Table 6-14 illustrates the overall format of the Version 1 aircraft operational status register. Note that some fields in this register are split between airborne and surface sub-type coding formats. The division of sub-fields within a data byte is not shown to scale.

TABLE 6-14

Version 1 Aircraft Operational Status Format (Reg. 65_{16})

<table>
<tr><th>Byte Number</th><th colspan="2">Data Field Description</th></tr>
<tr><td rowspan="2">1</td><td colspan="2">Format Type Code = 31</td></tr>
<tr><td>Subtype Code = 0 (airborne)</td><td>Subtype Code = 1 (surface)</td></tr>
<tr><td>2</td><td rowspan="2">Airborne Capability Class</td><td>Surface Capability Class</td></tr>
<tr><td>3</td><td>Length/Width Codes</td></tr>
<tr><td>4</td><td colspan="2" rowspan="2">Operational Mode Codes</td></tr>
<tr><td>5</td></tr>
<tr><td rowspan="3">6</td><td colspan="2">Version Number</td></tr>
<tr><td colspan="2">NIC Supplement bit</td></tr>
<tr><td colspan="2">NAC for Position</td></tr>
<tr><td rowspan="5">7</td><td>Barometric Altitude Quality (BAQ)</td><td>Reserved</td></tr>
<tr><td colspan="2">SIL Code</td></tr>
<tr><td>Barometric NIC</td><td>Track Angle/Heading</td></tr>
<tr><td colspan="2">Horizontal Reference Direction (HRD)</td></tr>
<tr><td colspan="2">Reserved</td></tr>
</table>

Like the Version 0 format for register 65_{16} (Section 6.6.4 above), the Version 1 format starts with a 5-bit format type code value of 31. A 3-bit sub-type code follows the format type code. Version 1 defines two possible sub-types: airborne (0), and surface (1). The next sixteen bits of the message format form a "capability class." Table 6-15 defines the airborne (0) capability class format for Version 1. Note that this format is backwards compatible with the Version 0 definition of the aircraft operational status message. In Version 1, register 65_{16} is broadcast every 0.8 seconds (on average) when there has been a change in any of the following parameters:

(a) ACAS operational;

(b) ACAS RA active;

(c) NAC_P; or

(d) SIL

during the last 24 seconds, or if the Target State and Status message (Section 6.7.4) is being broadcast. Otherwise, register 65_{16} is broadcast every 2.5 seconds (on average).

TABLE 6-15

Version 1 Airborne Capability Class for Aircraft Operational Status (Reg. 65_{16})

Field Content	Number of Bits	Encoding
Service Level MSBs (compatibility with Version 0)	2	00
Not ACAS	1	0=ACAS operational or unknown 1=ACAS not installed or not operational
Cockpit Display of Traffic Information (CDTI)	1	0=CDTI not operational 1=CDTI operational
Service Level LSBs	2	00
Air-referenced velocity (ARV) reporting capability	1	0=no ARV capability 1=ARV capability
Target State (TS) reporting	1	0=no TS capability 1=TS capability
Trajectory Change (TC) reporting	2	0=no TC capability 1=single TC capability 2=multiple TC capability
Reserved	6	Reserved

The surface capability class for the Version 1 format consists of twelve bits as defined in the Table 6-16.

TABLE 6-16

Version 1 Surface Capability Class for Aircraft Operational Status (Reg. 65_{16})

Field Content	Number of Bits	Encoding
Service Level MSBs (compatibility with Version 0)	2	00
Position Offset Applied (POA)	1	0=POA applied 1=POA not applied
Cockpit Display of Traffic Information (CDTI)	1	0=CDTI not operational 1=CDTI operational
Service Level LSBs	2	00
Class B2 low-power transmitter	1	0= ≥ 70 watts 1= < 70 watts
Reserved	5	Reserved

If the airborne operational status format is surface (sub-type=1), then a 4-bit length/width code field is appended to the capability class encoding (so that airborne and surface formats each use a total of 16 bits for the capability class portion of the overall register format). The aircraft length/width coding describes how much space the aircraft or ground vehicle occupies. Each aircraft or vehicle is assigned the smallest length/width code consistent with its actual dimensions. The smallest encoding from Table 6-17 is assigned for which the actual aircraft or vehicle's length and width are less than or equal to the bounding values from the table as given in units of meters. If the aircraft or vehicle is longer than 85 meters or wider than 90 meters, then the length/width of code of 15 is used.

TABLE 6-17

Version 1 Surface Length/Width Encoding for Aircraft Operational Status (Reg. 65_{16})

Length/Width Encoding	Upper Bound (Length)	Upper Bound (Width)
0	15	11.5
1	15	23
2	25	28.5
3	25	34
4	35	33
5	35	38
6	45	39.5
7	45	45
8	55	45
9	55	52
10	65	59.5
11	65	67
12	75	72.5
13	75	80
14	85	80
15	85	90

A 16-bit operational mode field follows the capability code in the Version 1 format for both airborne and surface sub-types. Table 6-18 defines the operational mode encoding.

TABLE 6-18

Version 1 Operational Mode Encoding for Aircraft Operational Status (Reg. 65_{16})

Field Content	Number of Bits	Encoding
Operational Mode Format	2	0=ACAS/IDENT/ATC 1...3=reserved
ACAS RA Active	1	0=ACAS II or ACAS RA not active 1=ACAS RA active
IDENT Switch Active	1	0=IDENT switch not active 1=IDENT switch active (for 18 seconds)
Receiving ATC services	1	0=not receiving ATC services 1=receiving ATC services
Reserved	11	Reserved

The next subfield in the Version 1 format is a 3-bit version number. A version number of zero indicates the support of Version 0 of the Mode S ADS-B squitter format [5]. A version number of one indicates support of Version 1 [6]. Note: reference [4] describes both Version 0 and Version 1. Version numbers 2 through 7 are reserved.

The next subfield in the Version 1 format is the NIC supplement bit as described in Section 6.7.1 above. Following the NIC supplement bit is a 4-bit "navigational accuracy for position" (NAC_P) encoding. This encoding is based on the 95% accuracy limit for "estimated position uncertainty" (EPU) and, for the higher NAC_P values, the 95% "vertical estimated position uncertainty" (VEPU). Table 6-19 defines the NAC_P value encoding. Note that if an update of NAC_P has not been received in more than 5 seconds, the NAC_P encoding of 0 (unknown) is to be used.

TABLE 6-19

Version 1 Aircraft Operational Status NAC_P Encoding for Aircraft Operational Status (Reg. 65_{16})

NAC_P	EPU	VEPU	RNP
0	EPU ≥ 10 Nmi	Unknown	Unknown
1	4.0 ≤ EPU < 10.0 Nmi.	—	10
2	2.0 ≤ EPU < 4.0 Nmi.	—	4
3	1.0 ≤ EPU < 2.0 Nmi.	—	2
4	0.5 ≤ EPU < 1.0 Nmi.	—	1
5	0.3 ≤ EPU < 0.5 Nmi.	—	0.5
6	0.1 ≤ EPU < 0.3 Nmi.	—	0.3
7	0.05 ≤ EPU < 0.1 Nmi.	—	0.1
8	30 ≤ EPU < 92.6 meters	—	GPS with SA on
9	10 ≤ EPU < 30 meters	15 ≤ VEPU < 45 meters	GPS with SA off
10	3 ≤ EPU < 10 meters	4 ≤ VEPU < 15 meters	GPS with WAAS
11	EPU < 3 meters	VEPU < 4 meters	GPS with LAAS
12...15	Reserved		

The next two bits in the Version 1 aircraft operational status message format are reserved for a barometric altitude quality (BAQ) indicator—currently defaulted to 00. The next two bits after the BAQ define the "surveillance integrity level" (SIL) value as given Table 6-20. The SIL value relates to the containment radius R_C described for NIC encoding in Section 6.7.1 above. The SIL value indicates the probability that the value of R_C denoted by the NIC value will be exceeded for the selected geometric position source, including any external signals used by that source, without a positive indication. The probability specified by the SIL value is the largest likelihood of any one of the following occurring when a valid geometric position is provided by the selected position source:

(a) A position source equipment malfunction (per hour);

(b) A per-sample probability of a position source error larger than the horizontal or vertical integrity containment regions associated with the NIC value(s); or

(c) For GNSS, the probability of the signal-in-space causing a position error larger than the horizontal or vertical containment region associated with the NIC value(s) without a positive indication.

Note that if an update of SIL has not been received in more than 5 seconds, the SIL encoding of 0 (unknown) is to be used.

TABLE 6-20

Version 1 Aircraft Operational Status SIL Encoding for Aircraft Operational Status ($Reg. 65_{16}$)

SIL Code	Probability of Exceeding the Horizontal Containment Radius (R_C) Reported in the NIC Subfield Without an Indication	Probability of Exceeding the Vertical Integrity Containment Region (VPL) Without an Indication
0	Unknown	Unknown
1	$< 10^{-3}$ per flight hour or per sample	$< 10^{-3}$ per flight hour or per sample
2	$< 10^{-5}$ per flight hour or per sample	$< 10^{-5}$ per flight hour or per sample
3	$< 10^{-7}$ per flight hour or per sample	$\leq 2 \times 10^{-7}$ per 150 seconds or per sample

Reference 6 defines a mapping between the Version 0 ADS-B format type codes (with their corresponding NUC_P values from Table 6-1) and the corresponding values of NIC and SIL to be assumed when a Version 0 message is converted to a Version 1 output. Table 6-21 summarizes this mapping.

TABLE 6-21

Mapping Version 0 Format Type Coding to Version 1 NIC and SIL Values

Version 0 Format Type Code	Format	Altitude Type	Reported NIC	Reported SIL
0	No position data	Barometric or none	0	0
5	Surface position	None	11	2
6	Surface position	None	10	2
7	Surface position	None	8	2
8	Surface position	None	0	2
9	Airborne position	Barometric	11	2
10	Airborne position	Barometric	10	2
11	Airborne position	Barometric	9	2
12	Airborne position	Barometric	7	2
13	Airborne position	Barometric	6	2
14	Airborne position	Barometric	5	2
15	Airborne position	Barometric	4	2
16	Airborne position	Barometric	1	2
17	Airborne position	Barometric	1	2
18	Airborne position	Either	0	0
20	Airborne position	GNSS	11	2
21	Airborne position	GNSS	10	2
22	Airborne position	GNSS	0	0

The next bit in the Version 1 aircraft operational status message format indicates the "barometric NIC" (NIC_{BARO}) for the airborne format (sub-type=0). This bit is reserved in the surface format (sub-type=1). A NIC_{BARO} value of 0 indicates that the barometric altitude is being reported using a Gilham coded input (subject to undetected bit errors) and has not been crosschecked against an alternative source of barometric altitude within the last 5 seconds. A NIC_{BARO} value of 1 indicates that the barometric altitude is either based on a non-Gilham data source or has been crosschecked within the last 5 seconds. For the surface format (sub-type=1), this bit is used to indicate whether the heading/ground track angle field in the surface position message (Reg. 06_{16} as described in Section 6.2) contains target heading angle (bit=0) or track angle (bit=1).

The next bit in the Version 1 aircraft operational status message format indicates whether the reference direction for such parameters as heading, track angle, selected heading, selected track angle, etc. are referenced to true north (bit=0) or to magnetic north (bit=1). The remaining 2 bits in the Version 1 aircraft operational status message format are reserved.

6.7.4 Proposed Version 1 Format for Target State and Status Information (Reg. 62_{16})

A redefinition of the contents for register 62_{16} has been proposed in [4] to provide more-complete aircraft state and status information via the squitter process. Much of the data in this register parallels data already provided in other registers (e.g., registers 40_{16}, 50_{16}, and 65_{16}). They are grouped here so that they may be obtained all at once without requiring multiple extractions. This register would be broadcast every 1.2 seconds (approximately).

The first five bits of the register contain a format type code of 29. The next two bits form a subtype code subfield – only subtype zero is to be defined at present. The next two bits form the vertical data available/source indicator subfield. This subfield indicates if aircraft vertical state information is available and present, as well as the source of the vertical data in subsequent fields. If no update has been received in the past 5 seconds, then the vertical data is considered to be missing. Table 6-22 defines the Vertical Data Available/Source encodings.

TABLE 6-22

Version 1 Target State and Status Vertical Data Available/Source Encodings (Reg. 62_{16})

Encoding	Meaning
0	No valid Vertical Target State data available
1	Autopilot control panel selected value, such as MCP or FCU (see Section 5.1)
2	Holding Altitude
3	FMS/RNAV System

The next bit of the register indicates whether the altitude reported in the Target Altitude subfield is referenced to mean sea level (1) or to pressure altitude (0). The next two bits form the Target Altitude Capability subfield. This subfield describes the aircraft's capabilities for providing the data reported in the Target Altitude subfield. Table 6-23 defines the Target Altitude Capability encodings.

TABLE 6-23

Version 1 Target State and Status Target Altitude Capability Encodings (Reg. 62_{16})

Encoding	Meaning
0	Holding altitude only
1	Either holding altitude or autopilot control panel selected altitude
2	Holding altitude, autopilot control panel selected altitude, or any FMS/RNAV level-off altitude
3	Reserved

The next two bits form the Vertical Mode Indicator subfield. This subfield indicates whether the target altitude is in the process of being acquired, is acquired, or is being held. Table 6-24 defines the Vertical Mode Indicator encodings.

TABLE 6-24

Version 1 Target State and Status Target Vertical Mode Indicator Encodings (Reg. 62_{16})

Encoding	Meaning
0	Unknown mode or information unavailable
1	"Acquiring" Mode
2	"Capturing" or "Maintaining" Mode
3	Reserved

The next ten bits form the Target Altitude subfield. The data in this subfield indicates the aircraft's next intended level-off altitude (if in a climb or descent), or the aircraft's current altitude (if the intend is to hold this altitude). The target altitude is coded in 100-foot increments from –1000 feet through 100,000 feet. Values of 1011 through 1023 in this subfield are invalid (out of range).

The next two bits form the Horizontal Data Available/Source Indicator subfield. This subfield indicates whether horizontal data is available and what is the source for the subsequent horizontal data subfields. If no update has been received in the past 5 seconds, then the horizontal data is considered to be invalid or missing. Table 6-25 defines the Horizontal Mode Indicator encodings.

TABLE 6-25

Version 1 Target State and Status Target Horizontal Mode Indicator Encodings (Reg. 62_{16})

Encoding	Meaning
0	No valid Horizontal Target State data available
1	Autopilot control panel selected value, such as MCP or FCU
2	Maintaining current heading or track angle (e.g., autopilot mode select)
3	FMS/RNAV System (indicates track angle specified by leg type)

The next nine bits form the Target Heading/Track Angle subfield. This subfield contains the aircraft's heading or track. The angle is coded in degrees from 0 to 359. Values 360 through 511 are invalid. The next bit indicates whether the angle subfield is a target heading (0) or track angle (1). Note: The reference direction for this subfield (true north or magnetic north) is specified by the Horizontal Reference Direction (HRD) bit in the Aircraft Operational Status Message (register 65_{16}) version 1 (Section 6.7.3 above).

The next two bits form a horizontal mode indicator subfield. The encodings for this field are the same as those for the vertical mode indicator as described in Table 6-24 above. The next four bits contain the value of NAC_P (see Table 6-19 in Section 6.7.3 above). The next bit contains the value for barometric altitude "NIC" (NIC_{BARO}) as described in Section 6.7.3 above). The next two bits contain the value of SIL (see Table 6-20 above). The next nine bits are reserved and should be cleared to zero.

The next two bits form a Capability/Mode Code subfield. This subfield indicates the current operational capability of onboard ACAS equipment. Bit 52 indicates whether ACAS equipment is operational (0) or not (1). Bit 53 indicates whether an ACAS RA is active (1) or not active (0).

The last three bits form an Emergency/Priority Status subfield. The encoding used for this subfield is the same as that used in the definition of emergency codes in register 61_{16} (see Section 6.6.1, Table 6-9, above).

7. MILITARY SURVEILLANCE APPLICATIONS

Registers $F1_{16}$ and $F2_{16}$ provide data in support of Military Surveillance Applications. Through these two registers, Mode S applications can gain access to the aircraft's military Mode 1 and Mode 2 codes. Military register $F1_{16}$ is accessed through the normal GICB register extraction protocol, while register $F2_{16}$ is intended for DF=19 military squitter applications.

7.1 MILITARY REGISTER $F1_{16}$

Military register $F1_{16}$ contains two data subfields, each with its own status bit. If the status bit indicates available data, the first data subfield contains the military Mode 1 code of the aircraft. The first bit of the subfield indicates the Mode 1 code format. If the format bit is 0, there are only 6 defined code bits expressed as two octal digits: A1,A2,A4 and B1,B2,B4. If the format bit is 1, there are twelve defined code bits expressed as four octal digits: A1, A2, A4, B1,B2,B4, C1,C2,C4, and D1,D2,D4. The actual bit ordering within the Mode 1 code data field is: C1,A1,C2,A2,C4,A4,X,B1,D1,B2,D2,B4,D4. The second data field in military register $F1_{16}$ contains the 12-bit Mode 2 code expressed as four octal digits in the same bit ordering as the Mode 1 bits. The remaining 27 bits in the register are reserved.

7.2 MILITARY REGISTER $F2_{16}$

Military register $F2_{16}$ is intended for DF=19 extended squitter applications (although it can be directly extracted as well). Such squitters contain a 3-bit "applications field" (AF) whose values are defined in Table 7-1.

TABLE 7-1

DF=19 Applications Field (AF) Values

AF Value	Application
0	Reserved for civilian extended squitter formats
1	Reserved for formation flight
2	Reserved for military applications
3...7	Reserved

The first 5 bits of military register $F2_{16}$ contain the "type code" that identifies the squitter format (similar to that described for civilian squitters in Section 6 above). For this military squitter, AF=2 and the type code is one. Following the type code, the military register $F2_{16}$ contains three data subfields, each with its own status bit. The first two data subfields contain the military Mode 1 and Mode 2 codes, as described for military register $F1_{16}$ above. The third data subfield contains the 12-bit civilian Mode 3/A identity code expressed as 4 octal digits and in the same bit ordering as the 12-bit military Mode 1 and Mode 2 codes. By combining the civilian and military identity codes in a single register (and squitter), the receiving application can obtain all the identity information about the aircraft without having to perform direct Mode S interrogations for the Mode 3/A code.

APPENDIX A
MODE S REGISTER LAYOUTS FROM ICAO DOC 9871

The following pages contain reproductions of the register format tables from ICAO DOC 9871 (FIRST EDITION, POST KOBE), "Technical Provisions for Mode S Services and Extended Squitter" (reference 4). These tables are reproduced here for ease of reference as they are discussed in this report; please see the published ICAO DOC 9871 for complete descriptions of the contents of the registers.

NOTE 1: The text accompanying the DOC 9871 tables on the following pages make references to other text and sections within DOC 9871 [4], not to text or references within this Guidance Material.

NOTE 2: Two definition diagrams are given for some of the ADS-B application transponder registers in this appendix. These diagrams cover those registers whose definitions have been modified between Version 0 and Version 1 of the specification [4]. The Version number for the affected tables is indicated in parentheses in this Appendix table number. The tables that have multiple definitions in this Appendix are:

- A-2;
- A-4;
- A-5;
- A-6;
- A-21; and
- A-23.

TABLE A-1

ICAO DOC 9871 Table A-2-5: BDS Code 0,5 – Extended Squitter Airborne Position

MB FIELD

1	MSB
2	FORMAT TYPE CODE
3	(specified in §A.2.3.1)
4	
5	LSB
6	MSB SURVEILLANCE STATUS
7	LSB (specified in §A.2.3.2.6)
8	SINGLE ANTENNA FLAG (SAF) (specified in §A.2.3.2.5)
9	MSB
10	
11	
12	ALTITUDE
13	(specified by the FORMAT TYPE CODE)
14	
15	
16	This is (1) the altitude code (AC) as specified in
17	§3.1.2.6.5.4 of Annex 10, Volume IV, but with the
18	M-bit removed, or (2) the GNSS height (HAE)
19	
20	LSB
21	TIME (T) (specified in §A.2.3.2.2)
22	CPR FORMAT (F) (specified in §A.2.3.2.1)
23	MSB
24	
25	
26	
27	
28	
29	
30	ENCODED LATITUDE
31	(CPR airborne format specified in §A.2.6)
32	
33	
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	
47	ENCODED LONGITUDE
48	(CPR airborne format specified in §A.2.6)
49	
50	
51	
52	
53	
54	
55	
56	LSB

PURPOSE: To provide accurate airborne position information.

Surveillance status shall be coded as follows:

0 = No condition
1 = Permanent alert (emergency condition)
2 = Temporary alert (change in Mode A identity code other than emergency condition)
3 = SPI condition

Codes 1 and 2 shall take precedence over code 3.

When horizontal position information is unavailable, but altitude information is available, the airborne position message shall be transmitted with a format TYPE Code of ZERO (0) in bits 1 – 5 and the barometric pressure altitude in bits 9 to 20. If neither horizontal position nor barometric altitude information is available, then all 56 bits of transponder register 05_{16} shall be zeroed. The ZERO format TYPE Code field shall indicate that latitude and longitude information is unavailable, while the ZERO altitude field shall indicate that altitude information is unavailable.

TABLE A-2(0)

ICAO DOC 9871 Table A-2-6. BDS Code 0,6 – Extended Squitter Surface Position (Version 0)

MB FIELD

1	MSB
2	FORMAT TYPE CODE
3	(specified in §A.2.3.1)
4	
5	LSB
6	MSB
7	
8	MOVEMENT
9	(specified in §A.2.3.3.1)
10	
11	
12	LSB
13	STATUS for ground track: 0 = Invalid, 1 = Valid
14	MSB = 180 degrees
15	
16	GROUND TRACK (TRUE)
17	(specified in §A.2.3.3.2)
18	
19	
20	LSB = 360/128 degrees
21	TIME (T) (specified in §A.2.3.3.4)
22	CPR FORMAT (F) (specified in §A.2.3.3.3)
23	MSB
24	
25	
26	
27	
28	
29	
30	ENCODED LATITUDE 17 bits
31	(CPR surface format specified in §A.2.6)
32	
33	
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	
47	ENCODED LONGITUDE 17 bits
48	(CPR surface format specified in §A.2.6)
49	
50	
51	
52	
53	
54	
55	
56	LSB

PURPOSE: To provide accurate surface position information.

TABLE A-2(1)

ICAO DOC 9871 Table A-2-6. BDS Code 0,6 – Extended Squitter Surface Position (Version 1)

MB FIELD

PURPOSE: To provide accurate surface position information.

1	MSB
2	FORMAT TYPE CODE
3	(specified in §B.2.3.1)
4	
5	LSB
6	MSB
7	
8	MOVEMENT
9	(specified in §B.2.3.3.1)
10	
11	
12	LSB
13	STATUS for ground track: 0 = Invalid, 1 = Valid
14	MSB = 180 degrees
15	
16	HEADING/GROUND TRACK
17	(specified in §B.2.3.3.2)
18	
19	
20	LSB = 360/128 degrees
21	TIME (T) (specified in §B.2.3.3.4)
22	CPR FORMAT (F) (specified in §B.2.3.3.3)
23	MSB
24	
25	
26	
27	
28	
29	
30	ENCODED LATITUDE 17 bits
31	(CPR surface format specified in §B.2.6)
32	
33	
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	
47	ENCODED LONGITUDE 17 bits
48	(CPR surface format specified in §B.2.6)
49	
50	
51	
52	
53	
54	
55	
56	LSB

TABLE A-3

ICAO DOC 9871 Table A-2-7. BDS Code 0,7 – Extended Squitter Status

MB FIELD

1	MSB	TRANSMISSION RATE
2	LSB	SUBFIELD (TRS)
3		ALTITUDE TYPE SUBFIELD (ATS)
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		RESERVED
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		
41		
42		
43		
44		
45		
46		
47		
48		
49		
50		
51		
52		
53		
54		
55		
56		

PURPOSE: To provide information on the capability and status of the extended squitter rate of the transponder.

Transmission rate subfield (TRS) shall be coded as follows:

0 = No capability to determine surface squitter rate
1 = High surface squitter rate selected
2 = Low surface squitter rate selected
3 = Reserved

Altitude type subfield (ATS) shall be coded as follows:

0 = Barometric altitude
1 = GNSS height (HAE)

Aircraft determination of surface squitter rate:

For aircraft that have the capability to automatically determine their surface squitter rate, the method used to switch between the high and low transmission rates shall be as follows:

a) Switching from high to low rate: Aircraft shall switch from high to low rate when the on-board navigation unit reports that the aircraft's position has not changed more than 10 meters in any 30 second interval. The algorithm used to control the squitter rate shall save the aircraft's position at the time that low rate is selected.

b) Switching from low to high rate: Aircraft shall switch from low to high rate as soon as the aircraft's position has changed by 10 meters or more since the low rate was selected.

For transponder-based implementations, the automatically selected transmission rate shall be subject to being overridden by commands received form the ground control.

TABLE A-4(0)

ICAO DOC 9871 Table A-2-8. BDS Code 0,8 – Extended Squitter Aircraft Identification and Category (Version 0)

MB FIELD

1	MSB	
2		FORMAT TYPE CODE
3		(specified in §A.2.3.1)
4		
5	LSB	
6	MSB	
7		AIRCRAFT CATEGORY
8	LSB	
9	MSB	
10		
11		CHARACTER 1
12		
13		
14	LSB	
15	MSB	
16		
17		CHARACTER 2
18		
19		
20	LSB	
21	MSB	
22		
23		CHARACTER 3
24		
25		
26	LSB	
27	MSB	
28		
29		CHARACTER 4
30		
31		
32	LSB	
33	MSB	
34		
35		CHARACTER 5
36		
37		
38	LSB	
39	MSB	
40		
41		CHARACTER 6
42		
43		
44	LSB	
45	MSB	
46		
47		CHARACTER 7
48		
49		
50	LSB	
51	MSB	
52		
53		CHARACTER 8
54		
55		
56	LSB	

PURPOSE: To provide aircraft identification and category.

Note. – Since there is no internationally agreed criteria for wake vortex categorization, code 4 (set "A") is interpreted as indicating a medium category aircraft exhibiting higher than typical wake vortex characteristics.

Format type shall be coded as follows:

1 = Identification aircraft, category set D
2 = Identification aircraft, category set C
3 = Identification aircraft, category set B
4 = Identification aircraft, category set A

Aircraft/vehicle category shall be coded as follows:

Set A:

0 = No aircraft category information
1 = Light (< 15 500 lbs or 7 031 kg)
2 = Medium 1 (>15 500 to 75 000 lbs, or 7 031 to 34 019 kg)
3 = Medium 2 (>75 000 to 300 000 lbs, or 34 019 to 136 078 kg)
4 = High vortex aircraft
5 = Heavy (> 300 000 lbs or 136 078 kg)
6 = High performance (> 5g acceleration) and high speed (> 400 kt)
7 = Rotorcraft

Set B:

0 = No aircraft category information
1 = Glider/sailplane
2 = Lighter-than-air
3 = Parachutist/skydiver
4 = Ultralight/hang-glider/paraglider
5 = Reserved
6 = Unmanned aerial vehicle
7 = Space/transatmospheric vehicle

Set C:

0 = No aircraft category information
1 = Surface vehicle – emergency vehicle
2 = Surface vehicle – service vehicle
3 = Fixed ground or tethered obstruction
4 – 7 = Reserved

Set D: Reserved

Aircraft identification coding (characters 1 – 8) shall be:

As specified in Table A-2-32.

TABLE A-4(1)

ICAO DOC 9871 Table A-2-8. BDS Code 0,8 – Extended Squitter Aircraft Identification and Category (Version 1)

MB FIELD

1	MSB	
2		FORMAT TYPE CODE
3		(specified in §B.2.3.1)
4		
5	LSB	
6	MSB	
7		EMITTER CATEGORY
8	LSB	
9	MSB	
10		
11		CHARACTER 1
12		
13		
14	LSB	
15	MSB	
16		
17		CHARACTER 2
18		
19		
20	LSB	
21	MSB	
22		
23		CHARACTER 3
24		
25		
26	LSB	
27	MSB	
28		
29		CHARACTER 4
30		
31		
32	LSB	
33	MSB	
34		
35		CHARACTER 5
36		
37		
38	LSB	
39	MSB	
40		
41		CHARACTER 6
42		
43		
44	LSB	
45	MSB	
46		
47		CHARACTER 7
48		
49		
50	LSB	
51	MSB	
52		
53		CHARACTER 8
54		
55		
56	LSB	

PURPOSE: To provide aircraft identification and category for aircra that are equipped with 1 090 MHz ADS-B.

Format type shall be coded as follows:

1 = Aircraft identification , category set D
2 = Aircraft identification, category set C
3 = Aircraft identification , category set B
4 = Aircraft identification, category set A

Aircraft/vehicle category shall be coded as follows:

Set A:

0 = No ADS-B emitter category information
1 = Light (< 15 500 lbs or 7 031 kg)
2 = Small (15 500 to < 75 000 lbs or 7 031 to < 34 019 kg)
3 = Large (75 000 to 300 000 lbs or 34 019 to 136 078 kg)
4 = High vortex aircraft
5 = Heavy (> 300 000 lbs or 136 078 kg)
6 = High performance (> 5g acceleration) and high speed (>
7 = Rotorcraft

Set B:

0 = No ADS-B emitter category information
1 = Glider/sailplane
2 = Lighter-than-air
3 = Parachutist/skydiver
4 = Ultralight/hang-glider/paraglider
5 = Reserved
6 = Unmanned aerial vehicle
7 = Space/Trans-atmospheric vehicle

Set C:

0 = No ADS-B emitter category information
1 = Surface vehicle – emergency vehicle
2 = Surface vehicle – service vehicle
3 = Fixed ground or tethered obstruction
4 = Cluster obstacle
5 = Line obstacle
6 -7 = Reserved

Set D: Reserved

Aircraft identification coding (characters 1 – 8) shall be:

As specified in Annex 10, Volume IV, Table 3-7.

TABLE A-5(0)

ICAO DOC 9871 Table A-2-9a. BDS Code 0,9 – Extended Squitter Airborne Velocity (Subtypes 1 and 2: Velocity over ground) (Version 0)

MB FIELD

1	MSB		1	
2			0	
3	FORMAT TYPE CODE = 19		0	
4			1	
5	LSB		1	
6	SUBTYPE 1	0	SUBTYPE 2	0
7		0		1
8		1		0
9	INTENT CHANGE FLAG (specified in §A.2.3.5.3)			
10	IFR CAPABILITY FLAG			
11	MSB	NAVIGATION UNCERTAINTY		
12		CATEGORY FOR VELOCITY		
13	LSB	(NUC_R)		
14	DIRECTION BIT for E-W Velocity: 0 = East, 1 = West			
15	EAST – WEST VELOCITY			
16	NORMAL: LSB = 1 knot		SUPERSONIC: LSB = 4 knots	
17	All zeros = no velocity information		All zeros = no velocity information	
18	Value	Velocity	Value	Velocity
19	1	0 kt	1	0 kt
20	2	1 kt	2	4 kt
21	3	2 kt	3	8 kt
22	…	…	…	…
23	1 022	1 021 kt	1 022	4 084 kt
24	1 023	>1 021.5 kt	1 033	>4 086 kt
25	DIRECTION BIT for N-S Velocity: 0 = North, 1 = South			
26	NORTH – SOUTH VELOCITY			
27	NORMAL: LSB = 1 knot		SUPERSONIC: LSB = 4 knots	
28	All zeros = no velocity information		All zeros = no velocity information	
29	Value	Velocity	Value	Velocity
30	1	0 kt	1	0 kt
31	2	1 kt	2	4 kt
32	3	2 kt	3	8 kt
33	…	…	…	…
34	1 022	1 021 kt	1 022	4 084 kt
35	1 023	>1 021.5 kt	1 023	>4 086 kt
36	SOURCE BIT FOR VERTICAL RATE: 0 = GNSS, 1 = Baro			
37	SIGN BIT FOR VERTICAL RATE: 0 = Up, 1 = Down			
38	VERTICAL RATE			
39	All zeros = no vertical rate information; LSB = 64 ft/min			
40	Value		Vertical Rate	
41	1		0 ft/min	
42	2		64 ft/min	
43	…		…	
44	510		32 576 ft/min	
45	511		>32 608 ft/min	
46				
47	RESERVED FOR TURN INDICATOR			
48				
49	GNSS ALT. SIGN BIT: 0 = Above baro alt., 1 = Below baro alt.			
50	GNSS ALT. DIFFERENCE FROM BARO. ALT.			
51	All zeros = no information; LSB = 25 ft			
52	Value		Difference	
53	1		0 ft	
54	2		25 ft	
55	126		3 125 ft	
56	127		3 137.5 ft	

PURPOSE: To provide additional state information for both normal and supersonic flight.

Subtype shall be coded as follows:

Code	Velocity	Type
0	Reserved	
1	Ground Speed	Normal
2		Supersonic
3	Airspeed, Heading	Normal
4		Supersonic
5	Reserved	
6	Reserved	
7	Reserved	

IFR capability shall be coded as follows:

0 = Transmitting aircraft has no capability for ADS-B-based conflict detection or higher level (class A1 or above) applications.

1 = Transmitting aircraft has capability for ADS-B-based conflict detection and higher level (class A1 or above) applications.

NUC_R shall be coded as follows:

NUC_R	Horizontal Velocity Error (95%)	Vertical Velocity Error (95%)
0	Unknown	Unknown
1	< 10 m/s	< 15.2 m/s (50 fps)
2	< 3 m/s	< 4.6 m/s (15 fps)
3	< 1 m/s	< 1.5 m/s (5 fps)
4	< 0.3 m/s	< 0.46 m/s (1.5 fps)

TABLE A-5(1)

ICAO DOC 9871 Table A-2-9a. BDS Code 0,9 – Extended Squitter Airborne Velocity (Subtypes 1 and 2: Velocity over ground) (Version 1)

MB FIELD

Bit				
1	MSB		1	
2			0	
3	FORMAT TYPE CODE = 19		0	
4			1	
5	LSB		1	
6	SUBTYPE 1	0	SUBTYPE 2	0
7		0		1
8		1		0
9	INTENT CHANGE FLAG (specified in §B.2.3.5.3)			
10	IFR CAPABILITY FLAG			
11	MSB			
12	NAVIGATION ACCURACY CATEGORY FOR VELOCITY			
13	LSB (NAC$_V$) (specified in §B.2.3.5.5)			
14	DIRECTION BIT for E-W Velocity: 0 = East, 1 = West			
15	EAST – WEST VELOCITY			
16	NORMAL: LSB = 1 knot		SUPERSONIC: LSB = 4 knots	
17	All zeros = no velocity information		All zeros = no velocity information	
18	Value	Velocity	Value	Velocity
19	1	0 kt	1	0 kt
20	2	1 kt	2	4 kt
21	3	2 kt	3	8 kt
22	…	…	…	…
23	1 022	1 021 kt	1 022	4 084 kt
24	1 023	>1 021.5 kt	1 033	>4 086 kt
25	DIRECTION BIT for N-S Velocity: 0 = North, 1 = South			
26	NORTH – SOUTH VELOCITY			
27	NORMAL: LSB = 1 knot		SUPERSONIC: LSB = 4 knots	
28	All zeros = no velocity information		All zeros = no velocity information	
29	Value	Velocity	Value	Velocity
30	1	0 kt	1	0 kt
31	2	1 kt	2	4 kt
32	3	2 kt	3	8 kt
33	…	…	…	…
34	1 022	1 021 kt	1 022	4 084 kt
35	1 023	>1 021.5 kt	1 023	>4 086 kt
36	SOURCE BIT FOR VERTICAL RATE: 0 = GNSS, 1 = Baro			
37	SIGN BIT FOR VERTICAL RATE: 0 = Up, 1 = Down			
38	VERTICAL RATE			
39	All zeros = no vertical rate information; LSB = 64 ft/min			
40	Value	Vertical Rate		
41	1	0 ft/min		
42	2	64 ft/min		
43	…	…		
44	510	32 576 ft/min		
45	511	>32 608 ft/min		
46				
47	RESERVED			
48				
49	GNSS ALT. SIGN BIT: 0 = Above baro alt., 1 = Below baro alt.			
50	GNSS ALT. DIFFERENCE FROM BARO. ALT.			
51	All zeros = no information; LSB = 25 ft			
52	Value	Difference		
53	1	0 ft		
54	2	25 ft		
55	126	3 125 ft		
56	127	> 3 137.5 ft		

PURPOSE: To provide additional state information for both normal and supersonic flight.

Subtype shall be coded as follows:

Code	Velocity	Type
0	Reserved	
1	Ground Speed	Normal
2		Supersonic
3	Airspeed, Heading	Normal
4		Supersonic
5	Reserved	
6	Reserved	
7	Reserved	

IFR capability shall be coded as follows:

0 = Transmitting aircraft has no capability for ADS-B-based conflict detection or higher level (class A1 or above) applications.

1 = Transmitting aircraft has capability for ADS-B-based conflict detection and higher level (class A1 or above) applications.

TABLE A-6(0)

ICAO DOC 9871 Table A-2-9b. BDS Code 0,9 – Extended Squitter Airborne Velocity (Subtypes 3 and 4: Airspeed and heading)(Version 0)

MB FIELD

Bit				
1	MSB		1	
2			0	
3	FORMAT TYPE CODE = 19		0	
4			1	
5	LSB		1	
6	SUBTYPE 3	0	SUBTYPE 4	1
7		1		0
8		1		0
9	INTENT CHANGE FLAG (specified in §A.2.3.5.3)			
10	IFR CAPABILITY FLAG			
11	MSB NAVIGATION UNCERTAINTY			
12	CATEGORY FOR VELOCITY			
13	LSB (NUC_R)			
14	STATUS BIT: 0 = Magnetic heading not available, 1 = available			
15	MSB = 180 degrees			
16				
17				
18	MAGNETIC HEADING			
19	(specified in §A.2.3.5.6)			
20				
21				
22				
23				
24	LSB = 360/1 024 degrees			
25	AIRSPEED TYPE: 0 = IAS, 1 = TAS			
26	AIRSPEED			
27	NORMAL: LSB = 1 knot		SUPERSONIC: LSB = 4 knots	
28	All zeros = no velocity information		All zeros = no velocity information	
29	Value	Velocity	Value	Velocity
30	1	0 kt	1	0 kt
31	2	1 kt	2	4 kt
32	3	2 kt	3	8 kt
33	…	…	…	…
34	1 022	1 021 kt	1 022	4 084 kt
35	1 023	>1 021.5 kt	1 023	>4 086 kt
36	SOURCE BIT FOR VERTICAL RATE: 0 = GNSS, 1 = Baro			
37	SIGN BIT FOR VERTICAL RATE: 0 = Up, 1 = Down			
38	VERTICAL RATE			
39	All zeros = no vertical rate information; LSB = 64 ft/min			
40	Value		Vertical Rate	
41	1		0 ft/min	
42	2		64 ft/min	
43	…		…	
44	510		32 576 ft/min	
45	511		>32 608 ft/min	
46				
47	RESERVED FOR TURN INDICATOR			
48				
49	DIFFERENCE SIGN BIT (0 = Above baro alt, 1 = Below baro alt.)			
50	GEOMETRIC HEIGHT DIFFERENCE FROM BARO. ALT.			
51	All zeros = no information; LSB = 25 ft			
52	Value		Difference	
53	1		0 ft	
54	2		25 ft	
55	126		3 125 ft	
56	127		>3 137.5 ft	

PURPOSE: To provide additional state information for both normal and supersonic flight based on airspeed and heading.

Subtype shall be coded as follows:

Code	Velocity	Type
0	Reserved	
1	Ground Speed	Normal
2		Supersonic
3	Airspeed, Heading	Normal
4		Supersonic
5	Reserved	
6	Reserved	
7	Reserved	

IFR capability shall be coded as follows:

0 = Transmitting aircraft has no capability for ADS-B-based conflict detection or higher level (class A1 or above) applications.

1 = Transmitting aircraft has capability for ADS-B-based conflict detection and higher level (class A1 or above) applications.

NUC_R shall be coded as follows:

NUC_R	Horizontal Velocity Error (95%)	Vertical Velocity Error (95%)
0	Unknown	Unknown
1	< 10 m/s	< 15.2 m/s (50 fps)
2	< 3 m/s	< 4.6 m/s (15 fps)
3	< 1 m/s	< 1.5 m/s (5 fps)
4	< 0.3 m/s	< 0.46 m/s (1.5 fps)

This format shall only be used if velocity over ground is not available.

TABLE A-6(1)

ICAO DOC 9871 Table A-2-9b. BDS Code 0,9 – Extended Squitter Airborne Velocity (Subtypes 3 and 4: Airspeed and heading)(Version 1)

MB FIELD

Bit		
1	MSB	1
2		0
3	FORMAT TYPE CODE = 19	0
4		1
5	LSB	1
6	SUBTYPE 3 0	SUBTYPE 4 1
7	1	0
8	1	0
9	INTENT CHANGE FLAG (specified in §B.2.3.5.3)	
10	IFR CAPABILITY FLAG	
11	MSB	
12	NAVIGATION ACCURACY CATEGORY FOR VELOCITY	
13	LSB (NAC$_V$) (specified in §B.2.3.5.5)	
14	STATUS BIT: 0 = Magnetic heading not available, 1 = available	
15	MSB = 180 degrees	
16		
17		
18	MAGNETIC HEADING	
19	(specified in §B.2.3.5.6)	
20		
21		
22		
23		
24	LSB = 360/1 024 degrees	
25	AIRSPEED TYPE: 0 = IAS, 1 = TAS	
26	AIRSPEED	
27	NORMAL: LSB = 1 knot	SUPERSONIC: LSB = 4 knots
28	All zeros = no velocity information	All zeros = no velocity information
29	Value / Velocity	Value / Velocity
30	1 / 0 kt	1 / 0 kt
31	2 / 1 kt	2 / 4 kt
32	3 / 2 kt	3 / 8 kt
33	… / …	… / …
34	1 022 / 1 021 kt	1 022 / 4 084 kt
35	1 023 / >1 021.5 kt	1 023 / >4 086 kt
36	SOURCE BIT FOR VERTICAL RATE: 0 = GNSS, 1 = Baro	
37	SIGN BIT FOR VERTICAL RATE: 0 = Up, 1 = Down	
38	VERTICAL RATE	
39	All zeros = no vertical rate information; LSB = 64 ft/min	
40	Value	Vertical Rate
41	1	0 ft/min
42	2	64 ft/min
43	…	…
44	510	32 576 ft/min
45	511	>32 608 ft/min
46		
47	RESERVED	
48		
49	DIFFERENCE SIGN BIT (0 = Above baro alt, 1 = Below baro alt.)	
50	GEOMETRIC HEIGHT DIFFERENCE FROM BARO. ALT.	
51	All zeros = no information; LSB = 25 ft	
52	Value	Difference
53	1	0 ft
54	2	25 ft
55	126	3 125 ft
56	127	>3 137.5 ft

PURPOSE: To provide additional state information for both normal and supersonic flight based on airspeed and heading.

Subtype shall be coded as follows:

Code	Velocity	Type
0	Reserved	
1	Ground Speed	Normal
2		Supersonic
3	Airspeed, Heading	Normal
4		Supersonic
5	Reserved	
6	Reserved	
7	Reserved	

IFR capability shall be coded as follows:

0 = Transmitting aircraft has no capability for ADS-B-based conflict detection or higher level (class A1 or above) applications.

1 = Transmitting aircraft has capability for ADS-B-based conflict detection and higher level (class A1 or above) applications.

This format shall only be used if velocity over ground is not available.

TABLE A-7

ICAO DOC 9871 Table A-2-16. BDS Code 1,0 – Data Link Capability Report

MB FIELD

1	MSB
2	
3	
4	BDS Code 1,0
5	
6	
7	
8	LSB
9	Continuation flag (see 9)
10	
11	
12	RESERVED
13	
14	
15	
16	Reserved for ACAS
17	MSB
18	
19	
20	Mode S subnetwork version number (see 12)
21	
22	
23	LSB
24	Transponder enhanced protocol indicator (see 4)
25	Mode S specific services capability (see 2)
26	MSB
27	Uplink ELM average throughput capability (see 13)
28	LSB
29	Downlink ELM: throughput capability of downlink ELM
30	containing the maximum number of ELM segments that the
31	transponder can deliver in response to a single requesting
32	interrogation (UF = 24). (see 14)
33	Aircraft identification capability (see 11)
34	Squitter capability subfield (SCS) (see 5)
35	Surveillance identifier code (SIC) (see 6)
36	Common usage GICB capability report (see 7)
37	
38	RESERVED FOR ACAS
39	
40	
41	MSB
42	
43	
44	
45	
46	
47	Bit array indicating the support status of DTE
48	Sub-addresses 0 to 15 (see 3 and 8)
49	
50	
51	
52	
53	
54	
55	
56	LSB

PURPOSE: To report the data link capability of the Mode S transponder/data link installation.

The coding of this register shall conform to:

1) Annex 10 Volume IV, §3.1.2.6.10.2.

2) When bit 25 is set to 1, it shall indicate that at least one Mode S specific service (other than GICB services related to registers 02_{16}, 03_{16}, 04_{16}, 10_{16}, 17_{16} to $1C_{16}$, 20_{16} and 30_{16}) is supported and the particular capability reports shall be checked.

   Note. – Registers accessed by BDS Codes 0,2; 0,3; 0,4; 1,0; 1,7 to 1,C; 2,0 and 3,0 do not affect the setting of bit 25.

3) Starting from the MSB, each subsequent bit position shall represent the DTE subaddress in the range from 0 to 15.

4) The enhanced protocol indicator shall denote a Level 5 transponder when set to 1, and a Level 2 to 4 transponder when set to 0.

5) The squitter capability subfield (SCS) shall be set to 1 if both registers 05_{16} and 06_{16} have been updated within the last ten, plus or minus one, seconds. Otherwise, it shall be set to 0.

   Note. – Registers 05_{16} and 06_{16} are used for the extended squitter Airborne and surface position reports, respectively.

6) The surveillance identifier code (SIC) bit shall be interpreted as follows:
   0 = no surveillance identifier code capability
   1 = surveillance identifier code capability

7) Bit 36 shall be toggled each time the common usage GICB capability report (register 17_{16}) changes. 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.

8) The current status of the on-board DTE shall be periodically reported to the GDLP by on-board sources. Since a change in this field results in a broadcast of the capability report, status inputs shall be sampled at approximately one minute intervals.

9) In order to determine the extent of any continuation of the data link capability report (into those registers reserved for this purpose: register 11_{16} to register 16_{16}), bit 9 shall be reserved as a continuation flag to indicate if the subsequent register shall be extracted. For example: upon detection of bit 9 = 1 in register 10_{16}, then register 11_{16} shall be extracted. If bit 9 = 1, in register 11_{16}, then register 12_{16} shall be extracted, and so on (up to register 16_{16}). Note that if bit 9 = 1 in register 16_{16}, then this shall be considered as an error condition.

(Requirements are continued on the next page)

TABLE A-8

ICAO DOC 9871 Table A-2-16. BDS Code 1,0 – Data Link Capability Report (Concluded)

10) The Mode S transponder may update bits 1-8, 16, 33, 35 and 37-40 independent of the ADLP. These bits are provided by the transponder when the data link capability report is broadcast as a result of a transponder detecte change in capability reported by the ADLP (§3.1.2 of Annex 10 Volume IV).

11) Bit 33 indicates the availability of Aircraft Identification data. It shall be set b the transponder if the data comes to the transponder through a separate interface and not through the ADLP.

12) The Mode S subnetwork version number shall be coded as follows:

Version Number	Year of Annex 10 amendment	Edition of this document
0	Mode S subnetwork not available	
1	1996	---
2	1998	---
3	2002	---
4	2007	Edition 1
5 - 127	Unassigned	

Note.– RTCA/DO-181D, EUROCAE ED-73C and ED-101A are consistent with ICAO Doc 9871, Edition 1.

13) Uplink ELM average throughput capability shall be coded as follows:

0 = No UELM Capability
1 = 16 UELM segments in 1 second
2 = 16 UELM segments in 500 ms
3 = 16 UELM segments in 250 ms
4 = 16 UELM segments in 125 ms
5 = 16 UELM segments in 60 ms
6 = 16 UELM segments in 30 ms
7 = Unassigned

14) Downlink ELM throughput capability shall be coded as follows:

0 = No DELM Capability
1 = One 4 segment DELM every second
2 = One 8 segment DELM every second
3 = One 16 segment DELM every second
4 = One 16 segment DELM every 500 ms
5 = One 16 segment DELM every 250 ms
6 = One 16 segment DELM every 125 ms
7-15 = Unassigned

TABLE A-9

ICAO DOC 9871 Table A-2-23. BDS Code 1,7 – Common Usage GICB Capability Report

MB FIELD

1	0,5 Extended squitter sirborne position
2	0,6 Extended squitter surface position
3	0,7 Extended squitter status
4	0,8 Extended squitter type and identification
5	0,9 Extended squitter airborne velocity information
6	0,A Extended squitter event-driven information
7	2,0 Aircraft identification
8	2,1 Aircraft registration number
9	4,0 Selected vertical intention
10	4,l Next waypoint identifier
11	4,2 Next waypoint position
12	4,3 Next waypoint information
13	4,4 Meteorological routine report
14	4,5 Meteorological hazard report
15	4.8 VHF channel report
16	5,0 Track and turn report
17	5,1 Position coarse
18	5,2 Position fine
19	5,3 Air-referenced state vector
20	5,4 Waypoint 1
21	5,5 Waypoint 2
22	5,6 Waypoint 3
23	5,F Quasi-static parameter monitoring
24	6,0 Heading and speed report
25	Reserved for aircraft capability
26	Reserved for aircraft capability
27	E,1 Reserved for Mode S BITE (Built In Test Equipment)
28	E,2 Reserved for Mode S BITE (Built In Test Equipment)
29	F,1 Military applications
30–56	RESERVED

PURPOSE: To indicate common usage GICB services currently Supported.

1) Each bit position shall indicate that the associated register is available in the aircraft installation when set to 1.

2) All registers shall be constantly monitored at a rate consistent with their individual required update rate and the corresponding capability bit shall be set to 1 only when valid data is being input to that register at the required rate or above.

3) The capability bit shall be set to a 1 if at least one field in the register is receiving valid data at the required rate with the status bits for all fields not receiving valid data at the required rate set to ZERO (0).

4) Registers 18_{16} to $1C_{16}$ shall be independent of register 17_{16}.

TABLE A-10

ICAO DOC 9871 Table A-2-24 . BDS Code 1,8 – Mode S Specific Services GICB Capability Report (1 of 5)

MB FIELD

1	BDS 3,8
2	BDS 3,7
3	BDS 3,6
4	BDS 3,5
5	BDS 3,4
6	BDS 3,3
7	BDS 3,2
8	BDS 3,1
9	BDS 3,0
10	BDS 2,F
11	BDS 2,E
12	BDS 2,D
13	BDS 2,C
14	BDS 2,B
15	BDS 2,A
16	BDS 2,9
17	BDS 2,8
18	BDS 2,7
19	BDS 2,6
20	BDS 2,5
21	BDS 2,4
22	BDS 2,3
23	BDS 2,2
24	BDS 2,1
25	BDS 2,0
26	BDS 1,F
27	BDS 1,E
28	BDS 1,D
29	BDS 1,C
30	BDS 1,B
31	BDS 1,A
32	BDS 1,9
33	BDS 1,8
34	BDS 1,7
35	BDS 1,6
36	BDS 1,5
37	BDS 1,4
38	BDS 1,3
39	BDS 1,2
40	BDS 1,1
41	BDS 1,0
42	BDS 0,F
43	BDS 0,E
44	BDS 0,D
45	BDS 0,C
46	BDS 0,B
47	BDS 0,A
48	BDS 0,9
49	BDS 0,8
50	BDS 0,7
51	BDS 0,6
52	BDS 0,5
53	BDS 0,4
54	BDS 0,3
55	BDS 0,2
56	BDS 0,1

PURPOSE: To indicate GICB services that are installed.

Each bit position shall indicate that the GICB service that it represents has been implemented in the aircraft installation when set to 1.

Starting from the LSB, each bit position shall represent the register number, in accordance with the following table:

BDS Code	Capability installed for register
BDS 1,8	01_{16} to 38_{16}
BDS 1,9	39_{16} to 70_{16}
BDS 1,A	71_{16} to $A8_{16}$
BDS 1,B	$A9_{16}$ to $E0_{16}$
BDS 1,C	$E1_{16}$ to FF_{16}

The 25 most significant bits of register $1C_{16}$ shall not be used.

TABLE A-11

ICAO DOC 9871 Table A-2-25. BDS Code 1,9 – Mode S Specific Services GICB Capability Report (2 of 5)

MB FIELD

1	BDS 7,0
2	BDS 6,F
3	BDS 6,E
4	BDS 6,D
5	BDS 6,C
6	BDS 6,B
7	BDS 6,A
8	BDS 6,9
9	BDS 6,8
10	BDS 6,7
11	BDS 6,6
12	BDS 6,5
13	BDS 6,4
14	BDS 6,3
15	BDS 6,2
16	BDS 6,1
17	BDS 6,0
18	BDS 5,F
19	BDS 5,E
20	BDS 5,D
21	BDS 5,C
22	BDS 5,B
23	BDS 5,A
24	BDS 5,9
25	BDS 5,8
26	BDS 5,7
27	BDS 5,6
28	BDS 5,5
29	BDS 5,4
30	BDS 5,3
31	BDS 5,2
32	BDS 5,1
33	BDS 5,0
34	BDS 4,F
35	BDS 4,E
36	BDS 4,D
37	BDS 4,C
38	BDS 4,B
39	BDS 4,A
40	BDS 4,9
41	BDS 4,8
42	BDS 4,7
43	BDS 4,6
44	BDS 4,5
45	BDS 4,4
46	BDS 4,3
47	BDS 4,2
48	BDS 4,1
49	BDS 4,0
50	BDS 3,F
51	BDS 3,E
52	BDS 3,D
53	BDS 3,C
54	BDS 3,B
55	BDS 3,A
56	BDS 3,9

PURPOSE: To indicate GICB services that are installed.

Each bit position shall indicate that the GICB service that it represents has been implemented in the aircraft installation when set to 1.

TABLE A-12

ICAO DOC 9871 Table A-2-26. BDS Code 1,A – Mode S Specific Services GICB Capability Report (3 of 5)

MB FIELD

1	BDS A,8
2	BDS A,7
3	BDS A,6
4	BDS A,5
5	BDS A,4
6	BDS A,3
7	BDS A,2
8	BDS A,1
9	BDS A,0
10	BDS 9,F
11	BDS 9,E
12	BDS 9,D
13	BDS 9,C
14	BDS 9,B
15	BDS 9,A
16	BDS 9,9
17	BDS 9,8
18	BDS 9,7
19	BDS 9,6
20	BDS 9,5
21	BDS 9,4
22	BDS 9,3
23	BDS 9,2
24	BDS 9,1
25	BDS 9,0
26	BDS 8,F
27	BDS 8,E
28	BDS 8,D
29	BDS 8,C
30	BDS 8,B
31	BDS 8,A
32	BDS 8,9
33	BDS 8,8
34	BDS 8,7
35	BDS 8,6
36	BDS 8,5
37	BDS 8,4
38	BDS 8,3
39	BDS 8,2
40	BDS 8,1
41	BDS 8,0
42	BDS 7,F
43	BDS 7,E
44	BDS 7,D
45	BDS 7,C
46	BDS 7,B
47	BDS 7,A
48	BDS 7,9
49	BDS 7,8
50	BDS 7,7
51	BDS 7,6
52	BDS 7,5
53	BDS 7,4
54	BDS 7,3
55	BDS 7,2
56	BDS 7,1

PURPOSE: To indicate GICB services that are installed.

Each bit position shall indicate that the GICB service that it represents has been implemented in the aircraft installation when set to 1.

TABLE A-13

ICAO DOC 9871 Table A-2-27. BDS Code 1,B – Mode S Specific Services GICB Capability Report (4 of 5)

MB FIELD

1	BDS E,0
2	BDS D,F
3	BDS D,E
4	BDS D,D
5	BDS D,C
6	BDS D,B
7	BDS D,A
8	BDS D,9
9	BDS D,8
10	BDS D,7
11	BDS D,6
12	BDS D,5
13	BDS D,4
14	BDS D,3
15	BDS D,2
16	BDS D,1
17	BDS D,0
18	BDS C,F
19	BDS C,E
20	BDS C,D
21	BDS C,C
22	BDS C,B
23	BDS C,A
24	BDS C,9
25	BDS C,8
26	BDS C,7
27	BDS C,6
28	BDS C,5
29	BDS C,4
30	BDS C,3
31	BDS C,2
32	BDS C,1
33	BDS C,0
34	BDS B,F
35	BDS B,E
36	BDS B,D
37	BDS B,C
38	BDS B,B
39	BDS B,A
40	BDS B,9
41	BDS B,8
42	BDS B,7
43	BDS B,6
44	BDS B,5
45	BDS B,4
46	BDS B,3
47	BDS B,2
48	BDS B,1
49	BDS B,0
50	BDS A,F
51	BDS A,E
52	BDS A,D
53	BDS A,C
54	BDS A,B
55	BDS A,A
56	BDS A,9

PURPOSE: To indicate GICB services that are installed.

Each bit position shall indicate that the GICB service that it represents has been implemented in the aircraft installation when set to 1.

TABLE A-14

ICAO DOC 9871 Table A-2-28. BDS Code 1,C – Mode S Specific Services GICB Capability Report (5 of 5)

MB FIELD

1	RESERVED
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	BDS F,F
27	BDS F,E
28	BDS F,D
29	BDS F,C
30	BDS F,B
31	BDS F,A
32	BDS F,9
33	BDS F,8
34	BDS F,7
35	BDS F,6
36	BDS F,5
37	BDS F,4
38	BDS F,3
39	BDS F,2
40	BDS F,1
41	BDS F,0
42	BDS E,F
43	BDS E,E
44	BDS E,D
45	BDS E,C
46	BDS E,B
47	BDS E,A
48	BDS E,9
49	BDS E,8
50	BDS E,7
51	BDS E,6
52	BDS E,5
53	BDS E,4
54	BDS E,3
55	BDS E,2
56	BDS E,1

PURPOSE: To indicate GICB services that are installed.

Each bit position shall indicate that the GICB service that it represents has been implemented in the aircraft installation when set to 1.

TABLE A-15

ICAO DOC 9871 Table A-2-32. BDS Code 2,0 – Aircraft Identification

MB FIELD

1	MSB	
2		
3		
4		BDS Code 2,0
5		
6		
7		
8	LSB	
9	MSB	
10		
11		CHARACTER 1
12		
13		
14	LSB	
15	MSB	
16		
17		CHARACTER 2
18		
19		
20	LSB	
21	MSB	
22		
23		CHARACTER 3
24		
25		
26	LSB	
27	MSB	
28		
29		
30		CHARACTER 4
31		
32	LSB	
33	MSB	
34		
35		
36		CHARACTER 5
37		
38	LSB	
39	MSB	
40		
41		
42		CHARACTER 6
43		
44	LSB	
45	MSB	
46		
47		
48		CHARACTER 7
49		
50	LSB	
51	MSB	
52		
53		
54		CHARACTER 8
55		
56	LSB	

PURPOSE: To report aircraft identification to the ground.

1) Annex 10, Volume IV, §3.1.2.9.

2) The character coding to be used shall be identical to that defined in Table 3-7 of Chapter 3, Annex 10, Volume IV.

3) This data may be input to the transponder from sources other than the Mode S ADLP.

4) Characters 1 – 8 of this format shall be used by the extended squitter application.

5) Capability to support this register shall be indicated by setting bit 33 in register 10_{16} and the relevant bits in registers 17_{16} and 18_{16}.

6) The aircraft identification shall be that employed in the flight plan. When no flight plan is available, the registration marking of the aircraft shall be used.

TABLE A-16

ICAO DOC 9871 Table A-2-48. BDS Code 3,0 – ACAS Active Resolution Advisory

MB FIELD

1	MSB
2	
3	
4	BDS Code 3,0
5	
6	
7	
8	LSB
9	MSB
10	
11	
12	
13	
14	
15	ACTIVE RESOLUTION ADVISORIES
16	
17	
18	
19	
20	
21	
22	LSB
23	MSB
24	RACs RECORD
25	
26	LSB
27	RA TERMINATED
28	MULTIPLE THREAT ENCOUNTER
29	MSB THREAT-TYPE INDICATOR
30	LSB
31	MSB
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	
42	
43	THREAT IDENTITY DATA
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	LSB

PURPOSE: To report resolution advisories (RAs) generated by ACAS equipment.

The coding of this register shall conform to:

1) Annex 10, Volume IV, §4.3.8.4.2.2.

2) Bit 27 shall mean RA terminated when set to 1.

TABLE A-17

ICAO DOC 9871 Table A-2-64. BDS Code 4,0 – Selected Vertical Intention

MB FIELD

1	STATUS	
2	MSB = 32 768 feet	
3		
4		
5	MCP/FCU SELECTED ALTITUDE	
6		
7	Range = [0, 65 520] feet	
8		
9		
10		
11		
12		
13	LSB = 16 feet	
14	STATUS	
15	MSB = 32 768 feet	
16		
17		
18	FMS SELECTED ALTITUDE	
19		
20	Range = [0, 65 520] feet	
21		
22		
23		
24		
25		
26	LSB = 16 feet	
27	STATUS	
28	MSB = 204.8 mb	
29		
30		
31		
32	BAROMETRIC PRESSURE SETTING	
33	MINUS 800 mb	
34		
35	Range = [0, 410] mb	
36		
37		
38		
39	LSB = 0.1 mb	
40		
41		
42		
43		
44	RESERVED	
45		
46		
47		
48	STATUS OF MCP/FCU MODE BITS	
49	VNAV MODE	
50	ALT HOLD MODE	MCP/FCU Mode bits
51	APPROACH MODE	
52	RESERVED	
53		
54	STATUS OF TARGET ALT SOURCE BITS	
55	MSB TARGET ALT SOURCE	
56	LSB	

PURPOSE: To provide ready access to information about the aircraft's current vertical intentions, in order to improve the effectiveness of conflict probes and to provide additional tactical information to controllers.

1) Target altitude shall be the short-term intent value, at which the aircraft will level off (or has leveled off) at the end of the current maneuver. The data source that the aircraft is currently using to determine the target altitude shall be indicated in the altitude source bits (54 to 56) as detailed below.

   Note. – This information which represents the real "aircraft intent," when available, represented by the altitude control panel selected altitude, the flight management system selected altitude, or the current aircraft altitude according to the aircraft's mode of flight (the intent may not be available at all when the pilot is flying the aircraft).

2) The data entered into bits 1 to 13 shall be derived from the mode control panel/flight control unit or equivalent equipment. Alerting devices may be used to provide data if it is not available from "control" equipment. The associated mode bits for this field (48 to 51) shall be as detailed below.

3) The data entered into bits 14 to 26 shall de derived from the flight management system or equivalent equipment managing the vertical profile of the aircraft.

4) The current barometric pressure setting shall be calculated from the value contained in the field (bits 28 to 39) plus 800 mb.

   When the barometric pressure setting is less than 800 mb or greater than 1 209.5 mb, the status bit for this field (bit 27) shall be set to indicate invalid data.

5) Bits 48 to 56 shall indicate the status (see §C.2.4.4) of the values provided in bits 1 to 26 as follows:

   Bit 48 shall indicate whether the mode bits (49, 50 and 51) are already being populated:

   0 = No mode information provided
   1 = Mode information deliberately provided

   Bits 49, 50 and 51:

   0 = Not active
   1 = Active

   Bit 54 shall indicate whether the target altitude source bits (55 and 56) are actively being populated:

   0 = No source information provided
   1 = Source information deliberately provided

   Bits 55 and 56 shall indicate target altitude source:

   00 = Unknown
   01 = Aircraft altitude
   10 = FCU/MCP selected altitude
   11 = FMS selected altitude

TABLE A-18

ICAO DOC 9871 Table A-2-80. BDS Code 5,0 – Track and Turn Report

MB FIELD

1	STATUS
2	SIGN 1 = Left Wing Down
3	MSB = 45 degrees
4	
5	
6	ROLL ANGLE
7	
8	Range = [-90, + 90] degrees
9	
10	
11	LSB = 45/256 degrees
12	STATUS
13	SIGN 1 = West (e.g., 315 = -45 degrees)
14	MSB = 90 degrees
15	
16	
17	TRUE TRACK ANGLE
18	
19	Range = [-180, +180] degrees
20	
21	
22	
23	LSB = 90/512 degrees
24	STATUS
25	MSB = 1 024 knots
26	
27	
28	GROUND SPEED
29	
30	Range = [0, 2 046] knots
31	
32	
33	
34	LSB = 1 024/512 knots
35	STATUS
36	SIGN 1 = Minus
37	MSB = 8 degrees/second
38	
39	
40	TRACK ANGLE RATE
41	Range = [-16, +16] degrees/second
42	
43	
44	
45	LSB = 8/256 degrees/second
46	STATUS
47	MSB = 1 024 knots
48	
49	
50	TRUE AIRSPEED
51	
52	Range = [0, 2 046] knots
53	
54	
55	
56	LSB = 2 knots

PURPOSE: To provide track and turn data to the ground systems.

1) If the value of the parameter from any source exceeds the range allowable in the register definition, the maximum allowable value in the correct positive or negative sense shall be used instead.

   Note 1. – This requires active intervention by the GFM.

2) The data entered into the register shall, whenever possible, be derived from the sources that are controlling the aircraft.

3) If any parameter is not available on the aircraft, all bits corresponding to that parameter shall be actively set to ZERO by the GFM.

4) The LSB of all fields shall be obtained by rounding.

   Note 2. – Two's complement coding is used for all signed fields as specified in §A.2.2.2.

TABLE A-19

ICAO DOC 9871 Table A-2-95. BDS Code 5,F – Quasi-Static Parameter Monitoring

MB FIELD

Bit		Field
1	MSB	MCP/FCU SELECTED ALTITUDE
2	LSB	
3		RESERVED
4		
5		RESERVED
6		
7		RESERVED
8		
9		RESERVED
10		
11		RESERVED
12		
13	MSB	NEXT WAYPOINT
14	LSB	
15		RESERVED
16		
17	MSB	FMS VERTICAL MODE
18	LSB	
19	MSB	VHF CHANNEL REPORT
20	LSB	
21	MSB	METEOROLOGICAL HAZARDS
22	LSB	
23	MSB	FMS SELECTED ALTITUDE
24	LSB	
25	MSB	BAROMETRIC PRESSURE
26	LSB	SETTING MINUS 800 mb
27–56		RESERVED

PURPOSE: To permit the monitoring of changes in parameters that do not normally change very frequently, i.e., those expected to be stable for 5 minutes or more by accessing a single register.

Parameter Monitor Coding:

1) The changing of each parameter shall be monitored by 2 bits. The value 00 shall indicate that no valid data are available on this parameter. The decimal value for this 2-bit field shall be cycled through 1, 2 and 3, each step indicating a change in the monitored parameter.

2) The meteorological hazards subfield shall report changes to turbulence, wind shear, wake vortex, icing and microburst, as in register number 45_{16}.

3) The next waypoint subfield shall report change to data contained in registers 41_{16}, 42_{16} and 43_{16}.

4) The FMS vertical mode shall report change to bits 48 to 51 in register 40_{16}.

TABLE A-20

ICAO DOC 9871 Table A-2-96. BDS Code 6,0 – Heading and Speed Report

MB FIELD

1	STATUS
2	SIGN 1=West (e.g., 315 = -45 degrees)
3	MSB = 90 degrees
4	
5	
6	MAGNETIC HEADING
7	
8	Range = [-180, +180] degrees
9	
10	
11	
12	LSB = 90/512 degrees
13	STATUS
14	MSB = 512 knots
15	
16	
17	INDICATED AIRSPEED
18	
19	Range = [0, 1023] knots
20	
21	
22	
23	LSB = 1 knot
24	STATUS
25	MSB = 2.048 MACH
26	
27	
28	MACH
29	
30	Range = [0, 4.092] MACH
31	
32	
33	
34	LSB = 2.048/512 MACH
35	STATUS
36	SIGN 1 = Below
37	MSB = 8 192 feet/minute
38	
39	
40	BAROMETRIC ALTITUDE RATE
41	
42	Range = [-16 384, +16 352] feet/minute
43	
44	
45	LSB = 8 192/256 = 32 feet/minute
46	STATUS
47	SIGN 1 = Below
48	MSB = 8 192 feet/minute
49	
50	
51	INERTIAL VERTICAL VELOCITY
52	
53	Range = [-16 384, +16 352] feet/minute
54	
55	
56	LSB = 8 192/256 = 32 feet/minute

PURPOSE: To provide heading and speed data to ground systems.

1) If the value of a parameter from any source exceeds the range allowable in the register definition, the maximum allowable value in the correct positive or negative sense shall be used instead.

   Note 1. – This requires active intervention by the GFM.

2) The data entered into the register shall whenever possible be derived from the sources that are controlling the aircraft.

3) The LSB of all fields shall be obtained by rounding.

4) When barometric altitude rate is integrated and smoothed with inertia vertical velocity (baro-inertial information), it shall be transmitted in the Inertial Vertical Velocity field.

   Note 2. – Barometric Altitude Rate contains values solely derived from barometric measurement. The Barometric Altitude Rate is usually very unsteady and may suffer from barometric instrument inertia.

   Note 3. – The Inertial Vertical Velocity is also providing information on vertical movement of the aircraft but it comes from equipments (IRS, AHRS) using different sources used for navigation. The information is a more filtered and smooth parameter.

   Note 4. – Two's complement coding is used for all signed fields as specified in §A.2.2.2.

Table A-21(0)

ICAO DOC 9871 Table A-2-97. BDS Code 6,1 – Extended Squitter Emergency/Priority Status (Version 0)

MB FIELD

1	MSB	
2		
3		FORMAT TYPE CODE = 28
4		
5	LSB	
6	MSB	
7		SUBTYPE CODE = 1
8	LSB	
9	MSB	
10		EMERGENCY STATE
11	LSB	
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		
32		
33		
34		RESERVED
35		
36		
37		
38		
39		
40		
41		
42		
43		
44		
45		
46		
47		
48		
49		
50		
51		
52		
53		
54		
55		
56		

PURPOSE: To provide additional information on aircraft status.

Subtype shall be coded as follows:

0 = No information
1 = Emergency/priority status
2 to 7 = Reserved

Emergency state shall be coded as follows:

Value	Meaning
0	No emergency
1	General emergency
2	Lifeguard/Medical
3	Minimum fuel
4	No communications
5	Unlawful interference
6	Reserved
7	Reserved

1) Message delivery shall be accomplished once per 0.8 seconds using the event-driven protocol.

2) Termination of emergency state shall be detected by coding in the surveillance status field of the airborne position message.

3) Emergency State value 1 shall be set when Mode A code 7700 is provided to the transponder.

4) Emergency State value 4 shall be set when Mode A code 7600 is provided to the transponder.

5) Emergency State value 5 shall be set when Mode A code 7500 is provided to the transponder.

TABLE A-21(1a)

ICAO DOC 9871 Table A-2-97. BDS Code 6,1 – Extended Squitter Emergency/Priority Status (Version 1a)

MB FIELD

1	MSB
2	
3	FORMAT TYPE CODE = 28
4	
5	LSB
6	MSB
7	SUBTYPE CODE = 1
8	LSB
9	MSB
10	EMERGENCY STATE
11	LSB
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	
31	
32	
33	
34	RESERVED
35	
36	
37	
38	
39	
40	
41	
42	
43	
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	

PURPOSE: To provide additional information on aircraft status.

Subtype shall be coded as follows:

0 = No information
1 = Emergency/priority status
2 = ACAS RA Broadcast
3 to 7 = Reserved

Emergency state shall be coded as follows:

Value	Meaning
0	No emergency
1	General emergency
2	Lifeguard/Medical
3	Minimum fuel
4	No communications
5	Unlawful interference
6	Downed aircraft
7	Reserved

1) Message delivery shall be accomplished once per 0.8 seconds using the event-driven protocol.

2) Termination of emergency state shall be detected by coding in the surveillance status field of the airborne position message.

3) Subtype 2 message broadcast shall take priority over subtype 1 message broadcast.

4) Emergency State value 1 shall be set when Mode A code 7700 is provided to the transponder.

5) Emergency State value 4 shall be set when Mode A code 7600 is provided to the transponder.

6) Emergency State value 5 shall be set when Mode A code 7500 is provided to the transponder.

TABLE A-21(1b)

ICAO DOC 9871 Table A-2-97. BDS Code 6,1 – Extended Squitter Emergency/Priority Status (Version 1b)

MB FIELD

1	MSB
2	
3	FORMAT TYPE CODE = 28
4	
5	LSB
6	MSB
7	SUBTYPE CODE = 2
8	LSB
9	MSB
10	
11	
12	
13	
14	
15	ACTIVE RESOLUTION ADVISORIES
16	
17	
18	
19	
20	
21	
22	LSB
23	MSB
24	RACs RECORD
25	
26	LSB
27	RA TERMINATED
28	MULTIPLE THREAT ENCOUNTER
29	MSB THREAT – TYPE INDICATOR
30	LSB
31	MSB
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	
42	
43	THREAT IDENTITY DATA
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	LSB

PURPOSE: To report resolution advisories (RAs) generated by ACAS equipment.

Subtype shall be coded as follows:

0 = No information
1 = Emergency/priority status
2 = ACAS RA Broadcast
3 to 7 = Reserved

Emergency state shall be coded as follows:

The coding of bits 9 to 56 of this register shall conform to the corresponding bits of Register 30_{16} as specified in Annex 10, Volume IV, §4.3.8.4.2.2.

1) Message delivery shall be accomplished once per 0.8 seconds using the event-driven protocol.

2) RA Broadcast shall begin within 0.5 seconds after transponder notification of the initiation of an ACAS RA.

3) RA Broadcast shall be terminated 10 seconds after the RAT flag (§4.3.8.4.2.2.1.3) transitions from ZERO to ONE.

4) Subtype 2 message broadcast shall take priority over subtype 1 message broadcast.

TABLE A-22

ICAO DOC 9871 Table D-2-98. BDS Code 6,2 – Target State and Status Information

MB FIELD

1	
2	
3	FORMAT TYPE CODE = 29
4	
5	
6	MSB SUBTYPE CODE = 0
7	LSB
8	MSB Vertical Data Available / Source Indicator
9	LSB (see §D.2.3)
10	Target Altitude Type (see §D.2.4)
11	Backward Compatibility Flag = 0
12	MSB Target Altitude Capability
13	LSB (see §D.2.5)
14	MSB Vertical Mode Indicator
15	LSB (see §D.2.6)
16	MSB
17	
18	
19	
20	Target Altitude
21	(see §D.2.7)
22	
23	
24	
25	LSB
26	MSB Horizontal Data Available / Source Indicator
27	LSB (see §D.2.8)
28	MSB
29	
30	
31	
32	Target Heading / Track Angle
33	(see §D.2.9)
34	
35	
36	LSB
37	Target Heading / Track Indicator (see §D.2.10)
38	MSB Horizontal Mode Indicator (see §D.2.11)
39	LSB
40	MSB
41	Navigation Accuracy Category – Position (NAC_P)
42	(see §D.2.12)
43	LSB
44	Navigation Integrity Category – Baro (NIC_{BARO}) (see §D.2.13)
45	MSB Surveillance Integrity Level (SIL)
46	LSB (see §D.2.14)
47	
48	
49	Reserved
50	
51	
52	MSB Capability / Mode Codes
53	LSB (see §D.2.15)
54	MSB
55	Emergency / Priority Status
56	LSB (see §D.2.16)

PURPOSE: To provide aircraft state and status information.

TABLE A-23(0)

ICAO DOC 9871 Table A-2-101. BDS Code 6,5 – Extended Squitter Aircraft Operational Status (Version 0)

MB FIELD

1	MSB	
2		
3		FORMAT TYPE CODE = 31
4		
5	LSB	
6	MSB	
7		SUBTYPE CODE = 0
8	LSB	
9	MSB	
10		EN-ROUTE OPERATIONAL
11		CAPABILITIES (CC-4)
12	LSB	(specified in §A.2.3.11.3)
13	MSB	
14		TERMINAL AREA OPERATIONAL
15		CAPABILITIES (CC-3)
16	LSB	(specified in §A.2.3.11.4)
17	MSB	
18		APPROACH/LANDING OPERATIONAL
19		CAPABILITIES (CC-2)
20	LSB	(specified in §A.2.3.11.5)
21	MSB	
22		SURFACE OPERATONAL
23		CAPABILITIES (CC-1)
24	LSB	(specified in §A.2.3.11.6)
25	MSB	
26		EN-ROUTE OPERATIONAL CAPABILITY
27		STATUS (OM-4)
28	LSB	(specified in §A.2.3.11.7)
29	MSB	
30		TERMINAL AREA OPERATIONAL CAPABILITY
31		STATUS (OM-3)
32	LSB	(specified in §A.2.3.11.8)
33	MSB	
34		APPROACH/LANDING OPERATIONAL CAPABILITY
35		STATUS (OM-2)
36	LSB	(specified in §A.2.3.11.9)
37	MSB	
38		SURFACE OPERATONAL CAPABILITY
39		STATUS (OM-1)
40	LSB	(specified in §A.2.3.11.10)
41		
42		
43		
44		
45		
46		
47		
48		RESERVED
49		
50		
51		
52		
53		
54		
55		
56		

PURPOSE: To provide the capability class and current operational mode of ATC-related applications on board the aircraft.

1) Message delivery shall be accomplished using the event-driven protocol.

TABLE A-23(1)

ICAO DOC 9871 Table A-2-101. BDS Code 6,5 – Extended Squitter Aircraft Operational Status (Version 1)

MB FIELD

Bit		
1	MSB	
2		
3	FORMAT TYPE CODE = 31	
4		
5	LSB	
6	MSB	MSB
7	SUBTYPE CODE = 0	SUBTYPE CODE = 1
8	LSB	LSB
9	MSB	MSB
10		
11		
12		
13		
14	AIRBORNE	SURFACE
15	CAPABILITY CLASS (CC)	CAPABILITY CLASS (CC)
16	CODES	CODES
17	(see §B.2.3.10.3)	(see §B.2.3.10.3)
18		
19		
20		LSB
21		MSB
22		LENGTH/WIDTH CODES
23		(see §B.2.3.10.11)
24	LSB	LSB
25	MSB	
26		
27		
28		
29		
30		
31		
32	OPERATIONAL MODE (OM) CODES	
33	(see §B.2.3.10.4)	
34		
35		
36		
37		
38		
39		
40	LSB	
41	MSB	
42	VERSION NUMBER (see §B.2.3.10.5)	
43	LSB	
44	NIC SUPPLEMENT (see §B.2.3.10.6)	
45	MSB	
46	NAVIGATIONAL ACCURACY CATEGORY – POSITION	
47	(NAC_P) (see §B.2.3.10.7)	
48	LSB	
49	MSB BAQ = 0	RESERVED
50	LSB (see §B.2.3.10.8)	
51	MSB SURVEILLANCE INTEGRITY LEVEL (SIL)	
52	LSB (see §B.2.3.10.9)	
53	NIC_{BARO} (see §B.2.3.10.10)	TRK/HDG (see §B.2.3.10.12)
54	HRD (see §B.2.3.10.13)	
55	RESERVED	
56		

PURPOSE: To provide the capability class and current operational mode of ATC-related applications and other operational information..

Subtype Coding:

0 = Airborne Status Message
1 = Surface Status Message
2 – 7 = Reserved

1) Message delivery shall be accomplished using the event-driven protocol.

TABLE A-24

ICAO DOC 9871 Table A-2-227. BDS Code E,3 – Transponder Type / Part Number

MB FIELD

Bit	Part number (P/N) coding	Character coding
1	STATUS	
2	MSB FORMAT TYPE	
3	LSB	
4	MSB	MSB
5	P/N	
6	Digit 1	CHARACTER 1
7	LSB	
8	MSB	
9	P/N	LSB
10	Digit 2	MSB
11	LSB	
12	MSB	CHARACTER 2
13	P/N	
14	Digit 3	
15	LSB	LSB
16	MSB	MSB
17	P/N	
18	Digit 4	CHARACTER 3
19	LSB	
20	MSB	
21	P/N	LSB
22	Digit 5	MSB
23	LSB	
24	MSB	CHARACTER 4
25	P/N	
26	Digit 6	
27	LSB	LSB
28	MSB	MSB
29	P/N	
30	Digit 7	CHARACTER 5
31	LSB	
32	MSB	
33	P/N	LSB
34	Digit 8	MSB
35	LSB	
36	MSB	CHARACTER 6
37	P/N	
38	Digit 9	
39	LSB	LSB
40	MSB	MSB
41	P/N	
42	Digit 10	CHARACTER 7
43	LSB	
44	MSB	
45	P/N	LSB
46	Digit 11	MSB
47	LSB	
48	MSB	CHARACTER 8
49	P/N	
50	Digit 12	
51	LSB	LSB
52		
53		
54	RESERVED	RESERVED
55		
56		

PURPOSE: To provide Mode S transponder part number or type as defined by the supplier.

FORMAT TYPE CODING:

Bit 2	Bit 3	
0	0	= Part number (P/N) coding
0	1	= Character coding
1	0	= Reserved
1	1	= Reserved

1) When available it is recommended to use the part number. P/N Digit are BCD encoded. Digit 1 is the first left digit of the part number.

2) If the part number is not available, the first 8 characters of the commercial name can be used with the format type "01."

3) If format type "01" is used, the coding of character 1 to 8 shall be as defined in Table 3-7 of Chapter 3, Annex 10, Volume IV.. Character is the first left character of the transponder type.

4) For operational reasons, some military installations may not impleme this format.

TABLE A-25

ICAO DOC 9871 Table A-2-228. BDS Code E,4 – Transponder Software Revision Number

MB FIELD

1	STATUS	
2	MSB FORMAT TYPE	
3	LSB	
4	MSB	MSB
5	P/N	
6	Digit 1	CHARACTER 1
7	LSB	
8	MSB	
9	P/N	LSB
10	Digit 2	MSB
11	LSB	
12	MSB	CHARACTER 2
13	P/N	
14	Digit 3	
15	LSB	LSB
16	MSB	MSB
17	P/N	
18	Digit 4	CHARACTER 3
19	LSB	
20	MSB	
21	P/N	LSB
22	Digit 5	MSB
23	LSB	
24	MSB	CHARACTER 4
25	P/N	
26	Digit 6	
27	LSB	LSB
28	MSB	MSB
29	P/N	
30	Digit 7	CHARACTER 5
31	LSB	
32	MSB	
33	P/N	LSB
34	Digit 8	MSB
35	LSB	
36	MSB	CHARACTER 6
37	P/N	
38	Digit 9	
39	LSB	LSB
40	MSB	MSB
41	P/N	
42	Digit 10	CHARACTER 7
43	LSB	
44	MSB	
45	P/N	LSB
46	Digit 11	MSB
47	LSB	
48	MSB	CHARACTER 8
49	P/N	
50	Digit 12	
51	LSB	LSB
52		
53		
54	RESERVED	RESERVED
55		
56		

PURPOSE: To provide Mode S transponder software revision number as defined by the supplier.

FORMAT TYPE CODING:

Bit 2	Bit 3	
0	0	= Part number (P/N) coding
0	1	= Character coding
1	0	= Reserved
1	1	= Reserved

1) When a part number is allocated to the software revision, it is recommended to use the format type "00." In this case, P/N Digits are BCD encoded. Digit 1 is the first left digit of the part number.

2) If format type "01" is used, the coding of character 1 to 8 shall be as defined in Table 3-7 of Chapter 3, Annex 10, Volume IV. Character 1 is the first left character of the software revision number.

3) For operational reasons, some military installations may not implement this format.

TABLE A-26

ICAO DOC 9871 Table A-2-229. BDS Code E,5 – ACAS Unit Part Number

MB FIELD

Bit	P/N coding	Character coding
1	STATUS	
2	MSB FORMAT TYPE	
3	LSB	
4	MSB	MSB
5	P/N	
6	Digit 1	CHARACTER 1
7	LSB	
8	MSB	
9	P/N	LSB
10	Digit 2	MSB
11	LSB	
12	MSB	CHARACTER 2
13	P/N	
14	Digit 3	
15	LSB	LSB
16	MSB	MSB
17	P/N	
18	Digit 4	CHARACTER 3
19	LSB	
20	MSB	
21	P/N	LSB
22	Digit 5	MSB
23	LSB	
24	MSB	CHARACTER 4
25	P/N	
26	Digit 6	
27	LSB	LSB
28	MSB	MSB
29	P/N	
30	Digit 7	CHARACTER 5
31	LSB	
32	MSB	
33	P/N	LSB
34	Digit 8	MSB
35	LSB	
36	MSB	CHARACTER 6
37	P/N	
38	Digit 9	
39	LSB	LSB
40	MSB	MSB
41	P/N	
42	Digit 10	CHARACTER 7
43	LSB	
44	MSB	
45	P/N	LSB
46	Digit 11	MSB
47	LSB	
48	MSB	CHARACTER 8
49	P/N	
50	Digit 12	
51	LSB	LSB
52		
53		
54	RESERVED	RESERVED
55		
56		

PURPOSE: To provide ACAS unit part number or type as defined by the supplier.

FORMAT TYPE CODING:

Bit 2	Bit 3	
0	0	= Part number (P/N) coding
0	1	= Character coding
1	0	= Reserved
1	1	= Reserved

1) When available it is recommended to use the part number. P/N Digits are BCD encoded. Digit 1 is the first left digit of the part number.

2) If the part number is not available, the first 8 characters of the commercial name can be used with the format type "01."

3) If format type "01" is used, the coding of character 1 to 8 shall be as defined in Table 3-7 of Chapter 3, Annex 10, Volume IV. Character 1 is the first left character of the ACAS unit type.

4) For operational reasons, some military installations may not implement this format.

TABLE A-27

ICAO DOC 9871 Table A-2-230. BDS Code E,6 – ACAS Unit Software Revision

MB FIELD

1	STATUS	
2	MSB FORMAT TYPE	
3	LSB	
4	MSB	MSB
5	P/N	
6	Digit 1	CHARACTER 1
7	LSB	
8	MSB	
9	P/N	LSB
10	Digit 2	MSB
11	LSB	
12	MSB	CHARACTER 2
13	P/N	
14	Digit 3	
15	LSB	LSB
16	MSB	MSB
17	P/N	
18	Digit 4	CHARACTER 3
19	LSB	
20	MSB	
21	P/N	LSB
22	Digit 5	MSB
23	LSB	
24	MSB	CHARACTER 4
25	P/N	
26	Digit 6	
27	LSB	LSB
28	MSB	MSB
29	P/N	
30	Digit 7	CHARACTER 5
31	LSB	
32	MSB	
33	P/N	LSB
34	Digit 8	MSB
35	LSB	
36	MSB	CHARACTER 6
37	P/N	
38	Digit 9	
39	LSB	LSB
40	MSB	MSB
41	P/N	
42	Digit 10	CHARACTER 7
43	LSB	
44	MSB	
45	P/N	LSB
46	Digit 11	MSB
47	LSB	
48	MSB	CHARACTER 8
49	P/N	
50	Digit 12	
51	LSB	LSB
52		
53		
54	RESERVED	RESERVED
55		
56		

PURPOSE: To provide ACAS unit software revision number as defined by the supplier.

FORMAT TYPE CODING:

Bit 2	Bit 3	
0	0	= Part number (P/N) coding
0	1	= Character coding
1	0	= Reserved
1	1	= Reserved

1) When available it is recommended to use the part number. P/N Digits are BCD encoded. Digit 1 is the first left digit of the part number.

2) If format type "01" is used, the coding of character 1 to 8 shall be as defined in Table 3-7 of Chapter 3, Annex 10, Volume IV. Character 1 is the first left character of the ACAS unit software revision.

3) For operational reasons, some military installations may not implement this format.

TABLE A-28

ICAO DOC 9871 Table A-2-241. BDS Code F,1 – Military Applications

MB FIELD

1	STATUS	
2	Character Field (see 1)	
3	C1	MODE 1 CODE
4	A1	
5	C2	
6	A2	
7	C4	
8	A4	
9	X	
10	B1	
11	D1	
12	B2	
13	D2	
14	B4	
15	D4	
16	STATUS	
17	C1	MODE 2 CODE
18	A1	
19	C2	
20	A2	
21	C4	
22	A4	
23	X	
24	B1	
25	D1	
26	B2	
27	D2	
28	B4	
29	D4	
30		RESERVED
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		
41		
42		
43		
44		
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56		

PURPOSE: To provide data in support of military applications.

1) The character field shall be used to indicate whether 2 characters or 4 characters are used in the Mode 1 code. The logic shall be as follows:

   0 = 2 octal codes
   (A1 – A4 and B1 – B4)

   1 = 4 octal codes
   (A1 – A4, B1 – B4, C1 – C4 and D1 – D4)

2) The status fields shall be used to indicate whether the data are available or unavailable. The logic shall be as follows:

   0 = Unavailable
   1 = Available

TABLE A-29

ICAO DOC 9871 Table A-2-242. BDS Code F,2 – Military Applications

MB FIELD

1	MSB	
2		
3	AF=2, TYPE CODE = 1	
4		
5	LSB	
6	STATUS	
7	CHARACTER FIELD (see 1)	
8	C1	
9	A1	
10	C2	
11	A2	
12	C4	
13	A4	
14	X	MODE 1 CODE
15	B1	
16	D1	
17	B2	
18	D2	
19	B4	
20	D4	
21	STATUS	
22	C1	
23	A1	
24	C2	
25	A2	
26	C4	
27	A4	
28	X	MODE 2 CODE
29	B1	
30	D1	
31	B2	
32	D2	
33	B4	
34	D4	
35	STATUS	
36	C1	
37	A1	
38	C2	
39	A2	
40	C4	
41	A4	
42	X	MODE A CODE
43	B1	
44	D1	
45	B2	
46	D2	
47	B4	
48	D4	
49		
50		
51		
52		RESERVED
53		
54		
55		
56		

PURPOSE: This register is used for military applications involving DF=19. Its purpose is to provide data in support of military applications.

'TYPE CODE' shall be encoded as follows:

0 = Unassigned
1 = Mode code information
2-31 = Unassigned

1) The character field shall be used to indicate whether 2 characters or 4 characters are used in the Mode 1 code. The logic shall be as follows:

0 = 2 octal codes
(A1 – A4 and B1 – B4)

1 = 4 octal codes
(A1 – A4, B1 – B4, C1 – C4 and D1 – D4)

2) The status fields shall be used to indicate whether the data are available or unavailable. The logic shall be as follows:

0 = Unavailable
1 = Available

DF = 19 Application Field (AF) shall be encoded as follows:

0 = Reserved for civil extended squitter formats
1 = Reserved for formation flight
2 = Reserved for military applications
3-7 = Reserved

LIST OF ACRONYMS

3D, 4D	Three Dimensional, Four Dimensional
ACAS	Airborne Collision Avoidance System
ADS-B	Automatic Dependent Surveillance - Broadcast
AF	Applications Field
ARA	Active Resolution Advisories
ARINC	Aeronautical Radio, Incorporated
ARV	Air-Referenced Velocity
ATC	Air Traffic Control
ATN	Aeronautical Telecommunications Network
BAQ	Barometric Altitude Quality
BCD	Binary-Coded Decimal
BDS	Comm-B Data Selector
CA	Mode S Transponder Capability
CDTI	Cockpit Display of Traffic Information
CPR	Compact Position Reporting
DF	Downlink format
DTE	Date Terminal Equipment
EHS	Enhanced Surveillance
ELM	Extended Length Message
ELS	Elementary Surveillance
EPU	Estimated Position Uncertainty
ES	1090 MHz “Extended Squitter”
EUROCAE	European Organization for Civil Aviation Equipment
FCU	Flight Control Unit
FMS	Flight Management System
GAMA	General Aviation Manufacturers Association
GICB	Ground-Initiated Comm B
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HFOM	Horizontal Figure of Merit

HIL	Horizontal Integrity Limit
HPL	Horizontal Protection Limit
HRD	Horizontal Reference Direction
ICAO	International Civil Aviation Organization
LAAS	Local Area Augmentation System
LSB	Least Significant Bit
MCP	Mode Control Panel
MHz	MegaHertz
MSP	Mode S-Specific Protocols
MSB	Most Significant Bit
MTI	Multiple Threat Indicator
NAC	Navigation Accuracy Category
NIC	Navigational Integrity Category
NUC	Navigation Uncertainty Category
POA	Position Offset Applied
RA	Resolution Advisory
RAC	RAs Active
RAT	RA Terminated
RNAV	Area Navigation
RTCA	Radio Technical Commission for Aeronautics
SA	Selected Availability
SI	Surveillance Identifier
SIL	Surveillance Integrity Level
SPI	Special Position Indicator
TA	Traffic Alert
TC	Trajectory Change
TCAS	Traffic Alert and Collision Avoidance System
TCP	Trajectory Change Point
TID	Threat Identity Data
TIS	Traffic Information Service
TS	Target State
TTG	Time To Go

TTI	Threat Type Indicator
USAF	United States Air Force
UTC	universal time code
VEPU	Vertical Estimated Position Uncertainty
VFOM	Vertical Figure of Merit
VMI	Vertical Mode Indicator
VNAV	Vertical navigation
VPL	Vertical Protection Limit
WAAS	Wide Area Augmentation System

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[3] ICAO International Standards and Recommended Practices, Aeronautical Telecommunications, Annex 10, Volume IV, Surveillance Radar and Collision Avoidance Systems, July 1998 – including Amendment 82 (2006).

[4] ICAO Technical Provisions for Mode S Services and Extended Squitter, Doc 9871, First Edition, 2007 (supercedes Doc 9688 “Manual on Mode S-Specific Services,” 2004).

[5] RTCA DO-260, “Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B),” 2000 – including Change 1 (2006).

[6] RTCA DO-260A, “Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B),” 2003 – including Change 1 and Change 2 (2006).