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AN/464

Technical Provisions for Mode S Services and Extended Squitter

Approved by the Secretary General
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AMENDMENTS

Amendments are announced in the supplements to the *Catalogue of ICAO Publications;* the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS		
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FOREWORD

The purpose of this manual is to specify technical provisions for the formats and associated protocols used in Mode S services and extended squitter. These detailed technical provisions supplement requirements contained in Annex 10 — *Aeronautical Telecommunications,* Volume III (Part I — Digital Data Communication Systems), and Volume IV — *Surveillance Radar and Collision Avoidance Systems,* and are necessary to ensure global interoperability.

The manual also includes implementation guidelines as well as information on future Mode S and extended squitter services that are under development.

The provision of Mode S services, specified in this document, include the following:

a) data formats for transponder registers;

b) formats for Mode S specific protocols:

   traffic information broadcast; and

   dataflash;

c) Mode S broadcast protocols, including:

   1) uplink broadcast; and

   2) downlink broadcast.

Formats and protocols for extended squitter automatic dependent surveillance — broadcast (ADS-B) messages are also included since registers are defined for each of these messages. Those registers are assigned so that the extended squitter messages can be read out on demand by a ground interrogator, in addition to being delivered via an ADS-B message.

This manual has been developed by the Aeronautical Surveillance Panel (ASP). Comments on this manual from States and other parties outside ICAO would be appreciated. Comments should be addressed to:

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GLOSSARY

Aircraft. The term aircraft may be used to refer to Mode S emitters (e.g. aircraft/vehicles), where appropriate.

Aircraft address. A unique combination of 24 bits available for assignment to an aircraft for the purpose of air-ground communications, navigation and surveillance.

Aircraft data link processor (ADLP). An aircraft-resident processor that is specific to a particular air-ground data link (e.g. Mode S) and which provides channel management, and segments and/or reassembles messages for transfer. It is connected on one side to aircraft elements common to all data link systems and on the other side to the air-ground link itself.

Aircraft/Vehicle. May be used to describe either a machine or device capable of atmospheric flight, or a vehicle on the airport surface movement area (i.e. runways and taxiways).

Air-initiated Comm-B (AICB) protocol. A procedure initiated by a Mode S aircraft installation for delivering a Comm-B message to the ground.

Automatic dependent surveillance — broadcast (ADS-B) IN. A function that receives surveillance data from ADS-B OUT data sources.

Automatic dependent surveillance — broadcast (ADS-B) OUT. A function on an aircraft or vehicle that periodically broadcasts its state vector (position and velocity) and other information derived from on-board systems in a format suitable for ADS-B IN capable receivers.

Automatic dependent surveillance — rebroadcast (ADS-R). The rebroadcast by a ground station of surveillance information received via one ADS-B link over an alternative ADS-B link providing interoperability in airspace where multiple different ADS-B data links are operating.

BDS Comm-B Data Selector. The 8-bit BDS code determines the transponder register whose contents are to be transferred in the MB field of a Comm-B reply. It is expressed in two groups of 4 bits each, BDS1 (most significant 4 bits) and BDS2 (least significant 4 bits).

Broadcast*.* The protocol within the Mode S system that permits uplink messages to be sent to all aircraft in the coverage area, and downlink messages to be made available to all interrogators that have the aircraft wishing to send the message under surveillance.

Capability Report. Information identifying whether the transponder has a data link capability as reported in the capability (CA) field of an all-call reply or squitter transmission (see *Data link capability report*).

Close-out. A command from a Mode S interrogator that terminates a Mode S link layer communications transaction.

Comm-A*.* A 112-bit interrogation containing the 56-bit MA message field. This field is used by the uplink standard length message (SLM) and broadcast protocols.

Comm-B. A 112-bit reply containing the 56-bit MB message field. This field is used by the downlink SLM, ground-initiated and broadcast protocols.

Comm-C. A 112-bit interrogation containing the 80-bit MC message field. This field is used by the uplink extended length message (ELM) protocol.

Comm-D. A 112-bit reply containing the 80-bit MD message field. This field is used by the downlink ELM protocol.

Data link capability report. Information in a Comm-B reply identifying the complete Mode S communication capabilities of the aircraft installation.

Downlink. A term referring to the transmission of data from an aircraft to the ground. Mode S air-to-ground signals are transmitted on the 1 090 MHz reply frequency channel.

Frame. The basic unit of data transfer at the link level. A frame can include from one to four Comm-A or Comm-B segments, from two to sixteen Comm-C segments, or from one to sixteen Comm-D segments.

General Formatter/Manager (GFM). The aircraft function responsible for formatting messages to be inserted in the transponder registers. It is also responsible for detecting and handling error conditions such as the loss of input data.

Ground Data Link Processor (GDLP). A ground-resident processor that is specific to a particular air-ground data link (e.g. Mode S) and which provides channel management, and segments and/or reassembles messages for transfer. It is connected on one side (by means of its data circuit terminating equipment (DCE)) to ground elements common to all data link systems, and on the other side to the air-ground link itself.

Ground-initiated Comm-B (GICB). The ground-initiated Comm-B protocol allows the interrogator to extract Comm-B replies containing data from one of the 255 transponder registers within the transponder in the MB field of the reply.

Ground-initiated protocol. A procedure initiated by a Mode S interrogator for delivering standard length (via Comm-A) or extended length (via Comm-C) messages to a Mode S aircraft installation.

Horizontal Integrity Limit (HIL). The radius of a circle in the horizontal plane (i.e. the plane tangent to the WGS-84 ellipsoid), with its center being the true position, which describes the region which is assured to contain the indicated horizontal position.

Horizontal Protection Limit (HPL). The radius of a circle in the horizontal plane (i.e. the plane tangent to the WGS-84 ellipsoid), with its center being the true position, which describes the region which is assured to contain the indicated horizontal position.

Note. **—** *The terms HPL and HIL (Horizontal Integrity Limit) are used interchangeably in various documents.*

Mode S broadcast protocols. Procedures allowing standard length uplink or downlink messages to be received by more than one transponder or ground interrogator, respectively.

Mode S packet. A packet conforming to the Mode S subnetwork standard, designed to minimize the bandwidth required from the air-ground link. ISO 8208 packets may be transformed into Mode S packets and vice versa.

Mode S Specific Protocol (MSP). A protocol that provides a restricted datagram service within the Mode S subnetwork.

Mode S specific services. A set of communication services provided by the Mode S system which are not available from other air-ground subnetworks and therefore not interoperable.

Packet. The basic unit of data transfer among communications devices within the network layer (e.g. an ISO 8208 packet or a Mode S packet).

Required Navigation Performance (RNP). A statement of the navigation performance accuracy necessary for operation within a defined airspace.

Segment. A portion of a message that can be accommodated within a single MA/MB field in the case of an SLM, or a single MC/MD field in the case of an ELM. This term is also applied to the Mode S transmissions containing these fields.

Standard Length Message (SLM). An exchange of digital data using selectively addressed Comm-A interrogations and/or Comm-B replies.

Subnetwork. An actual implementation of a data network that employs a homogeneous protocol and addressing plan and is under the control of a single authority.

Timeout. The cancellation of a transaction after one of the participating entities has failed to provide a required response within a pre-defined period of time.

Traffic information service — broadcast (TIS-B). The principle use of TIS-B is to complement the operation of ADS-B by providing ground-to-air broadcast of surveillance data on aircraft that are not equipped for 1 090 MHz ADS-B OUT as an aid to transition to a full ADS-B environment. The basis for this ground surveillance data may be an air traffic control (ATC) Mode S radar, a surface or approach multilateration system, or a multi-sensor data processing system. The TIS-B ground-to-air transmissions use the same signal formats as 1 090 MHz ADS-B and can therefore be accepted by a 1 090 MHz ADS-B receiver.

Uplink. A term referring to the transmission of data from the ground to an aircraft. Mode S ground-to-air signals are transmitted on the 1 030 MHz interrogation frequency channel.

ACRONYMS

ACAS	Airborne collision avoidance system
ADLP	Airborne data link processor
ADS-B	Automatic dependent surveillance — broadcast
ADS-R	Automatic dependent surveillance — rebroadcast
ANP	Actual navigation performance
ATN	Aeronautical telecommunication network
ATS	Air traffic service
A/V	Aircraft/vehicle
BDS	Comm-B data selector
BITE	Built-in test equipment
CFDIU	Centralized fault display interface unit
CPR	Compact position reporting
ELM	Extended length message
ES	Extended squitter
FCC	Flight control computer
FCU	Flight control unit
FMS	Flight management system
GDLP	Ground data link processor
GFM	General formatter/manager
GICB	Ground-initiated Comm-B
GNSS	Global navigation satellite system
HAE	Height above the ellipsoid
HIL	Horizontal integrity limit
HPL	Horizontal protection limit
II	Interrogator identifier
LSB	Least significant bit
MA	Message, Comm-A
MB	Message, Comm-B
MC	Message, Comm-C
MCP	Mode control panel
MD	Message, Comm-D
MOPS	Minimum operational performance standards
MSB	Most significant bit
MSP	Mode S specific protocol
MSSS	Mode S specific services
NAC_P	Navigational accuracy category — position
NAC_V	Navigational accuracy category — velocity
NIC	Navigation integrity category
NUC_P	Navigational uncertainty category — position
NUC_R	Navigational uncertainty category — rate
RNP	Required navigation performance
SAF	Single antenna flag
SARPs	Standards and Recommended Practices
SI	Surveillance identifier
SIL	Surveillance integrity level
SLM	Standard length message

SPI	Special position identification
SSE	Mode S specific services entity
SSR	Secondary surveillance radar
TIS	Traffic information service
TIS-B	Traffic information service — broadcast
UTC	Coordinated universal time

Chapter 1

INTRODUCTION

1.1 OUTLINE OF THE MANUAL

1.1.1 This manual specifies detailed technical provisions related to the implementation of the Standards and Recommended Practices (SARPs) for surveillance systems using Mode S services and extended squitter (ES): These detailed technical provisions supplement requirements that are contained in Annex 10 — *Aeronautical Telecommunications,* Volume III (Part I — Digital Data Communication Systems), and Volume IV — *Surveillance Radar and Collision Avoidance Systems*, and are necessary to ensure global interoperability.

1.1.2 The structure of the manual is as follows:

a) Chapter 1 presents the outline, objectives and scope of this manual;

b) Chapter 2 contains specifications for transponder register formats, protocols and related requirements for Mode S services and for Version 0 ES which is suitable for early implementation of ES applications. Using these ES message formats, ADS-B surveillance quality is reported by navigation uncertainty category (NUC) which can be an indication of either the accuracy or integrity of the navigation data being broadcast. However, there is no indication as to whether the NUC value is based on integrity or accuracy; and

c) Chapter 3 contains specifications for Version 1 ES message formats and related requirements that apply to more advanced ADS-B applications. Surveillance accuracy and integrity are reported separately as navigation accuracy category (NAC), navigation integrity category (NIC) and surveillance integrity level (SIL). Version 1 ES formats also include provisions for enhanced reporting of status information and the ground-to-air transmission of traffic information service — broadcast (TIS-B) messages.

1.1.3 The formats for the two versions are interoperable. An extended squitter receiver can recognize and decode both Version 0 and Version 1 message formats. It is recognized that Civil Aviation Authorities may require aircraft to support Version 1 transmit capabilities in combination with ES reception capabilities to support certain applications. Additional guidance is provided in Appendix C of this document and in the *Manual on the Secondary Surveillance Radar (SSR) Systems* (Doc 9684).

1.2 RELATED DOCUMENTS

Ref. 1. Annex 10 — *Aeronautical Telecommunications,* Volume III, Part I — *Digital Data Communication Systems*, Chapter 5.

Ref. 2. Annex 10 — *Aeronautical Telecommunications,* Volume IV — *Surveillance Radar and Collision Avoidance Systems*, Chapters 2 through 4.

Ref. 3. RTCA/DO-260A, *Minimum Operational Performance Standards for 1 090 MHz Automatic Dependent Surveillance — Broadcast (ADS-B) and Traffic Information Services (TIS-B)*, RTCA, April 2003, including Change 1 to RTCA/DO-260A, June 27, 2006, and Change 2 to RTCA/DO-260A, December 13, 2006.

Ref. 4. RTCA/DO-260, *Minimum Operational Performance Standards for 1 090 MHz Automatic Dependent Surveillance — Broadcast (ADS-B)*, RTCA, September 2000.

Chapter 2

OVERVIEW OF MODE S SERVICES AND EXTENDED SQUITTER VERSION 0

2.1 INTRODUCTION

2.1.1 The selective addressing feature of Mode S provides a natural mechanism for a data link. The link design provides for ground-to-air, air-to-air, air-to-ground, and surface message transfers. Air-to-ground messages may be either air initiated or ground initiated. The ground initiated message transfer is provided to efficiently read technical information available on board the aircraft. Mode S also includes certain unique data link capabilities that are referred to as Mode S services.

2.1.2 Formats and protocols for ES ADS-B messages are also included since registers are defined for each of these messages so that extended squitter messages can be read out on demand by a ground interrogator, in addition to being delivered via ADS-B.

2.2 PURPOSE

The purpose of this chapter is to specify detailed technical provisions for the formats and associated protocols for the following:

a) transponder registers;

b) Mode S specific protocols, including:
   i) traffic information broadcast; and
   ii) dataflash;

c) Mode S broadcast protocols, including:
   i) uplink broadcast;
   ii) downlink broadcast; and

d) extended squitter Version 0.

2.3 EXTENDED SQUITTER VERSION 0

The initial standardization of ES was consistent with RTCA/DO-260 [Ref 4] and was termed ES Version 0. Using these ES message formats, ADS-B surveillance quality is reported by navigation uncertainty category (NUC) which can be an indication of either the accuracy or integrity of the navigation data used by ADS-B. However, there is no indication as to whether the NUC value is based on integrity or accuracy.

Note.— A Change 1 to RTCA/DO-260 has been published as, "Minimum Operational Performance Standards for 1 090 MHz Automatic Dependent Surveillance — Broadcast (ADS-B), RTCA, dated June 26, 2006." The revisions identified in that change have not affected the material in this document.

2.4 DETAILED TECHNICAL PROVISIONS

Detailed technical provisions for data formats and control parameters for Mode S services and Version 0 ES are specified in Appendix A.

2.5 IMPLEMENTATION GUIDELINES

Implementation guidelines for Mode S services and Version 0 ES formats and protocols are provided in Appendix C.

2.6 SERVICES UNDER DEVELOPMENT

Technical information on potential future Mode S and extended squitter services is presented in Appendix D.

Chapter 3

OVERVIEW OF EXTENDED SQUITTER VERSION 1

3.1 EXTENDED SQUITTER VERSION 1

3.1.1 The formats and protocols for ES were revised in part to overcome the limitation of the reporting of surveillance quality using only navigation uncertainty category (NUC). In the revised formats and protocols, surveillance accuracy and integrity are reported separately as:

a) navigation accuracy category (NAC);

b) navigation integrity category (NIC); and

c) surveillance integrity level (SIL).

3.1.2 Other features added in Version 1 messages include the reporting of additional status parameters and formats for traffic information service — broadcast and ADS-B rebroadcast (ADS-R).

3.1.3 Version 1 formats are fully compatible with those of Version 0, in that a receiver of either version can correctly receive and process messages of either version. The Version 1 formats and protocols in this manual are consistent with RTCA DO-260A [Ref 3].

3.2 TRAFFIC INFORMATION SERVICE — BROADCAST (TIS-B)

3.2.1 The principle use of TIS-B is to complement the operation of ADS-B by providing ground-to-air broadcast of surveillance data on aircraft that are not equipped for 1 090 MHz ADS-B OUT as an aid to transition to a full ADS-B environment. The basis for this ground surveillance data may be an air traffic control (ATC) Mode S radar, a surface or approach multilateration system or a multi-sensor data processing system. The TIS-B ground-to-air transmissions use the same signal formats as 1 090 MHz ADS-B and can therefore be accepted by a 1 090 MHz ADS-B receiver.

3.2.2 TIS-B service is intended to provide a complete surveillance picture to 1 090 MHz ADS-B IN users during a transition period. After transition, it also provides a means to cope with a user that has lost 1 090 MHz ADS-B capability, or is broadcasting incorrect information.

3.3 AUTOMATIC DEPENDENT SURVEILLANCE — REBROADCAST (ADS-R)

The principle use of ADS-R is to provide interoperability in airspace where multiple different ADS-B data links are operating. ADS-B transmissions on a data link other than 1 090 MHz are received and converted to extended squitter formats and broadcast by a ground system on the 1 090 MHz ADS-B data link.

3.4 DETAILED TECHNICAL PROVISIONS

Detailed technical provisions for data formats and control parameters for ES Version 1 and TIS-B/ADS-R are specified in Appendix B.

3.5 IMPLEMENTATION GUIDELINES

Implementation guidelines for Mode S services and ES Version 1 formats and protocols are provided in Appendix C.

3.6 SERVICES UNDER DEVELOPMENT

Technical information on potential future Mode S and extended squitter services is presented in Appendix D.

Appendix A

DATA/MESSAGE FORMATS AND CONTROL PARAMETERS FOR MODE S SPECIFIC SERVICES AND EXTENDED SQUITTER VERSION 0

A.1. INTRODUCTION

A.1.1 Appendix A defines data/message formats and control parameters that shall be used for communications using Mode S services and extended squitter Version 0.

Note 1.— Appendix A is arranged in the following manner:

Section A.1 Introduction

Section A.2 Data formats for transponder registers

Section A.3 Formats for Mode S specific protocols (MSP)

Section A.4 Mode S broadcast protocols

Note 2.— Implementation guidelines on data sources, the use of control parameters, and the protocols involved are given in Appendix C.

A.2. DATA FORMATS FOR TRANSPONDER REGISTERS

A.2.1 REGISTER ALLOCATION

Applications shall use the allocated register numbers as shown in the table below:

Transponder register number	*Assignment*	*Maximum update interval*
00_{16}	Not valid	N/A
01_{16}	Unassigned	N/A
02_{16}	Linked Comm-B, segment 2	N/A
03_{16}	Linked Comm-B, segment 3	N/A
04_{16}	Linked Comm-B, segment 4	N/A
05_{16}	Extended squitter airborne position	0.2s
06_{16}	Extended squitter surface position	0.2s (see §A.2.3.3.1 and §A.2.3.3.2)
07_{16}	Extended squitter status	1.0s
08_{16}	Extended squitter identification and type	15.0s
09_{16}	Extended squitter airborne velocity	1.3s
$0A_{16}$	Extended squitter event-driven information	variable

Transponder register number	*Assignment*	*Maximum update interval*
$0B_{16}$	Air/air information 1 (aircraft state)	1.3s
$0C_{16}$	Air/air information 2 (aircraft intent)	1.3s
$0D_{16}$-$0E_{16}$	Reserved for air/air state information	To be determined
$0F_{16}$	Reserved for ACAS	To be determined
10_{16}	Data link capability report	≤4.0s (see §A.2.1.2)
11_{16}-16_{16}	Reserved for extension to datalink capability reports	5.0s
17_{16}	Common usage GICB capability report	5.0s
18_{16}-$1F_{16}$	Mode S specific services capability reports	5.0s
20_{16}	Aircraft identification	5.0s
21_{16}	Aircraft and airline registration markings	15.0s
22_{16}	Antenna positions	15.0s
23_{16}	Reserved for antenna position	15.0s
24_{16}	Reserved for aircraft parameters	15.0s
25_{16}	Aircraft type	15.0s
26_{16}-$2F_{16}$	Unassigned	N/A
30_{16}	ACAS active resolution advisory	[Ref 2, §4.3.8.4.2.2]
31_{16}-$3F_{16}$	Unassigned	N/A
40_{16}	Selected vertical intention	1.0s
41_{16}	Next waypoint identifier	1.0s
42_{16}	Next waypoint position	1.0s
43_{16}	Next waypoint information	0.5s
44_{16}	Meteorological routine air report	1.0s
45_{16}	Meteorological hazard report	1.0s
46_{16}	Reserved for flight management system Mode 1	To be determined
47_{16}	Reserved for flight management system Mode 2	To be determined
48_{16}	VHF channel report	5.0s
49_{16}-$4F_{16}$	Unassigned	N/A
50_{16}	Track and turn report	1.3s
51_{16}	Position report coarse	1.3s
52_{16}	Position report fine	1.3s
53_{16}	Air-referenced state vector	1.3s
54_{16}	Waypoint 1	5.0s
55_{16}	Waypoint 2	5.0s
56_{16}	Waypoint 3	5.0s
57_{16}-$5E_{16}$	Unassigned	N/A
$5F_{16}$	Quasi-static parameter monitoring	0.5s
60_{16}	Heading and speed report	1.3s
61_{16}	Extended squitter emergency/priority status	1.0s
62_{16}	Reserved for target state and status information	N/A
63_{16}	Reserved for extended squitter	N/A
64_{16}	Reserved for extended squitter	N/A
65_{16}	Extended squitter aircraft operational status	1.7s

Transponder register number	*Assignment*	*Maximum update interval*
66_{16}-$6F_{16}$	Reserved for extended squitter	N/A
70_{16}-75_{16}	Reserved for future aircraft downlink parameters	N/A
76_{16}-$E0_{16}$	Unassigned	N/A
$E1_{16}$-$E2_{16}$	Reserved for Mode S BITE	N/A
$E3_{16}$	Transponder type/part number	15s
$E4_{16}$	Transponder software revision number	15s
$E5_{16}$	ACAS unit part number	15s
$E6_{16}$	ACAS unit software revision number	15s
$E7_{16}$-$F0_{16}$	Unassigned	N/A
$F1_{16}$	Military applications	15s
$F2_{16}$	Military applications	15s
$F3_{16}$-FF_{16}	Unassigned	N/A

Note.— The term “minimum update rate” is used in the document. The minimum update rate is obtained when data is loaded in one register field once every maximum update interval.

A.2.1.1 The details of the data to be entered into the assigned registers shall be as defined in this appendix. The above table specifies the minimum update rates at which the appropriate transponder register(s) shall be reloaded with valid data. Any valid data shall be reloaded into the relevant register field as soon as it becomes available at the Mode S specific services entity (SSE) interface regardless of the update rate. If data are not available for a time no greater than twice the specified maximum update interval or 2 seconds (whichever is the greater), the status bit (if specified for that field) shall indicate that the data in that field are invalid and the field shall be zeroed.

Note.— Implementation guidelines on the loading and clearing of fields of transponder registers is provided in Appendix C.

A.2.1.2 The register number shall be equivalent to the Comm-B data selector (BDS) value used to address that register (see §3.1.2.6.11.2.1 of Annex 10, Volume IV). The data link capability report (register number 10_{16}) shall be updated within one second of the data changing and at least every four seconds thereafter.

A.2.2 GENERAL CONVENTIONS ON DATA FORMATS

A.2.2.1 VALIDITY OF DATA

The bit patterns contained in the 56-bit transponder registers (other than registers accessed by BDS codes 0,2; 0,3; 0,4; 1,0; 1,7 to 1,C; 2,0 and 3,0) shall be considered as valid application data only if:

1) the Mode S specific services capability bit is set in register number 10_{16}. This is indicated by bit 25 being set to “ONE”, and

2) the GICB service corresponding to the application is shown as “supported” by the corresponding bit in the GICB capability report register numbers 17_{16} to $1C_{16}$ being set to “ONE”; and

Note 1.— The intent of the capability bits in register number 17_{16} is to indicate that useful data are contained in the corresponding transponder register. For this reason, each bit for a register is cleared if data becomes unavailable (see §A.2.5.4.1) and set again when data insertion into the register resumes.

Note 2.— A bit set in register numbers 18_{16} to $1C_{16}$ indicates that the application using this register has been installed on the aircraft. These bits are not cleared to reflect the real-time loss of an application, as is done for register number 17_{16} (see §A.2.5.4.2).

3) the data value is valid at the time of extraction. This is indicated by a data field status bit (if specified for that field). When this status bit is set to “ONE” the data field(s) which follow, up to the next status bit, are valid. When this status bit is set to “ZERO”, the data field(s) are invalid.

A.2.2.2 REPRESENTATION OF NUMERICAL DATA

Numerical data shall be represented as follows:

1) Numerical data shall be represented as binary numerals. When the value is signed, two’s complement representation shall be used, and the bit following the status bit shall be the sign bit.

2) Unless otherwise specified, whenever more bits of resolution are available from the data source than in the data field into which that data are to be loaded, the data shall be rounded to the nearest value that can be encoded in that data field.

   Note.— Unless otherwise specified, it is accepted that the data source may have fewer bits of resolution than the data field.

3) When the data source provides data with a higher or lower range than the data field, the data shall be truncated to the respective maximum or minimum value that can be encoded in the data field.

4) Where ARINC 429 data are used, the ARINC 429 status bits 30 and 31 shall be replaced with a single status bit, for which the value is VALID or INVALID as follows:

   a) If bits 30 and 31 represent “Failure Warning, No Computed Data” then the status bit shall be set to “INVALID”.

   b) If bits 30 and 31 represent “Functional Test” then the status bit shall be set to “INVALID”.

   c) If bits 30 and 31 represent “Normal Operation,” “plus sign,” or “minus sign,” then the status bit shall be set to “VALID” provided that the data are being updated at the required rate (see §A.2.1.1).

   d) If the data are not being updated at the required rate (see §A.2.1.1), then the status bit shall be set to “INVALID”.

5) In all cases where a status bit is specified in the data field it shall be set to “ONE” to indicate VALID and to “ZERO” to indicate INVALID.

   Note.— This facilitates partial loading of the registers.

6) When specified in the field, the switch bit shall indicate which of two alternative data types is being used to update the parameter in the transponder register.

7) Bit numbering in the MB field shall be as specified in Annex 10, Volume IV (see §3.1.2.3.1.3).

8) Registers containing data intended for broadcast Comm-B shall have the broadcast identifier located in the eight most significant bits of the MB field.

A.2.2.2.1 **Recommendation**.— *When multiple data sources are available, the one with the highest resolution should be selected.*

Note 1.— Tables are numbered Table A.2-X where "X" is the decimal equivalent of the BDS code that is used to access the register to which the format applies.

Note 2.— By default, values indicated in the range of the different fields of registers have been rounded to the nearest integer value or represented as a fraction.

A.2.2.3 RESERVED FIELDS

Unless specified in this document, these bit fields shall be reserved for future allocation by ICAO.

A.2.3 EXTENDED SQUITTER FORMATS

This section defines the formats and coding that shall be used for extended squitter ADS-B messages. The convention for register numbering shall not be required for an extended squitter/non-transponder device (ES/NT, Annex 10, Volume IV, §3.1.2.8.7). The data content and the transmit times shall be the same as specified for the transponder case.

A.2.3.1 FORMAT TYPE CODES

The format TYPE Code shall differentiate the Mode S extended squitter messages into several classes as specified in the following table:

"TYPE" Subfield Code Definitions (DF = 17 or 18)

TYPE Code	*Format*	*Horizontal protection limit (HPL)*	*95% Containment radius, μ and v, on horizontal and vertical position error*	*Altitude type (see §A.2.3.2.4)*	*NUC_P*
0	No position information			Barometric altitude or no altitude information	0
1	Identification (Category Set D)			Not applicable	
2	Identification (Category Set C)			Not applicable	
3	Identification (Category Set B)			Not applicable	
4	Identification (Category Set A)			Not applicable	
5	Surface position	HPL < 7.5 m	μ < 3 m	No altitude information	9
6	Surface position	HPL < 25 m	3 m ≤ μ < 10 m	No altitude information	8
7	Surface position	HPL < 185.2 m (0.1 NM)	10 m ≤ μ < 92.6 m (0.05 NM)	No altitude information	7
8	Surface position	HPL > 185.2 m (0.1 NM)	(0.05 NM) 92.6 m ≤ μ	No altitude information	6

TYPE Code	*Format*	*Horizontal protection limit (HPL)*	*95% Containment radius, μ and v, on horizontal and vertical position error*	*Altitude type (see §A.2.3.2.4)*	*NUC_P*
9	Airborne position	HPL < 7.5 m	μ < 3 m	Barometric altitude	9
10	Airborne position	7.5 m ≤ HPL < 25 m	3 m ≤ μ < 10 m	Barometric altitude	8
11	Airborne position	25 m ≤ HPL < 185.2 m (0.1 NM)	10 m ≤ μ < 92.6 m (0.05 NM)	Barometric altitude	7
12	Airborne position	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)	Barometric altitude	6
13	Airborne position	370.4 m (0.2 NM) ≤ HPL < 926 m (0.5 NM)	185.2 m (0.1 NM) ≤ μ < 463 m (0.25 NM)	Barometric altitude	5
14	Airborne position	926 m (0.5 NM) ≤ HPL < 1 852 m (1.0 NM)	463 m (0.25 NM) ≤ μ < 926 m (0.5 NM)	Barometric altitude	4
15	Airborne position	1 852 m (1.0 NM) ≤ HPL < 3 704 m (2.0 NM)	926 m (0.5 NM) ≤ μ < 1 852 m (1.0 NM)	Barometric altitude	3
16	Airborne position	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)	Barometric altitude	2
17	Airborne position	18.52 km (10 NM) ≤ HPL < 37.04 km (20 NM)	9.26 km (5.0 NM) ≤ μ < 18.52 km (10.0 NM)	Barometric altitude	1
18	Airborne position	HPL ≥ 37.04 km (20 NM)	18.52 km (10.0 NM) ≤ μ	Barometric altitude	0
19	Airborne velocity	Not applicable	Not applicable	Difference between "Barometric altitude" and "GNSS height (HAE) or GNSS altitude (MSL)" (2.3.5.7)	N/A
20	Airborne position	HPL < 7.5 m	μ < 3 m and v < 4 m	GNSS height (HAE)	9
21	Airborne position	HPL < 25 m	μ < 10 m and v < 15 m	GNSS height (HAE)	8
22	Airborne position	HPL ≥ 25 m	μ > 10 m or v ≥ 15 m	GNSS height (HAE)	0
23	Reserved for test purposes				
24	Reserved for surface system status				
25 – 27	Reserved				
28	Extended squitter aircraft emergency priority status				
29	Reserved				
30	Reserved				
31	Aircraft operational status				

In normal operating conditions, HPL or HIL information is available from the navigation data source and shall be used to determine the format TYPE Code. The TYPE Code for airborne and surface position messages shall be determined based on the availability of integrity and/or accuracy information as defined below:

a) If horizontal protection level (HPL) information is available from the navigation data source, then the transmitting ADS-B system shall use HPL and Altitude Type to determine the TYPE Code used in the Airborne Position Message in accordance with the above table.

b) If HPL (or HIL) is temporarily not available from the navigation data source, then the transmitting ADS-B system shall use HFOM (95% bound on the horizontal position error), VFOM (95% bound on the vertical position error), and Altitude Type to determine the TYPE Code used in the Airborne Position Message in accordance with the above table.

c) If position data is available but the associated accuracy and/or integrity is unknown (i.e. the conditions in a) and b) above are not applicable), then the transmitting ADS-B system shall use for airborne position messages TYPE Code 18 or 22, depending on the altitude type, and for surface position messages TYPE Code 8 in accordance with the above table.

Note.— The term "broadcast", when applied to extended squitter, refers to a spontaneous transmission by the transponder. This is distinct from the Comm-B broadcast protocol.

A.2.3.2 AIRBORNE POSITION FORMAT

The airborne position squitter shall be formatted as specified in the definition of transponder register 05_{16}. Additional details are specified in the following paragraphs.

A.2.3.2.1 COMPACT POSITION REPORTING (CPR) FORMAT (F)

In order to achieve coding that is unambiguous worldwide, CPR shall use two format types, known as even and odd. This 1-bit field (bit 22) shall be used to define the CPR format type. F=0 shall denote an even format coding, while F=1 shall denote an odd format coding (see §A.2.6.7).

A.2.3.2.2 TIME SYNCHRONIZATION (T)

This 1-bit field (bit 21) shall indicate whether or not the time of applicability of the message is synchronized with UTC time. T=0 shall denote that the time is not synchronized to UTC. T=1 shall denote that the time of applicability is synchronized to UTC time. Synchronization shall only be used for airborne position messages having the top two horizontal position precision categories (format TYPE Codes 9, 10, 20 and 21).

When T=1, the time of validity in the airborne position message format shall be encoded in the 1-bit F field which, in addition to CPR format type, indicates the 0.2-second time tick for UTC time of position validity. The F bit shall alternate between 0 and 1 for successive 0.2-second time ticks, beginning with F=0 when the time of applicability is an exact even-numbered UTC second.

A.2.3.2.3 LATITUDE/LONGITUDE

The latitude/longitude field in the airborne position message shall be a 34-bit field containing the latitude and longitude of the aircraft airborne position. The latitude and longitude shall each occupy 17 bits. The airborne latitude and longitude encodings shall contain the 17 bits of the CPR-encoded values defined in §A.2.6.

Note 1.— The unambiguous range for the local decoding of airborne messages is 666 km (360 NM). The positional accuracy maintained by the airborne CPR encoding is approximately 5.1 metres. The latitude/longitude encoding is also a function of the CPR format value (the "F" bit) described above.

Note 2.— Although the positional accuracy of the airborne CPR encoding is approximately 5.1 metres in most cases, the longitude position accuracy may only be approximately 10.0 metres when the latitude is either –87.0 ±1.0 degrees, or +87 ±1.0 degrees.

A.2.3.2.3.1 Extrapolating position (when T = 1)

If T is set to one, airborne position messages with format TYPE Codes 9, 10, 20 and 21 shall have times of applicability which are exact 0.2s UTC epochs. In that case, the F bit shall be 0 if the time of applicability is an even-numbered 0.2s UTC epoch, or 1 if the time of applicability is an odd-numbered 0.2s UTC epoch.

Note.— In such a case, an "even-numbered 0.2s epoch" means an epoch which occurs an even number of 200-ms time intervals after an even-numbered UTC second. An "odd-numbered 0.2s epoch" means an epoch which occurs an odd number of 200-ms time intervals after an even-numbered UTC second. Examples of even-numbered 0.2s UTC epochs are 12.0s, 12.4s, 12.8s, 13.2s, 13.6s, etc. Examples of odd-numbered UTC epochs are 12.2s, 12.6s, 13.0s, 13.4s, 13.8s, etc.

The CPR-encoded latitude and longitude that are loaded into the airborne position register shall comprise an estimate of the aircraft/vehicle (A/V) position at the time of applicability of that latitude and longitude, which is an exact 0.2s UTC epoch. The register shall be loaded no earlier than 150 ms before the time of applicability of the data being loaded, and no later than 50 ms before the time of applicability of that data.

This timing shall ensure that the receiving ADS-B system may recover the time of applicability of the data in the airborne position message, as follows:

1) If F = 0, the time of applicability shall be the nearest even-numbered 0.2s UTC epoch to the time that the airborne position message is received.

2) If F = 1, the time of applicability shall be the nearest odd-numbered 0.2s UTC epoch to the time that the airborne position message is received.

Recommendation.— *If the airborne position register is updated at its minimum (every 200 ms), that register should be loaded 100 ms before the time of applicability. The register should then be reloaded, with data applicable at the next subsequent 0.2s UTC epoch, 100 ms before that next subsequent 0.2s epoch.*

Note 1.— In this way, the time of transmission of an airborne position message would never differ by more than 100 ms from the time of applicability of the data in that message. By specifying "100 ms ± 50 ms" rather than 100 ms exactly, some tolerance is allowed for variations in implementation.

Note 2.— The position may be estimated by extrapolating the position from the time of validity of the fix (included in the position fix) to the time of applicability of the data in the register (which, if T = 1, is an exact 0.2s UTC time tick). This may be done by a simple linear extrapolation using the velocity provided with the position fix and the time difference between the position fix validity time and the time of applicability of the transmitted data. Alternatively, other methods of estimating the position, such as alpha-beta trackers or Kalman filters, may be used.

Every 200 ms, the contents of the position registers shall be updated by estimating the A/V position at the next subsequent 0.2s UTC epoch. This process shall continue with new position fixes as they become available from the source of navigation data.

A.2.3.2.3.2 Extrapolating position (when T = 0)

T shall be set to zero if the time of applicability of the data being loaded into the position register is not synchronized to any particular UTC epoch. In that case, the position register shall be reloaded with position data at intervals that are no more than 200 ms apart. The position being loaded into the register shall have a time of applicability that is never more than 200 ms different from any time during which the register holds that data.

Note.— This may be accomplished by loading the airborne position register at intervals that are, on average, no more than 200 ms apart, with data for which the time of applicability is between the time the register is loaded and the time that it is loaded again. (Shorter intervals than 200 ms are permitted, but not required.)

If T = 0, receiving ADS-B equipment shall accept airborne position messages as being current as of the time of receipt. The transmitting ADS-B equipment shall reload the airborne position register with updated estimates of the A/V position, at intervals that are no more than 200 ms apart. The process shall continue with new position reports as they become available.

A.2.3.2.3.3 Time-out when new position data are unavailable

In the event that the navigation input ceases, the extrapolation described in §A.2.3.2.3.1 and §A.2.3.2.3.2 shall be limited to no more than two seconds. At the end of this time-out of two seconds, all fields of the airborne position register, except the altitude field, shall be cleared (set to zero). When the appropriate register fields are cleared, the zero TYPE Code field shall serve to notify ADS-B receiving equipment that the data in the latitude and longitude fields are invalid.

A.2.3.2.4 ALTITUDE

This 12-bit field shall provide the aircraft altitude. Depending on the TYPE Code, this field shall contain either:

1) Barometric altitude encoded in 25- or 100-foot increments (as indicated by the Q bit) or,

2) GNSS height above ellipsoid (HAE).

Barometric altitude shall be interpreted as barometric pressure-altitude, relative to a standard pressure of 1 013.25 hectopascals (29.92 in Hg). It shall not be interpreted as barometric corrected altitude.

Format TYPE Code 20 to 22 shall be reserved for the reporting of GNSS height (HAE) which represents the height above the surface of the WGS-84 ellipsoid and may be used when barometric altitude is not available.

Note.— GNSS altitude (MSL) is not accurate enough for use in the position report.

A.2.3.2.5 SINGLE ANTENNA FLAG (SAF)

This 1-bit field shall indicate the type of antenna system that is being used to transmit extended squitters. SAF=1 shall signify a single transmit antenna. SAF=0 shall signify a dual transmit antenna system.

At any time that the diversity configuration cannot guarantee that both antenna channels are functional, then the single antenna subfield shall be set to ONE.

A.2.3.2.6 SURVEILLANCE STATUS

The surveillance status field in the airborne position message format shall encode information from the aircraft's Mode A code and SPI condition indication as specified in Annex 10, Volume IV, §3.1.2.8.6.3.1.1.

A.2.3.3 SURFACE POSITION FORMAT

The surface position squitter shall be formatted as specified in the definition of register number 06_{16} in the following paragraphs.

A.2.3.3.1 MOVEMENT

This 7-bit field shall provide information on the ground speed of the aircraft. The minimum update rate of this field, as well as the ground track (true) field, shall be once per 1.3s, whereas the minimum update rate of all other fields of register 06_{16} shall be once per 0.2s. A non-linear scale shall be used as defined in the following table where speeds are given in km/h and kt.

Encoding	*Meaning*	*Quantization*
0	No information available	
1	Aircraft stopped (ground speed < 0.2315 km/h (0.125 kt))	
2 — 8	0.2315 km/h (0.125 kt) ≤ ground speed < 1.852 km/h (1 kt)	(in 0.2315 km/h (0.125 kt) steps)
9 — 12	1.852 km/h (1 kt) ≤ ground speed < 3.704 km/h (2 kt)	(in 0.463 km/h (0.25 kt) steps)
13 — 38	3.704 km/h (2 kt) ≤ ground speed < 27.78 km/h (15 kt)	(in 0.926 km/h (0.5 kt) steps)
39 — 93	27.78 km/h (15 kt) ≤ ground speed < 129.64 km/h (70 kt)	(in 1.852 km/h (1.0 kt) steps)
94 — 108	129.64 km/h (70 kt) ≤ ground speed < 185.2 km/h (100 kt)	(in 3.704 km/h (2.0 kt) steps)
109 — 123	185.2 km/h (100 kt) ≤ ground speed < 324.1 km/h (175 kt)	(in 9.26 km/h (5.0 kt) steps)
124	Ground speed ≥ 324.1 km/h (175 kt)	
125	Reserved	
126	Reserved	
127	Reserved	

A.2.3.3.2 GROUND TRACK (TRUE)

A.2.3.3.2.1 Ground track status

This 1-bit field shall define the validity of the ground track value. Coding for this field shall be as follows: 0=invalid and 1=valid. The minimum update rate of this field, as well as the movement field, shall be once per 1.3s, whereas the minimum update rate of all other fields of register 06_{16} shall be once per 0.2s.

A.2.3.3.2.2 Ground track value

This 7-bit (14-20) field shall define the direction (in degrees clockwise from true north) of aircraft motion on the surface. The ground track shall be encoded as an unsigned angular weighted binary numeral, with an MSB of 180 degrees and an LSB of 360/128 degrees, with zero indicating true north. The data in the field shall be rounded to the nearest multiple of 360/128 degrees.

A.2.3.3.3 COMPACT POSITION REPORTING (CPR) FORMAT (F)

The 1-bit (22) CPR format field for the surface position message shall be encoded as specified for the airborne message. That is, F=0 shall denote an even format coding, while F=1 shall denote an odd format coding (see §A.2.6.7).

A.2.3.3.4 TIME SYNCHRONIZATION (T)

This 1-bit field (21) shall indicate whether or not the time of applicability of the message is synchronized with UTC time. T = 0 shall denote that the time is not synchronized to UTC. T = 1 shall denote that time of applicability is synchronized to UTC time. Synchronization shall only be used for surface position messages having the top two horizontal position precision categories (format TYPE Codes 5 and 6).

When T = 1, the time of validity in the surface message format shall be encoded in the 1-bit F field which (in addition to CPR format type) indicates the 0.2s time tick for UTC time of position validity. The F bit shall alternate between 0 and 1 for successive 0.2s time ticks, beginning with F = 0 when the time of applicability is an exact even-numbered UTC second.

A.2.3.3.5 LATITUDE/LONGITUDE

The latitude/longitude field in the surface message shall be a 34-bit field containing the latitude and longitude coding of the aircraft's surface position. The latitude (*Y*) and longitude (*X*) shall each occupy 17 bits. The surface latitude and longitude encodings shall contain the low-order 17 bits of the 19-bit CPR-encoded values defined in §A.2.6.

Note 1.— The unambiguous range for local decoding of surface messages is 166.5 km (90 NM). The positional accuracy maintained by the surface CPR encoding is approximately 1.25 metres. The latitude/longitude encoding is also a function of the CPR format value (the "F" bit) described above.

Note 2.— Although the positional accuracy of the surface CPR encoding is approximately 1.25 meters in most cases, the longitude position accuracy may only be approximately 3.0 meters when the latitude is either –87.0 ±1.0 degrees, or +87 ±1.0 degrees.

A.2.3.3.5.1 Extrapolating position (when T = 1)

This extrapolation shall conform to §A.2.3.2.3.1 (substitute "surface" for "airborne" where appropriate).

A.2.3.3.5.2 Extrapolating position (when T = 0)

This extrapolation shall conform to §A.2.3.2.3.2 (substitute "surface" for "airborne" where appropriate).

A.2.3.3.5.3 Time-out when new position data are unavailable

This time-out shall conform to §A.2.3.2.3.3 (substitute "surface" for "airborne" where appropriate).

A.2.3.4 IDENTIFICATION AND CATEGORY FORMAT

The identification and category squitter shall be formatted as specified in the definition of transponder register 08_{16}.

A.2.3.5 AIRBORNE VELOCITY FORMAT

The airborne velocity squitter shall be formatted as specified in the definition of transponder register number 09_{16} and in the following paragraphs.

A.2.3.5.1 SUBTYPES 1 AND 2

Subtypes 1 and 2 of the airborne velocity format shall be used when the transmitting aircraft's velocity over ground is known. Subtype 1 shall be used at subsonic velocities while subtype 2 shall be used when the velocity exceeds 1 022 kt.

This message shall not be broadcast if the only valid data are the intent change flag and the IFR capability flag (see §A.2.3.5.3, §A.2.3.5.4). After initialization, the broadcast shall be suppressed by loading register 09_{16} with all zeros and then discontinuing the updating of the register until data input is available again.

The supersonic version of the velocity coding shall be used if either the east-west OR north-south velocities exceed 1 022 kt. A switch to the normal velocity coding shall be made if both the east-west AND north-south velocities drop below 1 000 kt.

A.2.3.5.2 SUBTYPES 3 and 4

Subtypes 3 and 4 of the airborne velocity format shall be used when the transmitting aircraft's velocity over ground is not known. These subtypes substitute airspeed and heading for the velocity over ground. Subtype 3 shall be used at subsonic velocities, while subtype 4 shall be used when the velocity exceeds 1 022 kt.

This message shall not be broadcast if the only valid data are the intent change flag and the IFR capability flag (see §A.2.3.5.3, §A.2.3.5.4). After initialization, broadcast shall be suppressed by loading register 09_{16} with all zeros and then discontinuing the updating of the register until data input is available again.

The supersonic version of the velocity coding shall be used if the airspeed exceeds 1 022 kt. A switch to the normal velocity coding shall be made if the airspeed drops below 1 000 kt.

A.2.3.5.3 INTENT CHANGE FLAG IN AIRBORNE VELOCITY MESSAGES

An intent change event shall be triggered 4 seconds after the detection of new information being inserted in registers 40_{16} to 42_{16}. The code shall remain set for 18 ±1 second following an intent change.

Intent change flag coding:
0 = no change in intent
1 = intent change

Note 1.— Register 43_{16} is not included since it contains dynamic data which will be continuously changing.

Note 2.— A four-second delay is required to provide for settling time for intent data derived from manually set devices.

A.2.3.5.4 IFR CAPABILITY FLAG (IFR) IN AIRBORNE VELOCITY MESSAGES

The IFR capability flag shall be a 1-bit (bit 10) subfield in the subtypes 1, 2, 3 and 4 airborne velocity messages. IFR=1 shall signify that the transmitting aircraft has a capability for applications requiring ADS-B equipage class A1 or above. Otherwise, IFR shall be set to 0.

A.2.3.5.5 RESERVED

A.2.3.5.6 Magnetic heading in airborne velocity messages

A.2.3.5.6.1 Magnetic heading status

This 1-bit field shall define the availability of the magnetic heading value. Coding for this field shall be: 0 = not available and 1 = available.

A.2.3.5.6.2 Magnetic heading value

This 10-bit field shall contain the aircraft magnetic heading (in degrees clockwise from magnetic north) when velocity over ground is not available. The magnetic heading shall be encoded as an unsigned angular weighted binary numeral with an MSB of 180 degrees and an LSB of 360/1 024 degrees, with zero indicating magnetic north. The data in the field shall be rounded to the nearest multiple of 360/1 024 degrees.

A.2.3.5.7 Difference from barometric altitude in airborne velocity messages

This 8-bit field shall contain the signed difference between barometric and GNSS altitude. (Coding for this field shall be as indicated in Tables A-2-9a and A-2-9b.)

The difference between barometric altitude and GNSS height above ellipsoid (HAE) shall be used if available. If GNSS HAE is not available, GNSS altitude (MSL) shall be used when airborne position is being reported using format TYPE Codes 11 through 18.

If airborne position is being reported using format TYPE Code 9 or 10, only GNSS (HAE) shall be used. For format TYPE Code 9 or 10, if GNSS (HAE) is not available, the field shall be coded with all zeros. The basis for the barometric altitude difference (either GNSS (HAE) or GNSS altitude MSL) shall be used consistently for the reported difference.

A.2.3.6 Status register format

The status register shall be formatted as specified in the definition of transponder register number 07_{16} and in the following paragraphs.

A.2.3.6.1 Purpose

Unlike the other extended squitter registers, the contents of this register shall not be broadcast. The purpose of this register shall be to serve as an interface between the transponder function and the general formatter/manager function (GFM, 2.5). The two fields defined for this format shall be the transmission rate subfield and the altitude type subfield.

A.2.3.6.2 Transmission rate subfield (TRS)

This field is only used for a transponder implementation of extended squitter.

The TRS shall be used to notify the transponder of the aircraft motion status while on the surface. If the aircraft is moving, the surface position squitter shall be broadcast at a rate of twice per second, and identity squitters at a rate of once per 5 seconds. If the aircraft is stationary, the surface position squitter shall be broadcast at a rate of once per 5 seconds and the identity squitter at a rate of once per 10 seconds.

The algorithm specified in the definition of transponder register number 07_{16} shall be used by the GFM (2.5) to determine motion status and the appropriate code shall be set in the TRS subfield. The transponder shall examine the TRS subfield to determine which rate to use when it is broadcasting surface squitters.

A.2.3.6.3 ALTITUDE TYPE SUBFIELD (ATS)

This field shall only be used for a transponder implementation of extended squitter.

The transponder shall load the altitude field of the airborne position squitter from the same digital source as used for addressed replies.

Note.— This is done to minimize the possibility that the altitude in the squitter is different from the altitude that would be obtained by direct interrogation.

If the GFM (2.5) inserts GNSS height (HAE) into the airborne position squitter, it shall instruct the transponder not to insert the barometric altitude into the altitude field. The ATS subfield shall be set to ONE for this purpose.

A.2.3.7 EVENT-DRIVEN PROTOCOL

The event-driven protocol register shall be as specified in the definition of transponder register number $0A_{16}$ in §A.2.5.5 and in the following paragraphs.

A.2.3.7.1 PURPOSE

The event-driven protocol shall be used as a flexible means to support the broadcast of messages beyond those defined for position, velocity, and identification.

Note.— These typically will be messages that are broadcast regularly for a period of time based on the occurrence of an event. An example is the broadcast of emergency/priority status every second during a declared aircraft emergency. A second example is the periodic broadcast of intent information for the duration of the operational condition.

A.2.3.8 EMERGENCY/PRIORITY STATUS

The emergency/priority status squitter shall be formatted as specified in the definition of transponder register number 61_{16} and in the following paragraphs.

A.2.3.8.1 TRANSMISSION RATE

This message shall be broadcast once per second for the duration of the emergency.

A.2.3.8.2 MESSAGE DELIVERY

Message delivery shall be accomplished using the event-driven protocol (see §A.2.3.7). The broadcast of this message shall take priority over the event-driven protocol broadcast of all other message types, as specified in §A.2.5.5.3.

A.2.3.9 RESERVED

A.2.3.10 RESERVED

A.2.3.11 AIRCRAFT OPERATIONAL STATUS

The aircraft operational status message squitter shall be formatted as specified in the definition of register number 65_{16} and in the following paragraphs.

A.2.3.11.1 TRANSMISSION RATE

This message shall be broadcast once per 1.7 seconds for the duration of the operation.

A.2.3.11.2 MESSAGE DELIVERY

Message delivery shall be accomplished using the event-driven protocol (see §A.2.3.7).

A.2.3.11.3 EN-ROUTE OPERATIONAL CAPABILITIES (CC-4)

This 4-bit (9-12) subfield shall be used to indicate en-route operational capabilities of the ADS-B transmitting system to other aircraft as specified by the following encoding.

CC-4 ENCODING: EN-ROUTE OPERATIONAL CAPABILITIES

CC-4 CODING		
Bit 9, 10	*Bit 11, 12*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

A.2.3.11.4 TERMINAL AREA OPERATIONAL CAPABILITIES (CC-3)

This 4-bit (13-16) subfield shall be used to indicate terminal area operational capabilities of the ADS-B transmitting system to other aircraft as specified by the following encoding.

CC-3 ENCODING: TERMINAL AREA OPERATIONAL CAPABILITIES

CC-3 CODING		
Bit 13, 14	*Bit 15, 16*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

A.2.3.11.5 APPROACH AND LANDING OPERATIONAL CAPABILITIES (CC-2)

This 4-bit (17-20) subfield shall be used to indicate approach and landing operational capabilities of the ADS-B transmitting system to other aircraft as specified by the following encoding.

CC-2 ENCODING: APPROACH AND LANDING OPERATIONAL CAPABILITIES

CC-2 CODING		
Bit 17, 18	*Bit 19, 20*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

CC-2 ENCODING: APPROACH AND LANDING OPERATIONAL CAPABILITIES

CC-2 CODING		
Bit 17, 18	*Bit 19, 20*	*MEANING*
0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

A.2.3.11.6 SURFACE OPERATIONAL CAPABILITIES (CC-1)

This 4-bit (21-24) subfield shall be used to indicate surface operational capabilities of the ADS-B transmitting system to other aircraft as specified by the following encoding.

CC-1 ENCODING: SURFACE OPERATIONAL CAPABILITIES

CC-1 CODING		
Bit 21, 22	*Bit 23, 24*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

CC-1 ENCODING: SURFACE OPERATIONAL CAPABILITIES

CC-1 CODING		
Bit 21, 22	*Bit 23, 24*	*MEANING*
1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

A.2.3.11.7 EN-ROUTE OPERATIONAL CAPABILITY STATUS (OM-4)

This 4-bit (25-28) subfield shall be used to indicate the en-route operational capability status of the ADS-B transmitting system to other aircraft as specified by the following encoding.

OM-4 ENCODING: EN-ROUTE OPERATIONAL CAPABILITY STATUS

OM-4 CODING		
Bit 25, 26	*Bit 27, 28*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

A.2.3.11.8 TERMINAL AREA OPERATIONAL CAPABILITY STATUS (OM-3)

This 4-bit (29-32) subfield shall be used to indicate the terminal area operational capability status of the ADS-B transmitting system to other aircraft as specified by the following encoding.

OM-3 ENCODING: TERMINAL AREA OPERATIONAL CAPABILITY STATUS

OM-3 CODING		
Bit 29, 30	*Bit 31, 32*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

A.2.3.11.9 APPROACH AND LANDING OPERATIONAL CAPABILITY STATUS (OM-2)

This 4-bit (33-36) subfield shall be used to indicate the approach and landing operational capability status of the ADS-B transmitting system to other aircraft as specified by the following encoding.

OM-2 ENCODING: APPROACH AND LANDING OPERATIONAL CAPABILITY STATUS

OM-2 CODING		
Bit 33, 34	*Bit 35, 36*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

OM-2 ENCODING: APPROACH AND LANDING OPERATIONAL CAPABILITY STATUS

OM-2 CODING		
Bit 33, 34	*Bit 35, 36*	*MEANING*
1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

A.2.3.11.10 SURFACE OPERATIONAL CAPABILITY STATUS (OM-1)

This 4-bit (37-40) subfield shall be used to indicate the surface operational capability status of the ADS-B transmitting system to other aircraft as specified by the following encoding.

OM-1 ENCODING: SURFACE OPERATIONAL CAPABILITY STATUS

OM1 CODING		
Bit 37, 38	*Bit 39, 40*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

A.2.4 EXTENDED SQUITTER INITIALIZATION AND TIME-OUT

Initialization and time-out functions for extended squitter broadcast shall be performed by the transponder and are specified in Annex 10, Volume IV, §3.1.2.8.6.4 and §3.1.2.8.6.6.

Note.— A description of these functions is presented in the following paragraphs to serve as reference material for the section on the general formatter/manager (GFM) (see §A.2.5).

A.2.4.1 INITIATION OF EXTENDED SQUITTER BROADCAST

At power-up initialization, the transponder shall commence operation in a mode in which it broadcasts only acquisition squitters. The transponder shall initiate the broadcast of extended squitters for airborne position, surface position, airborne velocity and aircraft identification when data are inserted into transponder registers 05_{16}, 06_{16}, 09_{16} and 08_{16}, respectively. This determination shall be made individually for each squitter type. The insertion of altitude or surveillance status data into transponder register 05_{16} by the transponder shall not satisfy the minimum requirement for broadcast of the airborne position squitter.

Note.— This suppresses the transmission of extended squitters from aircraft that are unable to report position, velocity or identity information.

A.2.4.2 REGISTER TIME-OUT

The transponder shall clear all but the altitude and surveillance status subfields in the airborne position register (transponder register 05_{16}) and all 56 bits of the surface position, squitter status and airborne velocity registers (transponder register numbers 06_{16}, 07_{16} and 09_{16}) if these registers are not updated for a time no greater than twice the specified maximum update interval, or 2 seconds (whichever is the greater). This time-out shall be determined separately for each of these registers. The insertion of altitude or surveillance status data by the transponder into these registers shall not qualify as a register update for the purposes of this time-out condition.

Note 1.— These registers are cleared to prevent the reporting of outdated position, velocity and squitter rate information.

Note 2.— The identification register, 08_{16}, is not cleared since it contains data that rarely changes in flight and is less frequently updated. The event-driven register, $0A_{16}$ or equivalent transmit register, does not need to be cleared since its contents are only broadcast once each time that the register is loaded (see §A.2.5.5).

Note 3.— During a register time-out event, the ME field of the extended squitter may contain all zeros, except for any data inserted by the transponder.

A.2.4.3 TERMINATION OF EXTENDED SQUITTER BROADCAST

If input to the register for a squitter type stops for 60 seconds, broadcast of that extended squitter type shall be discontinued until data insertion is resumed. The insertion of altitude by the transponder satisfies the minimum requirement for continuing to broadcast the airborne position squitter.

Note 1.— Until time-out, a squitter type may contain an ME field of all zeros.

Note 2.— Continued transmission for 60 seconds is required so that receiving aircraft will know that the data source for the message has been lost.

A.2.4.4 REQUIREMENTS FOR NON-TRANSPONDER DEVICES

Non-transponder devices shall provide the same functionality for initialization; register time-out and broadcast termination as specified for the transponder case in §A.2.4.1 to §A.2.4.3, except that:

a) It shall not broadcast acquisition squitters; and

b) When the navigation input fails, when operating on the surface it shall continue to broadcast DF=18 with message TYPE Code = 0 at the high rate specified for the surface position message (Annex 10, Volume IV, §3.1.2.8.6.4.3).

Note.— Continued broadcast of the surface position message is needed to support the operation of surface multilateration systems.

A.2.5 GENERAL FORMATTER/MANAGER (GFM)

The general formatter/manager (GFM) shall format messages for insertion in the transponder registers.

A.2.5.1 NAVIGATION SOURCE SELECTION

The GFM shall be responsible for the selection of the default source for aircraft position and velocity, the commanded altitude source, and for the reporting of the associated position and altitude errors.

A.2.5.2 LOSS OF INPUT DATA

The GFM shall be responsible for loading the registers for which it is programmed at the required update rate. If for any reason data are unavailable, the GFM shall perform the actions specified in §A.2.1.1.

For transponder registers 05_{16} and 06_{16}, a loss of position data shall cause the GFM to set the format TYPE Code to zero as the means of indicating “no position data” since all zeros in the latitude/longitude fields is a legal value.

A.2.5.3 SPECIAL PROCESSING FOR FORMAT TYPE CODE ZERO

A.2.5.3.1 SIGNIFICANCE OF FORMAT TYPE CODE EQUAL TO ZERO

Format TYPE Code = 0 shall signify “no position information”. This shall be used when the latitude/longitude information is not available or invalid and still permit the reporting of barometric altitude loaded by the transponder.

Note 1.— The principal use of this message is to provide ACAS the ability to passively receive altitude.

Note 2.— Special handling is required for the airborne and surface position messages because a CPR encoded value of all zeros in the latitude/longitude field is a valid value.

A.2.5.3.2 BROADCAST OF FORMAT TYPE CODE EQUAL TO ZERO

Format TYPE Code = 0 shall only be set by the following events:

1) An extended squitter register monitored by the transponder (registers 05_{16}, 06_{16}, 07_{16} and 09_{16}) has timed out (see §A.2.4.2). In this case, the transponder shall clear the entire 56 bits of the register that timed out. In the case of the airborne position register, the altitude subfield shall only be zeroed if no altitude data are available. Transmission of the extended squitter that broadcasts the timed out register shall itself stop in 60 seconds. Broadcast of this extended squitter shall resume when the GFM begins to insert data into the register.

2) The GFM determines that all navigation sources that can be used for the extended squitter airborne or surface position message are either missing or invalid. In this case, the GFM shall clear the format TYPE Code and all other fields of the airborne or surface position message and insert this zeroed message in the appropriate register. This shall only be done once so that the transponder can detect the loss of data insertion and suppress the broadcast of the related squitter.

Note.— In all of the above cases, a format TYPE Code of zero contains a message of all zeros. The only exception is the airborne position format that may contain barometric altitude and surveillance status data as set by the transponder. There is no analogous case for the other extended squitter message types, since a zero value in any of the fields indicates no information.

A.2.5.3.3 RECEPTION OF FORMAT TYPE CODE EQUAL TO ZERO

An extended squitter containing format TYPE Code equal to zero shall not be used to initiate an ADS-B track.

Note.— If a squitter with format TYPE Code equal to zero is received and if altitude is present it can be used to update altitude of an existing ADS-B track.

A.2.5.4 TRANSPONDER CAPABILITY REPORTING

The GFM shall be responsible for setting the transponder capability register numbers 10_{16}, and 18_{16} to $1C_{16}$. It shall also clear individual bits in register number 17_{16} in the event of a loss of a data source or an application.

A particular bit shall remain set if at least one field in the corresponding register message is being updated.

A.2.5.4.1 COMMON USAGE CAPABILITY REPORT (REGISTER NUMBER 17_{16})

A bit in register number 17_{16} shall be cleared if there is a loss of corresponding input data (see §A.2.5.2), for all data fields of the register, and shall be set when data insertion into the register resumes. Bit 36 of register 10_{16} shall be toggled to indicate a change of capability.

A.2.5.4.2 MODE S SPECIFIC SERVICES CAPABILITY REPORT

A.2.5.4.2.1 Mode S specific services GICB capability report (register numbers 18_{16} to $1C_{16}$)

A bit set in one of these registers shall indicate that the service loading the register indicated by that bit has been installed on the aircraft. In this regard, these bits shall not be cleared to reflect a real-time loss of an application, as is done for register 17_{16}.

A.2.5.4.2.2 Mode S specific services MSP capability report (register numbers $1D_{16}$ to $1F_{16}$)

Each bit shall indicate that the MSP it represents requires service when set to 1.

A.2.5.4.3 TRANSPONDER MONITORING

As indicated in §A.2.4, the transponder's role in this process shall be to serve as a backup in the event of the loss of GFM functionality. For this reason, the transponder shall:

1) clear the extended squitter registers (05_{16}, 06_{16}, 07_{16} and 09_{16}) if they have not been updated for a time no greater than twice the specified maximum update interval, or 2 seconds (whichever is the greater).

2) clear all of the registers loaded by the GFM if it detects a loss of GFM capability (e.g. a bus failure). In this case, it would also clear all of the bits in register number 17_{16} since a bit in this register means "application installed and operational".

The transponder shall not clear the other capability register numbers (18_{16} to $1C_{16}$) since they are intended to mean only "application installed".

A.2.5.5 HANDLING OF EVENT-DRIVEN PROTOCOL

The event-driven interface protocol provides a general purpose interface into the transponder function for messages beyond those that are regularly transmitted all the time (provided input data are available). This protocol shall operate by having the transponder broadcast a message once each time the event-driven register is loaded by the GFM.

Note.— This gives the GFM complete freedom in setting the update rate (up to a maximum) and duration of broadcast for applications such as emergency status and intent reporting.

In addition to formatting, the GFM shall control the timing of message insertion so that it provides the necessary pseudo-random timing variation and does not exceed the maximum transponder broadcast rate for the event-driven protocol.

A.2.5.5.1 TRANSPONDER SUPPORT FOR EVENT-DRIVEN MESSAGES

A message shall only be transmitted once by the transponder each time that register number $0A_{16}$ is loaded. Transmission shall be delayed if the transponder is busy at the time of insertion.

Note 1.— Delay times are short. They are usually a maximum of several milliseconds for the longest transponder transaction.

The maximum transmission rate for the event-driven protocol shall be limited by the transponder to twice per second. If a message is inserted in the event-driven register and cannot be transmitted due to rate limiting, it shall be held and transmitted when the rate limiting condition has cleared. If a new message is received before transmission is permitted, it shall overwrite the earlier message.

Note 2.— The squitter transmission rate and the duration of squitter transmissions are application dependent.

A.2.5.5.1.1 **Recommendation**.— *The minimum rate and duration consistent with the needs of the application should be chosen.*

A.2.5.5.2 GFM USE OF EVENT-DRIVEN PROTOCOL

An application that selects the event-driven protocol shall notify the GFM of the format type and required update rate. The GFM shall then locate the necessary input data for this format type and begin inserting data into register number $0A_{16}$ at the required rate. The GFM shall also insert this message into the register for this format type. This register image shall be maintained to allow read-out of this information by air-ground or air-air register read-out. When broadcast of a format type ceases, the GFM shall clear the corresponding register assigned to this message.

The maximum rate that shall be supported by the event-driven protocol is twice per second from one or a collection of applications. For each event-driven format type being broadcast, the GFM shall retain the time of the last insertion into register number $0A_{16}$. The next insertion shall be scheduled at a random interval that shall be uniformly distributed over the range of the update interval ±0.1 second (using a time quantization no greater than 15 ms) relative to the previous insertion into register number $0A_{16}$ for this format type.

The GFM shall monitor the number of insertions scheduled in any one second interval. If more than two would occur, it shall add a delay as necessary to ensure that the limit of two messages per second is observed.

A.2.5.5.3 EVENT-DRIVEN PRIORITY

If the event-driven message transmission rate must be reduced in order not to exceed the maximum rate specified in §A.2.5.5.2, transmission priority shall be assigned as follows:

1) If the emergency/priority status message (see §A.2.3.8) is active, it shall be transmitted at the specified rate of once per second. Other active event-driven messages shall be assigned equal priority for the remaining capacity.

2) If the emergency/priority status message is not active, transmission priority shall be allocated equally to all active event-driven messages.

A.2.5.6 DERIVATION OF MODE FIELD BITS FOR AIRCRAFT INTENTION PARAMETERS

For aircraft architectures that do not present the GFM with a dedicated status word (containing the mode field definitions associated with aircraft intention parameters), the GFM shall derive the status from each of the appropriate FCC status words in order to set the respective bits in each of the mode fields of the register number 40_{16}.

A.2.6 LATITUDE/LONGITUDE CODING USING COMPACT POSITION REPORTING (CPR)

A.2.6.1 PRINCIPLE OF THE CPR ALGORITHM

The Mode S extended squitters use compact position reporting (CPR) to encode latitude and longitude efficiently into messages.

Notes.—

1. *The resulting messages are compact in the sense that several higher-order bits, which are normally constant for long periods of time, are not transmitted in every message. For example, in a direct binary representation of latitude, one bit would designate whether the aircraft is in the northern or southern hemisphere. This bit would remain constant for a long time, possibly the entire life of the aircraft. To repeatedly transmit this bit in every position message would be inefficient.*

2. *Because the higher-order bits are not transmitted, it follows that multiple locations on the earth will produce the same encoded position. If only a single position message were received, the decoding would involve ambiguity as to which of the multiple solutions is the correct location of the aircraft. The CPR technique includes a provision to*

enable a receiving system to unambiguously determine the location of the aircraft. This is done by encoding in two ways that differ slightly. The two formats, called even-format and odd-format, are each transmitted 50 per cent of the time. Upon reception of both types within a short period (approximately 10 seconds), the receiving system can unambiguously determine the location of the aircraft.

3. *Once this process has been carried out, the higher-order bits are known at the receiving station, so subsequent single message receptions serve to unambiguously indicate the location of the aircraft as it moves.*

4. *In certain special cases, a single reception can be decoded into the correct location without an even/odd pair. This decoding is based on the fact that the multiple locations are spaced by at least 360 NM. In addition to the correct locations, the other locations are separated by integer multiples of 360 NM to the north and south and also integer multiples of 360 NM to the east and west. In a special case in which it is known that reception is impossible beyond a range of 180 NM, the nearest solution is the correct location of the aircraft.*

5. *The parameter values in the preceding paragraph (360 and 180 NM) apply to the airborne CPR encoding. For aircraft on the surface, the CPR parameters are smaller by a factor of 4. This encoding yields better resolution but reduces the spacing of the multiple solutions.*

A.2.6.2 CPR ALGORITHM PARAMETERS AND INTERNAL FUNCTIONS

The CPR algorithm shall utilize the following parameters whose values are set as follows for the Mode S extended squitter application:

a) The number of bits used to encode a position coordinate, *Nb*, is set as follows:

Nb = 17 for airborne encoding used in the ADS-B airborne position message and the TIS-B fine airborne message,

Nb = 19 for surface encoding used in the ADS-B surface position message and the TIS-B fine surface position message,

Nb = 14 for intent encoding,

Nb = 12 for TIS-B encoding, used in the TIS-B coarse airborne position message.

Note 1.— The Nb parameter determines the encoded position precision (approximately 5 m for the airborne encoding, 1.25 m for the surface encoding, and 41 m for the intent encoding and 164 m for the TIS-B encoding).

b) The number of geographic latitude zones between the equator and a pole, denoted *NZ*, is set to 15.

Note 2.— The NZ *parameter determines the unambiguous airborne range for decoding (360 NM). The surface latitude/longitude encoding omits the high-order 2 bits of the 19 bit CPR encoding, so the effective unambiguous range for surface position reports is 90 NM.*

The CPR algorithm shall define internal functions to be used in the encoding and decoding processes.

c) The notation **floor**(x) denotes the floor of *x*, which is defined as the greatest integer value *k* such that $k \leq x$.

Note 3.— For example, ***floor****(3.8) = 3, while* ***floor****(–3.8) = –4.*

d) The notation **|***x***|** denotes the absolute value of *x*, which is defined as the value *x* when $x \geq 0$ and the value $-x$ when $x<0$.

e) The notation **MOD**(*x,y*) denotes the "modulus" function, which is defined to return the value

$$\mathrm{MOD}(x,y) = x - y \cdot \mathrm{floor}\left(\frac{x}{y}\right) \text{ where } y \neq 0$$

Note 4.— The value y *is always positive in the following CPR algorithms. When* x *is non-negative,* ***MOD***(x,y) *is equivalent to the remainder of* x *divided by* y*. When* x *represents a negative angle, an alternative way to calculate* ***MOD***(x,y) *is to return the remainder of* (x+360°) *divided by* y*.*

For example, MOD (–40°,6°) = MOD(320°, 6°) = 2°

f) The notation **NL**(*x*) denotes the "number of longitude zones" function of the latitude angle *x*. The value returned by **NL**(*x*) is constrained to the range from 1 to 59. **NL**(*x*) is defined for most latitudes by the equation,

$$\mathrm{NL}(lat) = \mathrm{floor}\left(2\pi \cdot \left[\arccos\left(1 - \frac{1-\cos\left(\frac{\pi}{2 \cdot NZ}\right)}{\cos^2\left(\frac{\pi}{180°} \cdot |lat|\right)}\right)\right]^{-1}\right)$$

where *lat* denotes the latitude argument in degrees. For latitudes at or near the N or S pole, or the equator, the following points shall be defined:

For *lat* = 0 (the equator), NL = 59
For *lat* = +87 degrees, NL = 2
For *lat* = -87 degrees, NL = 2
For *lat* > +87 degrees, NL = 1
For *lat* < -87 degrees, NL = 1

Note 5.— This equation for NL( ) is impractical for real-time implementation. A table of transition latitudes can be pre-computed using the following equation:

$$lat = \frac{180°}{\pi} \cdot \arccos\left(\sqrt{\frac{1-\cos\left(\frac{\pi}{2 \cdot NZ}\right)}{1-\cos\left(\frac{2\pi}{NL}\right)}}\right) \text{ for } NL = 2 \text{ to } 4 \cdot NZ - 1$$

and a table search procedure used to obtain the return value for NL( ). The table value for NL = 1 is 90 degrees. When using the look-up table established by using the equation above, the NL value is not expected to change to the next lower NL value until the boundary (latitude established by the above equation) has actually been crossed when moving from the equator towards the pole.

A.2.6.3 CPR ENCODING PROCESS

The CPR encoding process shall calculate the encoded position values XZ_i and YZ_i for either airborne, surface intent or TIS-B latitude and longitude fields from the global position *lat* (latitude in degrees), *lon* (longitude in degrees), and the

CPR encoding type i (0 for even format and 1 for odd format), by performing the following sequence of computations. The CPR encoding for intent shall always use the even format (i = 0), whereas the airborne, surface and TIS-B encoding shall use both even (i = 0) and odd (i = 1) formats.

a) $Dlat_i$ (the latitude zone size in the N-S direction) is computed from the equation:

$$Dlat_i = \frac{360^\circ}{4 \cdot NZ - i}$$

b) YZ_i (the Y-coordinate within the Zone) is then computed from $Dlat_i$ and lat using separate equations:

For Nb=17 encoding: $$YZ_i = \text{floor}\left(2^{17} \cdot \frac{\text{MOD}(lat, Dlat_i)}{Dlat_i} + \frac{1}{2}\right)$$

For Nb=19 encoding: $$YZ_i = \text{floor}\left(2^{19} \cdot \frac{\text{MOD}(lat, Dlat_i)}{Dlat_i} + \frac{1}{2}\right)$$

For Nb=14 encoding: $$YZ_0 = \text{floor}\left(2^{14} \cdot \frac{\text{MOD}(lat, Dlat_0)}{Dlat_0} + \frac{1}{2}\right)$$

For Nb=12 encoding: $$YZ_i = \text{floor}\left(2^{12} \cdot \frac{\text{MOD}(lat, Dlat_i)}{Dlat_i} + \frac{1}{2}\right)$$

c) $Rlat_i$ (the latitude that a receiving ADS-B system will extract from the transmitted message) is then computed from lat, YZ_i, and $Dlat_i$ using separate equations:

For Nb=17 encoding: $$Rlat_i = Dlat_i \cdot \left(\frac{YZ_i}{2^{17}} + \text{floor}\left(\frac{lat}{Dlat_i}\right)\right)$$

For Nb=19 encoding: $$Rlat_i = Dlat_i \cdot \left(\frac{YZ_i}{2^{19}} + \text{floor}\left(\frac{lat}{Dlat_i}\right)\right)$$

For Nb=14 encoding: $$Rlat_0 = Dlat_0 \cdot \left(\frac{YZ_0}{2^{14}} + \text{floor}\left(\frac{lat}{Dlat_0}\right)\right)$$

For Nb=12 encoding $$Rlat_i = Dlat_i \cdot \left(\frac{YZ_i}{2^{12}} + \text{floor}\left(\frac{lat}{Dlat_i}\right)\right)$$

d) $Dlon_i$ (the longitude zone size in the E-W direction) is then computed from $Rlat_i$ using the equation:

$$Dlon_i = \begin{cases} \dfrac{360^\circ}{\text{NL}(Rlat_i) - i}, & \text{when } \text{NL}(Rlat_i) - i > 0 \\ 360^\circ, & \text{when } \text{NL}(Rlat_i) - i = 0 \end{cases}$$

Note.— When performing the NL function, the encoding process must ensure that the NL value is established in accordance with Note 5 of §A.2.6.2.f.

e) XZ_i (the X-coordinate within the Zone) is then computed from *lon* and $Dlon_i$ using separate equations:

For Nb=17 encoding: $$XZ_i = \text{floor}\left(2^{17} \cdot \frac{\text{MOD}(lon, Dlon_i)}{Dlon_i} + \frac{1}{2}\right)$$

For Nb=19 encoding: $$XZ_i = \text{floor}\left(2^{19} \cdot \frac{\text{MOD}(lon, Dlon_i)}{Dlon_i} + \frac{1}{2}\right)$$

For Nb=14 encoding: $$XZ_0 = \text{floor}\left(2^{14} \cdot \frac{\text{MOD}(lon, Dlon_0)}{Dlon_0} + \frac{1}{2}\right)$$

For Nb=12 encoding: $$XZ_i = \text{floor}\left(2^{12} \cdot \frac{\text{MOD}(lon, Dlon_i)}{Dlon_i} + \frac{1}{2}\right)$$

f) Finally, limit the values of XZ_i and YZ_i to fit in the 17-bit or 14-bit field allotted to each coordinate:

For Nb=17 encoding: $$YZ_i = \text{MOD}\left(YZ_i, 2^{17}\right),$$ $$XZ_i = \text{MOD}\left(XZ_i, 2^{17}\right)$$

For Nb=19 encoding: $$YZ_i = \text{MOD}\left(YZ_i, 2^{17}\right),$$ $$XZ_i = \text{MOD}\left(XZ_i, 2^{17}\right)$$

For Nb=14 encoding: $$YZ_0 = \text{MOD}\left(YZ_0, 2^{14}\right),$$ $$XZ_0 = \text{MOD}\left(XZ_0, 2^{14}\right)$$

For Nb=12 encoding: $$YZ_i = \text{MOD}\left(YZ_i, 2^{12}\right),$$ $$XZ_i = \text{MOD}\left(XZ_i, 2^{12}\right)$$

A.2.6.4 LOCALLY UNAMBIGUOUS CPR DECODING

The CPR algorithm shall decode a geographic position (latitude, $Rlat_i$, and longitude, $Rlon_i$,) that is locally unambiguous with respect to a reference point (lat_s, lon_s) known to be within 180 NM of the true airborne position (or within 45 NM for a surface message).

Note.— This reference point may be a previously tracked position that has been confirmed by global decoding (see §A.2.6.7) or it may be the own-aircraft position, which would be used for decoding a new tentative position report.

The encoded position coordinates XZ_i and YZ_i and the CPR encoding type *i* (0 for the even encoding and 1 for the odd encoding) contained in a Mode S extended squitter message shall be decoded by performing the sequence of computations given in §A.2.6.5 for the airborne intent and TIS-B format types and in §A.2.6.6 for the surface format type.

A.2.6.5 LOCALLY UNAMBIGUOUS AIRBORNE POSITION DECODING

The following computations shall be performed to obtain the locally ambiguous decoded latitude/longitude for the airborne intent and TIS-B message formats. For the intent format, *i* will always be set to 0 (even encoding), whereas the airborne format shall use both even (i = 0) and odd (i = 1) encoding. For the airborne and fine TIS-B formats, Nb shall equal 17, for the intent format, Nb shall equal 14 and for the coarse TIS-B format, Nb shall equal 12.

a) Dlat_i is computed from the equation:

$$Dlat_i = \frac{360°}{4 \cdot NZ - i}$$

b) The latitude zone index number, j, is then computed from the values of lat_s, $Dlat_i$ and YZ_i using the equation:

$$j = \text{floor}\left(\frac{lat_s}{Dlat_i}\right) + \text{floor}\left(\frac{1}{2} + \frac{\text{MOD}(lat_s, Dlat_i)}{Dlat_i} - \frac{YZ_i}{2^{Nb}}\right)$$

c) The decoded position latitude, $Rlat_i$, is then computed from the values of j, $Dlat_i$, and YZ_i using the equation:

$$Rlat_i = Dlat_i \cdot \left(j + \frac{YZ_i}{2^{Nb}}\right)$$

d) $Dlon_i$ (the longitude zone size in the E-W direction) is then computed from $Rlat_i$ using the equation:

$$Dlon_i = \begin{cases} \dfrac{360°}{\text{NL}(Rlat_i) - i}, & \text{when } \text{NL}(Rlat_i) - i > 0 \\ 360°, & \text{when } \text{NL}(Rlat_i) - i = 0 \end{cases}$$

Note.— When performing the NL function, the encoding process must ensure that the NL value is established in accordance with Note 5 of §A.2.6.2.f.

e) The longitude zone coordinate m is then computed from the values of lon_s, $Dlon_i$, and XZ_i using the equation:

$$m = \text{floor}\left(\frac{lon_s}{Dlon_i}\right) + \text{floor}\left(\frac{1}{2} + \frac{\text{MOD}(lon_s, Dlon_i)}{Dlon_i} - \frac{XZ_i}{2^{Nb}}\right)$$

f) The decoded position longitude, $Rlon_i$, is then computed from the values of m, XZ_i, and $Dlon_i$ using the equation:

$$Rlon_i = Dlon_i \cdot \left(m + \frac{XZ_i}{2^{Nb}}\right)$$

A.2.6.6 LOCALLY UNAMBIGUOUS SURFACE POSITION DECODING

The following computations shall be performed to obtain the decoded latitude and longitude for the surface position format.

a) $Dlat_i$ is computed from the equation:

$$Dlat_i = \frac{90°}{4 \cdot NZ - i}$$

b) The latitude zone index, j, is then computed from the values of lat_s, $Dlat_i$ and YZ_i using the equation:

$$j = \text{floor}\left(\frac{lat_s}{Dlat_i}\right) + \text{floor}\left(\frac{1}{2} + \frac{\text{MOD}(lat_s, Dlat_i)}{Dlat_i} - \frac{YZ_i}{2^{17}}\right)$$

c) The decoded position latitude, $Rlat_i$, is then computed from the values of j, $Dlat_i$, and YZ_i using the equation:

$$Rlat_i = Dlat_i \cdot \left(j + \frac{YZ_i}{2^{17}} \right)$$

d) $Dlon_i$ (the longitude zone size, in the E-W direction) is then computed from $Rlat_i$ using the equation:

$$Dlon_i = \begin{cases} \dfrac{90°}{\mathrm{NL}(Rlat_i) - i}, & \text{when } \mathrm{NL}(Rlat_i) - i > 0 \\ 90°, & \text{when } \mathrm{NL}(Rlat_i) - i = 0 \end{cases}$$

Note.— When performing the NL function, the encoding process must ensure that the NL value is established in accordance with Note 5 of §A.2.6.2.f.

e) The longitude zone coordinate m is then computed from the values of lon_s, $Dlon_i$, and XZ_i using the equation:

$$m = \mathrm{floor}\left(\frac{lon_s}{Dlon_i} \right) + \mathrm{floor}\left(\frac{1}{2} + \frac{\mathrm{MOD}(lon_s, Dlon_i)}{Dlon_i} - \frac{XZ_i}{2^{17}} \right)$$

f) The decoded position longitude, $Rlon_i$, is then computed from the values of m, XZ_i, and $Dlon_i$ using the equation:

$$Rlon_i = Dlon_i \cdot \left(m + \frac{XZ_i}{2^{17}} \right)$$

A.2.6.7 GLOBALLY UNAMBIGUOUS AIRBORNE POSITION DECODING

The CPR algorithm shall utilize one airborne-encoded "**even**" format reception (denoted XZ_0, YZ_0), together with one airborne-encoded "**odd**" format reception (denoted XZ_1, YZ_1), to regenerate the global geographic position latitude, *Rlat*, and longitude, *Rlon*. The time between the "**even**" and "**odd**" format encoded position reports shall be no longer than 10 seconds.

Note 1.— This algorithm might be used to obtain globally unambiguous position reports for aircraft out of the range of ground sensors, whose position reports are coming via satellite data links. It might also be applied to ensure that local positions are being correctly decoded over long ranges from the receiving sensor.

Note 2.— The time difference limit of 10 seconds between the even- and odd-format position reports is determined by the maximum permitted separation of 3 NM. Positions greater than 3 NM apart cannot be used to solve a unique global position. An aircraft capable of a speed of 1 852 km/h (1 000 kt) will fly about 5.1 km (2.8 NM) in 10 seconds. Therefore, the CPR algorithm will be able to unambiguously decode its position over a 10-second delay between position reports.

As airborne-format messages are initially received from a particular aircraft, if there is no established track on this aircraft, then a global decode shall be performed using even and odd format receptions, as described in this section.

Note 3.— If the aircraft has been transmitting surface format messages and their receptions were in track, then it is not necessary to use even-odd decoding. Beginning with the first individual airborne message reception, the location can be decoded using the local decode technique, based on the previous target location as the reference.

Given a 17-bit airborne position encoded in the "**even**" format (XZ_0, YZ_0) and another encoded in the "**odd**" format (XZ_1, YZ_1), separated by no more than 10 seconds (= 3 NM), the CPR algorithm shall regenerate the geographic position from the encoded position reports by performing the following sequence of steps:

a) Compute $Dlat_0$ and $Dlat_1$ from the equation:

$$Dlat_i = \frac{360°}{4 \cdot NZ - i}$$

b) Compute the latitude index:

$$j = \text{floor}\left(\frac{59 \cdot YZ_0 - 60 \cdot YZ_1}{2^{17}} + \frac{1}{2}\right)$$

c) Compute the values of $Rlat_0$ and $Rlat_1$ using the following equation:

$$Rlat_i = Dlat_i \cdot \left(\text{MOD}\left(j, 60 - i\right) + \frac{YZ_i}{2^{17}}\right)$$

Southern hemisphere values of $Rlat_i$ will fall in the range from 270° to 360°. Subtract 360° from such values, thereby restoring $Rlat_i$ to the range from –90° to +90°.

d) If **NL**($Rlat_0$) is not equal to **NL**($Rlat_1$) then the two positions straddle a transition latitude, thus a solution for global longitude is not possible. Wait for positions where they are equal.

e) If **NL**($Rlat_0$) is equal to **NL**($Rlat_1$) then proceed with computation of $Dlon_{i}$ $_i$, according to whether the most recently received airborne position message was encoded with the even format (i = 0) or the odd format (i = 1):

$$Dlon_i = \frac{360°}{n_i}$$

where n_i = greater of [NL($Rlat_i$) – i] and 1.

f) Compute m, the longitude index:

$$m = \text{floor}\left(\frac{XZ_0 \cdot (NL - 1) - XZ_1 \cdot NL}{2^{17}} + \frac{1}{2}\right)$$

where NL = NL($Rlat_i$).

g) Compute the global longitude, $Rlon_0$ or $Rlon_1$, according to whether the most recently received airborne position message was encoded using the even format (that is, with i = 0) or the odd format (i = 1):

$$Rlon_i = Dlon_i \cdot \left(\text{MOD}\left(m, n_i\right) + \frac{XZ_i}{2^{17}}\right)$$

where n_i = greater of [NL($Rlat_i$) – i] and 1.

h) A reasonableness test is applied to the resulting decoded position in accordance with §A.2.7.2.

A.2.6.8 GLOBALLY UNAMBIGUOUS SURFACE POSITION DECODING

This algorithm shall utilize one CPR surface position encoded "even" format message together with one CPR surface position encoded "odd" format message, to regenerate the geographic position of the aircraft or target.

As surface-format messages are initially received from a particular aircraft, if there is no established track on this aircraft, then a global decode shall be performed using even and odd format receptions, as described in this section.

Note 1.— If the aircraft has been transmitting airborne format messages and their receptions were in track, then it is not necessary to use even-odd decoding. Beginning with the first individual surface message reception, the location can be decoded using the local-decode technique, based on the previous target location as the reference.

Note 2.— Even if the aircraft is appearing for the first time in surface format receptions, any single message could be decoded by itself into multiple locations, one being the correct location of the transmitting aircraft, and all of the others being separated by 90 NM or more from the correct location. Therefore, if it were known that the transmitting aircraft cannot be farther away than 45 NM from a known location, then the first received message could be decoded using the locally unambiguous decoding method described in §A.2.6.6. Under some circumstances it may be possible for an aircraft to be first detected when it is transmitting surface position messages farther than 45 NM away from the receiving station. For this reason, even-odd decoding is required when messages are initially received from a particular aircraft. After this initial decode, as subsequent messages are received, they can be decoded individually (without using the even-odd technique), provided that the intervening time is not excessive. This subsequent decoding is based on the fact that the aircraft location has not changed by more than 45 NM between each new reception and the previously decoded location.

The even-odd decoding process shall begin by identifying a pair of receptions, one in the "even" format, the other in the "odd" format, and whose separation in time does not exceed the time interval of X seconds, where X=50 seconds, unless the Ground Speed in either Surface Position Message is greater than 25 knots, or is unknown, in which cases X=25 seconds.

Note 3.— The limit of 25 seconds is based on the possible change of location within this time interval. Detailed analysis of CPR indicates that if the change of location is 0.75 NM or less, then the decoding will yield the correct location of the aircraft. To assure that the change of location is actually no larger, and considering the maximum aircraft speed of 100 knots specified for the transmission of the surface format, the combination indicates that 25 seconds will provide the needed assurance. For targets on the airport surface when speeds are much less and the transmission rate is as low as one per 5 seconds, the corresponding time limit is 50 seconds.

Given a CPR 17-bit surface position encoded in the "even" format (XZ0, YZ0) and another encoded in the "odd" format (XZ1, YZ1), separated by no more than X seconds, the algorithm shall regenerate the geographic position (latitude *Rlat,* and longitude *Rlon*) of the aircraft or target by performing the following sequence of steps:

a) Compute the latitude zone sizes $Dlat_0$ and $Dlat_1$ from the equation:

$$Dlat_i = \frac{90°}{60 - i}$$

b) Compute the latitude index:

$$j = floor\left(\frac{59 \cdot YZ_o - 60YZ_1}{2^{17}} + \frac{1}{2}\right)$$

c) *Latitude.* The following formulas will yield two mathematical solutions for latitude (for each value of i), one in the northern hemisphere and the other in the southern hemisphere. Compute the northern hemisphere solution of $Rlat_0$ and $Rlat_1$ using the following equation:

$$Rlat_i = Dlat_i\left(MOD\left(j, 60-i\right)+\frac{YZ_i}{2^{17}}\right)$$

The southern hemisphere value is the above value minus 90 degrees.

To determine the correct latitude of the target, it is necessary to make use of the location of the receiver. Only one of the two latitude values will be consistent with the known receiver location, and this is the correct latitude of the transmitting aircraft.

d) The first step in longitude decoding is to check that the even-odd pair of messages do not straddle a transition latitude. It is rare, but possible, that NL($Rlat_0$) is not equal to NL($Rlat_i$). If so, a solution for longitude cannot be calculated. In this event, abandon the decoding of this even-odd pair, and examine further receptions to identify another pair. Perform the decoding computations up to this point and check that these two NL values are equal. When that is true, proceed with the following decoding steps.

e) Compute the longitude zone size Dloni, according to whether the most recently received surface position message was encoded with the even format (i = 0) or the odd format (i = 1):

$$Dlon_i = \frac{90°}{n_i}$$, where n_i is the greater of [$NL(Rlat_i) - i$] and 1.

f) Compute m, the longitude index:

$$m = floor\left(\frac{XZ_0\cdot\left(NL-1\right)-XZ_1\cdot NL}{2^{17}}+\frac{1}{2}\right)$$

where NL = NL ($Rlat_i$)

g) *Longitude.* The following formulas will yield four mathematical solutions for longitude (for each value of i), one being the correct longitude of the aircraft, and the other three separated by at least 90 degrees. To determine the correct location of the target, it will be necessary to make use of the location of the receiver. Compute the longitude, $Rlon_0$ or $Rlon_1$, according to whether the most recently received surface position message was encoded using the even format (that is, with i = 0) or the odd format (i = 1):

$$Rlon_i = Dlon_i\cdot\left(MOD\left(m, n_i\right)+\frac{XZi}{2^{17}}\right)$$

where n_i = greater of [NL($Rlat_i$) – i] and 1.

This solution for $Rlon_i$ will be in the range 0° to 90°. The other three solutions are 90°, 180°, and 270° to the east of this first solution.

To then determine the correct longitude of the transmitting aircraft, it is necessary to make use of the known location of the receiver. Only one of the four mathematical solutions will be consistent with the known receiver location, and this is the correct longitude of the transmitting aircraft.

Note.— Near the equator the minimum distance between the multiple longitude solutions is more than 5 000 NM, so there is no question as to the correct longitude. For locations away from the equator, the distance *between solutions is less, and varies according to the cosine of latitude. For example at 87 degrees latitude, the minimum distance between solutions is 280 NM. This is sufficiently large to provide assurance that the correct aircraft location will always be obtained. Currently no airports exist within 3 degrees of either pole, so the decoding as specified here will yield the correct location of the transmitting aircraft for all existing airports.*

h) A reasonableness test is applied to the resulting decoded position in accordance with §A.2.7.2.

A.2.6.9 CPR DECODING OF RECEIVED POSITION MESSAGES

A.2.6.9.1 *OVERVIEW*

The techniques described in the preceding paragraphs (locally and globally unambiguous decoding) shall be used together to decode the latitude/longitude contained in airborne, surface, intent and TIS-B position messages. The process shall begin with globally unambiguous decoding based upon the receipt of an even and an odd encoded position squitter. Once the globally unambiguous position is determined, emitter centered decoding shall be used to support subsequent decoding based upon a single position report, either even or odd encoding.

A.2.6.9.2 *EMITTER CENTERED LOCAL DECODING*

In this approach, the most recent position of the emitter shall be used as the basis for the local decoding.

Note.— This produces an unambiguous decoding at each update since the transmitting aircraft cannot move more than 180 NM between position updates.

A.2.7 REASONABLENESS TEST FOR CPR DECODING OF RECEIVED POSITION MESSAGES

A.2.7.1 OVERVIEW

Note.— Although receptions of position messages will normally lead to a successful target position determination, it is necessary to safeguard against position messages that would be used to initiate or update a track with an erroneous position. A reasonableness test applied to the computed position resulting from receipt of a position message can be used to discard erroneous position updates. Since an erroneous globally unambiguous CPR decode could potentially exist for the life of a track, a reasonableness test and validation of the position protects against such occurrences.

A.2.7.2 REASONABLENESS TEST APPLIED TO POSITIONS DETERMINED FROM GLOBALLY UNAMBIGUOUS DECODING

A reasonableness test shall be applied to a position computed using the globally unambiguous CPR decoding per §A.2.6.7 for airborne participants or per §A.2.6.8 for surface participants. Upon receipt of the even or odd encoded position message that completes the globally unambiguous CPR decode, the receiver shall perform a reasonableness test on the position decode by the following:

If the receiver position is known, calculate the distance between the decoded position and the receiver position and verify that the distance is less than the maximum operating range. If the validation fails, the receiver shall discard the decoded position, the even and odd position messages used to perform the globally unambiguous CPR decode, and reinitiate the globally unambiguous CPR decode process.

A further validation of the globally unambiguous CPR decode, passing the above test, shall be performed by the computation of a second globally unambiguous CPR decode based on reception of a new odd and an even position message as per §A.2.6.7 for an airborne participant or per §A.2.6.8 for a surface participant, both received subsequent to the respective odd and even position message used in the globally unambiguous CPR decode under validation. Upon accomplishing the additional globally unambiguous CPR decode, this decoded position and the position from the locally unambiguous CPR decode resulting from the most recently received position message shall be checked to be identical to within 5 m for an airborne decode and 1.25 m for a surface decode. If the two positions are not identical to within this tolerance, the validation is failed and the initial globally unambiguous CPR decode under validation shall be discarded and the track shall be reinitialized.

Note.— The position obtained from the initial global CPR decode is subsequently updated using local CPR decoding, until an independent odd and even message pair has been received. When this occurs a second global CPR decode is performed. The resulting position is compared to the position update obtained from the local CPR decode using the most recently received message. These two positions should agree since they are computed from the same message.

A.2.7.3 REASONABLENESS TEST APPLIED TO POSITIONS DETERMINED FROM LOCALLY UNAMBIGUOUS DECODING

A reasonableness test shall be performed to verify that the new position does not represent an unreasonable offset from the previous aircraft position. If an unreasonable offset is detected, the local decode shall not be used to update the track.

Note 1.— An unreasonable offset can result from an undetected error in the received position message.

Note 2.— Although the 24-bit aircraft address for every aircraft is required to be unique, if situations arise where multiple aircraft within range of a receiver are transmitting the same 24-bit aircraft address, loss of detection of aircraft can result from performing the above reasonableness test. To safeguard against this, the position data that failed the reasonableness test can be used to support detection and reporting of a duplicate address track. Since data transmitted from aircraft with duplicate addresses can not always be easily and reliably distinguished, receivers that support detection and tracking of duplicate addresses are expected to appropriately identify these as duplicate address reports.

TABLES FOR SECTION A.2

Tables are numbered A-2-X where “X” is the decimal equivalent of the BDS code Y,Z where Y is the BDS1 code and Z is the BDS2 code, used to access the data format for a particular register.

The following tables are not included in this document because they are used by communications protocols, or reserved and not yet defined:

A-2-1

A-2-2 to A-2-4 (Used by the linked Comm-B protocol)

A-2-13 to A-2-14 (Reserved for air/air state information)

A-2-15 (Reserved for ACAS)

A-2-17 to A-2-22

A-2-35 (Reserved for antenna position)

A-2-36 (Reserved for aircraft parameters)

A-2-38 to A-2-47

A-2-49 to A-2-63

A-2-70 to A-2-71

A-2-73 to A-2-79

A-2-87 to A-2-94

A-2-98 to A-2-100

A-2-102 to A-2-111 (Reserved for extended squitter)

A-2-112 to A-2-224

A-2-225 to A-2-226 (Reserved for Mode S BITE)

A-2-231 to A-2-240

A-2-243 to A-2-255

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-2-6. BDS code 0,6 — Extended squitter surface position

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-2-7. BDS Code 0,7 — Extended squitter status

MB FIELD

1	MSB TRANSMISSION RATE SUBFIELD (TRS)
2	LSB
3	ALTITUDE TYPE SUBFIELD (ATS)
4–56	RESERVED

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 metres 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 metres 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 from the ground control.

Table A-2-8. BDS code 0,8 — Extended squitter aircraft identification and category

MB FIELD

1	MSB	FORMAT TYPE CODE (specified in §A.2.3.1)
2		
3		
4		
5	LSB	
6	MSB	AIRCRAFT CATEGORY
7		
8	LSB	
9	MSB	CHARACTER 1
10		
11		
12		
13		
14	LSB	
15	MSB	CHARACTER 2
16		
17		
18		
19		
20	LSB	
21	MSB	CHARACTER 3
22		
23		
24		
25		
26	LSB	
27	MSB	CHARACTER 4
28		
29		
30		
31		
32	LSB	
33	MSB	CHARACTER 5
34		
35		
36		
37		
38	LSB	
39	MSB	CHARACTER 6
40		
41		
42		
43		
44	LSB	
45	MSB	CHARACTER 7
46		
47		
48		
49		
50	LSB	
51	MSB	CHARACTER 8
52		
53		
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-2-9a. BDS code 0,9 — Extended squitter airborne velocity (Subtypes 1 and 2: Velocity over ground)

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 §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	GroundSpeed	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-2-9b. BDS code 0,9 — Extended squitter airborne velocity (Subtypes 3 and 4: Airspeed and heading)

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	GroundSpeed	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-2-10. BDS code 0,A — Extended squitter event-driven information

MB FIELD

1	
2	
3	
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PURPOSE: To provide a flexible means to squitter messages other than position, velocity and identification.

1) A message inserted in this register (or an equivalent transmit buffer) shall be broadcast once by the transponder at the earliest opportunity.

2) Formats for messages using this protocol shall be specified in transponder registers 61_{16} to $6F_{16}$.

3) The GFM (§A.2.5) shall be responsible for ensuring pseudo-random timing and for observing the maximum transmission rate for this register of 2 per second (§A.2.5.5.1).

4) Read-out (if required) of this register shall be accomplished by extracting the contents of the appropriate transponder registers 61_{16} and $6F_{16}$.

Note.—The data in this register is not intended for extraction using GICB or ACAS cross-link protocols.

Table A-2-11. BDS code 0,B — Air/air state information 1 (aircraft state)

MB FIELD

1	STATUS
2	MSB = 1 024 knots
3	
4	
5	TRUE AIR SPEED
6	
7	
8	Range = [0, 2 047] knots
9	
10	
11	
12	LSB = 1.0 knot
13	SWITCH (0 = Magnetic heading, 1 = True heading)
14	STATUS
15	SIGN
16	MSB = 90 degrees
17	
18	HEADING
19	
20	
21	Range = [–180, +180] degrees
22	
23	
24	LSB = 360/1 024 degrees
25	STATUS
26	SIGN
27	MSB = 90 degrees
28	
29	
30	
31	TRUE TRACK ANGLE
32	
33	
34	
35	
36	Range = [–180, +180] degrees
37	
38	
39	
40	LSB = 360/32 768 degrees
41	STATUS
42	MSB = 1 024 knots
43	
44	
45	
46	GROUND SPEED
47	
48	
49	
50	
51	Range = [0, 2 048] knots
52	
53	
54	
55	LSB = 1/8 knot
56	RESERVED

PURPOSE: To report threat aircraft state information in order to improve the ability of ACAS to evaluate the threat and select a resolution manoeuvre.

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

Table A-2-12. BDS code 0,C — Air/air state information 2 (aircraft intent)

MB FIELD

1	STATUS
2	MSB = 32 768 feet
3	
4	
5	
6	LEVEL OFF ALTITUDE
7	
8	Range = [0, 65 520] feet
9	
10	
11	
12	
13	LSB = 16 feet
14	STATUS
15	SIGN
16	MSB = 90 degrees
17	
18	
19	NEXT COURSE (TRUE GROUND TRACK)
20	
21	Range = [–180, +180] degrees
22	
23	
24	LSB = 360/1 024 degrees
25	STATUS
26	MSB = 128 seconds
27	
28	TIME TO NEXT WAYPOINT
29	All ONEs = time exceeds 255 seconds
30	
31	
32	Range = [0, 256] seconds
33	
34	LSB = 0.5 seconds
35	STATUS
36	SIGN
37	MSB = 8 192 ft/min
38	
39	VERTICAL VELOCITY (UP IS POSITIVE)
40	
41	Range = [–16 384, +16 320] ft/min
42	
43	
44	LSB = 64 ft/min
45	STATUS
46	SIGN
47	MSB = 45 degrees
48	
49	ROLL ANGLE
50	
51	Range = [–90, +89] degrees
52	
53	LSB = 45/64 degrees
54	
55	RESERVED
56	

PURPOSE: To report threat aircraft state information in order to improve the ability of ACAS to evaluate the threat and select a resolution maneuver.

Note.— Two’s complement coding is used for all signed fields as specified in §A.2.2.2.

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 (see 1)
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 containing the maximum number of ELM segments that the transponder can deliver in response to a single requesting interrogation (UF = 24). (see 14)
30	
31	
32	
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 (see 1)
39	
40	
41	MSB
42	
43	
44	
45	
46	
47	Bit array indicating the support status of DTE
48	Sub-addresses 0 to 1 5 (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 and §4.3.8.4.2.2.2.

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-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 detected 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 by 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	1st Edition
5 – 127	Unassigned	

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

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

Note.— Additional implementation guidelines are provided in §C.2.4.1.

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,l 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-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.

Note.— Additional implementation guidelines are provided in §C.2.4.2.

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.

Note.— Additional implementation guidelines are provided in §C.2.4.2.

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.

Note.— Additional implementation guidelines are provided in §C.2.4.2.

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.

Note.— Additional implementation guidelines are provided in §C.2.4.2.

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.

Note.— Additional implementation guidelines are provided in §C.2.4.2.

Table A-2-29. BDS code 1,D — Mode S specific services
MSP capability report (1 of 3)

MB FIELD

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

PURPOSE: To indicate MSP services that are installed and require a service.

Each bit shall indicate that the MSP it represents requires service when set to 1.

Starting from the MSB, each bit position shall represent the MSP channel number for both uplink and downlink channel fields, in accordance with the following table:

BDS code	MSP channels
BDS 1,D	1 to 28 up and down
BDS 1,E	29 to 56 up and down
BDS 1,F	57 to 63 up and down

1) In register $1F_{16}$ the least significant bits of both uplink and downlink channel fields shall not be used.

2) The conditions for setting the capability bits shall be as defined in the specification of the corresponding service, see section §A.3.

Table A-2-30. BDS code 1,E — Mode S specific services
MSP capability report (2 of 3)

MB FIELD

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

PURPOSE: To indicate MSP services that are installed and require a service.

Each bit shall indicate that the MSP it represents requires service when set to 1.

1) The conditions for setting the capability bits shall be as defined in the specification of the corresponding service, see section §A.3.

Table A-2-31. BDS code 1,F — Mode S specific services MSP capability report (3 of 3)

MB FIELD

1	Uplink MSP Channel 57
2	Uplink MSP Channel 58
3	Uplink MSP Channel 59
4	Uplink MSP Channel 60
5	Uplink MSP Channel 61
6	Uplink MSP Channel 62
7	Uplink MSP Channel 63
8–28	RESERVED
29	Downlink MSP Channel 57
30	Downlink MSP Channel 58
31	Downlink MSP Channel 59
32	Downlink MSP Channel 60
33	Downlink MSP Channel 61
34	Downlink MSP Channel 62
35	Downlink MSP Channel 63
36–56	RESERVED

PURPOSE: To indicate MSP services that are installed and require a service.

Each bit shall indicate that the MSP it represents requires service when set to 1.

1) In register $1F_{16}$ the least significant bits of both uplink and downlink channel fields shall not be used.

2) The conditions for setting the capability bits shall be as defined in the specification of the corresponding service, see section §A.3.

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.

Note.— Additional implementation guidelines are provided in §C.2.4.3.

Table A-2-33. BDS code 2,1 — Aircraft and airline registration markings

MB FIELD

1	STATUS	AIRCRAFT REGISTRATION NUMBER	**PURPOSE:** To permit ground systems to identify the aircraft without the necessity of compiling and maintaining continuously updated data banks. The character coding shall be as defined in Table 3-7 of Chapter 3, Annex 10, Volume IV.
2	MSB		
3			
4	CHARACTER 1		
5			
6			
7	LSB		
8	MSB		
9			
10	CHARACTER 2		
11			
12			
13	LSB		
14	MSB		
15			
16	CHARACTER 3		
17			
18			
19	LSB		
20	MSB		
21			
22	CHARACTER 4		
23			
24			
25	LSB		
26	MSB		
27			
28	CHARACTER 5		
29			
30			
31	LSB		
32	MSB		
33			
34	CHARACTER 6		
35			
36			
37	LSB		
38	MSB		
39			
40	CHARACTER 7		
41			
42			
43	LSB		
44	STATUS	ICAO AIRLINE REGISTRATION MARKING	
45	MSB		
46			
47	CHARACTER 1		
48			
49			
50	LSB		
51	MSB		
52			
53	CHARACTER 2		
54			
55			
56	LSB		

Table A-2-34. BDS code 2,2 — Antenna positions

MB FIELD

1	MSB	
2	ANTENNA TYPE	
3	LSB	
4	MSB = 32 metres	
5		
6	X POSITION	
7	Range = [1, 63]	ANTENNA 1
8		
9	LSB = 1 metre	
10	MSB = 16 metres	
11		
12	Z POSITION	
13	Range = [1, 31]	
14	LSB = 1 metre	
15	MSB	
16	ANTENNA TYPE	
17	LSB	
18	MSB = 32 metres	
19		
20	X POSITION	
21	Range = [1, 63]	ANTENNA 2
22		
23	LSB = 1 metre	
24	MSB = 16 metres	
25		
26	Z POSITION	
27	Range = [1, 31]	
28	LSB = 1 metre	
29	MSB	
30	ANTENNA TYPE	
31	LSB	
32	MSB = 32 metres	
33		
34	X POSITION	
35	Range = [1, 63]	ANTENNA 3
36		
37	LSB = 1 metre	
38	MSB = 16 metres	
39		
40	Z POSITION	
41	Range = [1, 31]	
42	LSB = 1 metre	
43	MSB	
44	ANTENNA TYPE	
45	LSB	
46	MSB = 32 metres	
47		
48	X POSITION	
49	Range = [1, 63]	ANTENNA 4
50		
51	LSB = 1 metre	
52	MSB = 16 metres	
53		
54	Z POSITION	
55	Range = [1, 31]	
56	LSB = 1 metre	

PURPOSE: To provide information on the position of Mode S and GNSS antennas on the aircraft in order to make very accurate measurements of aircraft position possible.

1) The antenna type field shall be interpreted as follows:

   0 = Invalid
   1 = Mode S bottom antenna
   2 = Mode S top antenna
   3 = GNSS antenna
   4 to 7 = Reserved

2) The X position field shall be the distance in meters along the aircraft center line measured from the nose of the aircraft. The field shall be interpreted as invalid if the value is ZERO (0) and the value of 63 shall mean that the antenna position is 63 metres or more from the nose.

3) The Z position field shall be the distance in meters of the antenna from the ground, measured with the aircraft unloaded and on the ground. The field shall be interpreted as invalid if the value is ZERO (0), and the value of 31 shall mean that the antenna position is 31 metres or more from the ground.

Table A-2-37. BDS code 2,5 — Aircraft type

MB FIELD

1	MSB	AIRCRAFT TYPE	
2			
3			
4			
5			
6	LSB		
7	MSB	NUMBER OF ENGINES	
8			
9	LSB		
10	MSB	ENGINE TYPE	
11			
12			
13			
14			
15	LSB		
16	MSB	CHARACTER 1	MODEL DESIGNATION
17			
18			
19			
20			
21	LSB		
22	MSB	CHARACTER 2	
23			
24			
25			
26			
27	LSB		
28	MSB	CHARACTER 3	
29			
30			
31			
32			
33	LSB		
34	MSB	CHARACTER 4	
35			
36			
37			
38			
39	LSB		
40	MSB	CHARACTER 5	
41			
42			
43			
44			
45	LSB		
46	MSB	WAKE TURBULENCE CATEGORY	
47			
48			
49			
50			
51	LSB		
52		RESERVED	
53			
54			
55			
56			

PURPOSE: To provide information on aircraft type.

1) Subfield coding

The coding shall be as in Doc 8643 — *Aircraft Type Designators*. All the subfields that contain characters shall be encoded using the 6-bit subset of IA-5 as specified in Table 3-9 of Annex 10, Volume IV.

2) Model designation

Coding shall consist of four characters as specified in Doc 8643. The fifth character shall be reserved for future expansion and shall contain all ZEROs until it is specified. 2222 in the first four characters shall mean that the designator is not specified.

3) Number of engines

This subfield shall be encoded as a binary number where number 7 means 7 or more engines.

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-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 (MCP/FCU Mode bits)
50	ALT HOLD MODE (MCP/FCU Mode bits)
51	APPROACH MODE (MCP/FCU Mode bits)
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

   Note.— Additional implementation guidelines are provided in §C.2.4.4.

Table A-2-65. BDS code 4,1 — Next waypoint details

MB FIELD

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

PURPOSE: To provide ready access to details about the next waypoint on an aircraft's route, without the need to establish a data link dialogue with the flight management system. This will assist with short and medium term tactical control.

1) Each character shall be encoded as specified in Annex 10, Volume IV, §3.1.2.9.1.2.

Table A-2-66. BDS code 4,2 — Next waypoint details

MB FIELD

1	STATUS
2	SIGN
3	MSB = 90 degrees
4	
5	
6	
7	
8	
9	WAYPOINT LATITUDE
10	
11	Range = [–180, +180] degrees
12	
13	
14	
15	
16	
17	
18	
19	
20	LSB = 90/131 072 degrees
21	STATUS
22	SIGN
23	MSB = 90 degrees
24	
25	
26	
27	
28	
29	
30	WAYPOINT LONGITUDE
31	
32	Range = [–180, +180] degrees
33	
34	
35	
36	
37	
38	
39	
40	LSB = 90/131 072 degrees
41	STATUS
42	SIGN
43	MSB = 65 536 feet
44	
45	
46	
47	WAYPOINT CROSSING
48	ALTITUDE
49	
50	Range = [–131 072, +131 064] feet
51	
52	
53	
54	
55	
56	LSB = 8 feet

PURPOSE: To provide ready access to details about the next waypoint on an aircraft's route, without the need to establish a data link dialogue with the flight management system. This will assist with short and medium term tactical control.

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

Table A-2-67. BDS code 4,3 — Next waypoint details

MB FIELD

1	STATUS
2	SIGN
3	MSB = 90 degrees
4	
5	
6	BEARING TO WAYPOINT
7	
8	Range = [–180, +180] degrees
9	
10	
11	
12	LSB = 360/2 048 degrees
13	STATUS
14	MSB = 204.8 minutes
15	
16	
17	
18	TIME TO GO
19	
20	Range = [0, 410] minutes
21	
22	
23	
24	
25	LSB = 0.1 minutes
26	STATUS
27	MSB = 3 276.8 NM
28	
29	
30	
31	
32	
33	DISTANCE TO GO
34	
35	Range = [0, 6 554] NM
36	
37	
38	
39	
40	
41	
42	LSB = 0.1 NM
43	
44	
45	
46	
47	
48	
49	
50	RESERVED
51	
52	
53	
54	
55	
56	

PURPOSE: To provide ready access to details about the next waypoint on an aircraft's route, without the need to establish a data link dialogue with the flight management system. This will assist with short and medium term tactical control.

1) The bearing to waypoint is the bearing from the current aircraft heading position to the waypoint position referenced to true north.

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

Table A-2-68. BDS code 4,4 — Meteorological routine air report

MB FIELD

1	MSB
2	FOM/SOURCE
3	
4	LSB
5	STATUS (wind speed and direction)
6	MSB = 256 knots
7	
8	
9	WIND SPEED
10	
11	Range = [0, 511] knots
12	
13	
14	LSB = 1 knot
15	MSB = 180 degrees
16	
17	
18	WIND DIRECTION (True)
19	
20	Range = [0, 360] degrees
21	
22	
23	LSB =180/256 degrees
24	SIGN
25	MSB = 64°C
26	
27	
28	
29	STATIC AIR TEMPERATURE
30	
31	Range = [–128, +128] °C
32	
33	
34	LSB = 0.25°C
35	STATUS
36	MSB = 1 024 hPa
37	
38	
39	
40	AVERAGE STATIC PRESSURE
41	
42	Range = [0, 2 048] hPa
43	
44	
45	
46	LSB = 1 hPa
47	STATUS
48	MSB TURBULENCE (see 1)
49	LSB
50	STATUS
51	MSB = 100 %
52	
53	HUMIDITY
54	Range = [0, 100] %
55	
56	LSB = 100/64 %

PURPOSE: To allow meteorological data to be collected by ground systems.

FOM/SOURCE coding:

The decimal value of the binary coded (figure of merit) FOM/SOURCE parameter shall be interpreted as follows:

0 = Invalid
1 = INS
2 = GNSS
3 = DME/DME
4 = VOR/DME
5 to 15 = Reserved

1) The interpretation of the two bits assigned to TURBULENCE shall be as shown in the table for register 45_{16}.

Note 1.— The average static pressure is not a requirement of Annex 3.

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

Note 3.— The requirement for the range of wind speeds in Annex 3 is from 0 to 250 knots.

Note 4.— The requirement for the range of static air temperature in Annex 3 is from –80° C to +60° C.

Table A-2-69. BDS code 4,5 — Meteorological hazard report

MB FIELD

1	STATUS	
2	MSB	TURBULENCE
3	LSB	
4	STATUS	
5	MSB	WIND SHEAR
6	LSB	
7	STATUS	
8	MSB	MICROBURST
9	LSB	
10	STATUS	
11	MSB	ICING
12	LSB	
13	STATUS	
14	MSB	WAKE VORTEX
15	LSB	
16	STATUS	
17	SIGN	
18	MSB = 64°C	
19		
20		STATIC AIR TEMPERATURE
21		
22		Range = [–128, +128] °C
23		
24		
25		
26	LSB = 0.25°C	
27	STATUS	
28	MSB = 1 024 hPa	
29		
30		
31		
32		AVERAGE STATIC PRESSURE
33		
34		Range = [0, 2 048] hPa
35		
36		
37		
38	LSB = 1 hPa	
39	STATUS	
40	MSB = 32 768 feet	
41		
42		
43		
44		RADIO HEIGHT
45		
46		Range = [0, 65 528] ft
47		
48		
49		
50		
51	LSB = 16 ft	
52		
53		
54		RESERVED
55		
56		

PURPOSE: To provide reports on the severity of meteorological hazards, in particular for low flight.

Hazard coding:

The interpretation of the two bits assigned to each hazard shall be as defined in the table below:

Bit 1	Bit 2	
0	0	NIL
0	1	LIGHT
1	0	MODERATE
1	1	SEVERE

The definition of the terms LIGHT, MODERATE and SEVERE shall be those defined in the PANS-ATM (Doc 4444), where applicable.

Note 1.— The requirement for the range of static air temperature in Annex 3 is from –80° C to +60° C.

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

Table A-2-72. BDS code 4,8 — VHF channel report

MB FIELD

Bit		
1	MSB	
2		
3		
4		
5		
6		
7		
8		VHF 1
9		
10		
11		
12		
13		
14		
15	LSB	
16	STATUS	
17	MSB	VHF 1
18	LSB	AUDIO STATUS
19	MSB	
20		
21		
22		
23		
24		
25		
26		VHF 2
27		
28		
29		
30		
31		
32		
33	LSB	
34	STATUS	
35	MSB	VHF 2
36	LSB	AUDIO STATUS
37	MSB	
38		
39		
40		
41		
42		
43		VHF 3
44		
45		
46		
47		
48		
49		
50		
51	LSB	
52	STATUS	
53	MSB	VHF 3
54	LSB	AUDIO STATUS
55	MSB	121.5 MHz
56	LSB	AUDIO STATUS

PURPOSE: To allow the ATC system to monitor the settings of the VHF communications channel and to determine the manner in which each channel is being monitored by the aircrew.

Channel report coding:

Each VHF communications channel shall be determined form the 15-bit positive binary number, N in kHz, according to the formula:

Channel (MHz) = Base + N x 0.001 (MHz)
where: Base = 118.000 MHz

Notes. —
1) *The use of binary to define the channel improves the coding efficiency.*
2) *This coding is compatible with analogue channels on 25 kHz, 8.33 kHz channel spacing and VDL as described below.*
3) *VDL has a full four bits allocated such that the active status of each of its four multiplex channels can be ascertained.*

25 kHz **Bit**	**VDL: Mode 3**	**Analogue**
16	Status	Status
15 (LSB)	MSB (12 800 kHz)	MSB (12 800 kHz)
...	Range 118.000 to 143.575	Range 118.000 to 143.575
	136.975 (military use)	136.975 (military use)
6	LSB (25 kHz)	LSB (25 kHz)
5		Unused
4	4 x channel active flags	Unused
3		Unused
2		8.33 indicator = 0
1 (MSB)	VDL indicator = 1	VDL indicator = 0

8.33 kHz **Bit**	**Analogue**
16	Status
15 (LSB)	MSB (17 066 kHz)
...	Range 118.000 to 152.112
	136.975 (military use)
4	LSB (17 066/2 048 kHz)
3	Unused
2	8.33 indicator = 1
1 (MSB)	VDL indicator = 0

Audio status coding:

Each pair of audio status bits shall be used to describe the aircrew monitoring of that audio channel according to the following table:

Bit 1 (MSB)	**Bit 2 (LSB)**	
0	0	UNKNOWN
0	1	NOBODY
1	0	HEADPHONES ONLY
1	1	LOUDSPEAKER

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. — 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 1.— Two's complement coding is used for all signed fields as specified in §A.2.2.2.

Note 2.— Additional implementation guidelines are provided in §C.2.4.5.

Table A-2-81. BDS code 5,1 — Position report coarse

MB FIELD

1	STATUS (see 1)
2	SIGN
3	MSB = 90 degrees
4	
5	
6	
7	
8	
9	LATITUDE
10	
11	Range = [–180, +180] degrees
12	(see 2)
13	
14	
15	
16	
17	
18	
19	
20	
21	LSB = 360/1 048 576 degrees
22	SIGN
23	MSB = 90 degrees
24	
25	
26	
27	
28	LONGITUDE
29	
30	Range = [–180, +180] degrees
31	
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	LSB = 360/1 048 576 degrees
42	SIGN
43	MSB = 65 536 feet
44	
45	
46	
47	PRESSURE
48	ALTITUDE
49	
50	Range = [–1 000, +126 752] feet
51	
52	
53	
54	
55	
56	LSB = 8 feet

PURPOSE: To provide a three-dimensional report of aircraft position.

1) The single status bit (bit 1) shall be set to ZERO (0) if any of the three parameters is invalid. This bit shall be identical to the status bit in register 52_{16}.

2) The required valid range for latitude is +90 degrees to –90 degrees, but the parameter shall be coded with an MSB of 90 degrees to allow the use of the same coding algorithm as for longitude.

3) The source of the information in this register shall be the same as that indicated in the FOM/SOURCE field of register 52_{16}.

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

Table A-2-82. BDS code 5,2 — Position report fine

MB FIELD

1	STATUS (see 1)
2	MSB
3	FOM/SOURCE
4	
5	LSB
6	MSB = 90/128 degrees
7	
8	
9	
10	
11	
12	
13	LATITUDE FINE
14	
15	Range = [0, 180/128] degrees
16	
17	
18	
19	
20	
21	
22	
23	LSB = 90/16 777 216 degrees
24	MSB = 90/128 degrees
25	
26	
27	
28	
29	
30	
31	LONGITUDE FINE
32	
33	Range = [0, 180/128] degrees
34	
35	
36	
37	
38	
39	
40	
41	LSB = 90/16 777 216 degrees
42	SIGN
43	MSB = 65 536 feet
44	
45	
46	
47	PRESSURE-ALTITUDE
48	OR
49	GNSS HEIGHT (HAE)
50	
51	(as specified by FOM / SOURCE coding)
52	
53	Range = [–1 000, +126 752] feet
54	
55	
56	LSB = 8 feet

PURPOSE: To provide a high-precision three-dimensional report on aircraft position when used in conjunction with register 51_{16}. information on the source of the data is included.

FOM/SOURCE Coding:

The decimal value of the binary-coded (Figure of Merit) FOM / SOURCE parameter shall be interpreted as follows:

0 = FOM > 10 NM or Unknown Accuracy
1 = FOM 10 NM/18.5 km (e.g. INS data) pressure-altitude
2 = FOM 4 NM/7.4 km (e.g. VOR/DME) pressure-altitude
3 = FOM 2 NM/3.7 km (e.g. DME/DME or GNSS) pressure-altitude
4 = FOM 1 NM/1.85 km (e.g. DME/DME or GNSS) pressure-altitude
5 = FOM 0.5 NM/926 m (e.g. DME/DME or GNSS) pressure-altitude
6 = FOM 0.3 NM/555.6 m (e.g. DME/DME or GNSS) pressure-altitude
7 = FOM 0.1 NM/185.2 m (ILS, MLS or differential GNSS) pressure-altitude
8 = FOM 0.05 NM/92.6 m (ILS, MLS or differential GNSS) pressure-altitude
9 = FOM 30 m (ILS, MLS or differential GNSS) pressure-altitude
10 = FOM 10 m (ILS, MLS or differential GNSS) pressure-altitude
11 = FOM 3 m (ILS, MLS or differential GNSS) pressure-altitude
12 = FOM 30 m (ILS, MLS or differential GNSS) GNSS height
13 = FOM 10 m (ILS, MLS or differential GNSS) GNSS height
14 = FOM 3 m (ILS, MLS or differential GNSS) GNSS height
15 = Reserved

Note 1. — When GNSS is the source, then the FOM is encoded by the HFOM parameter. When RNP FMS is the source the FOM is encoded by the ANP.

1) The single status bit (bit 1) shall be set to ZERO (0) if any of the three parameters are invalid and is identical to the status bit in register $51_{16.}$

2) The LATITUDE (fine) and LONGITUDE (fine) parameters are in 2's complement coding so they shall be interpreted in conjunction with the corresponding parameters in register $51_{16.}$

3) When GNSS height is contained in bits 42 to 56, the pressure-altitude can be obtained from register $51_{16.}$

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

Note 3.— The Figure of Merit selected is the smallest number that encompasses the HFOM or the ANP.

Table A-2-83. BDS code 5,3 — Air-referenced state vector

MB FIELD

1	STATUS
2	SIGN
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 (IAS)
18	
19	Range = [0, 1 023] knots
20	
21	
22	
23	LSB = 1 knot
24	STATUS
25	MSB = MACH 2.048
26	
27	
28	MACH NUMBER
29	
30	Range = [0, 4.096] MACH
31	
32	
33	LSB = MACH 0.008
34	STATUS
35	MSB = 1 024 knots
36	
37	
38	
39	
40	TRUE AIRSPEED
41	
42	Range = [0, 2 048] knots
43	
44	
45	
46	LSB = 0.5 knots
47	STATUS
48	SIGN
49	MSB = 8 192 feet/minute
50	
51	ALTITUDE RATE
52	
53	Range = [–16 384, +16 320] feet/minute
54	
55	
56	LSB = 64 feet/minute

PURPOSE: To provide the ATC system with current measured values of magnetic heading, IAS/MACH, altitude rate and TAS.

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

Table A-2-84 to A-2-86. BDS codes 5,4 to 5,6 — Waypoints 1, 2 and 3

MB FIELD

Bit	Field
1	STATUS (see 1)
2	MSB
3	
4	CHARACTER 1
5	
6	
7	LSB
8	MSB
9	
10	CHARACTER 2
11	
12	
13	LSB
14	MSB
15	
16	CHARACTER 3
17	
18	
19	LSB
20	MSB
21	
22	CHARACTER 4
23	
24	
25	LSB
26	MSB
27	
28	CHARACTER 5
29	
30	
31	LSB
32	MSB = 30 minutes
33	
34	ESTIMATED TIME OF ARRIVAL
35	(NORMAL FLIGHT)
36	
37	Range = [0, 60] minutes
38	
39	
40	LSB = 60/512 minutes
41	MSB = 320 FL
42	
43	ESTIMATED FLIGHT LEVEL
44	(NORMAL FLIGHT)
45	Range = [0, 630] FL
46	LSB = 10 FL
47	MSB = 30 minutes
48	
49	TIME TO GO
50	(DIRECT ROUTE)
51	
52	Range = [0, 60] minutes
53	
54	
55	LSB = 60/512 minutes
56	RESERVED

PURPOSE: To provide information on the next three waypoints, register 54_{16} contains information on the next waypoint, register 55_{16} contains information on the next waypoint plus one, and register 56_{16} contains information on the next waypoint plus two.

1) The single status bit shall be set to ZERO (0) if any of the parameters are invalid.

2) The actual time or flight level shall be calculated from the trajectory scheduled in the FMS.

Note.— Mode detail on the next waypoint is given in register 41_{16} to 43_{16}.

3) When the waypoint identity has only three characters, two leading ZERO characters shall be added (e.g. CDN becomes 00CDN).

4) Estimated time is in minutes and all ones shall be used to indicate that the waypoint referred to is one hour or more away.

Table A-2-95. BDS code 5,F — Quasi-static parameter monitoring

MB 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		
28		
29		
30		
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		
41		RESERVED
42		
43		
44		
45		
46		
47		
48		
49		
50		
51		
52		
53		
54		
55		
56		

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-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.— 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 inertial vertical velocity (baro-inertial information), it shall be transmitted in the Inertial Vertical Velocity field.

Note 1.— 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 2.— 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 3. — Two's complement coding is used for all signed fields as specified in §A.2.2.2.

Note 4.— Additional implementation guidelines are provided in §C.2.4.6.

Table A-2-97. BDS code 6,1 — Extended squitter emergency/priority status

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-2-101. BDS code 6,5 — Extended squitter aircraft operational status

MB FIELD

1	MSB	FORMAT TYPE CODE = 31
2		
3		
4		
5	LSB	
6	MSB	SUBTYPE CODE = 0
7		
8	LSB	
9	MSB	EN-ROUTE OPERATIONAL CAPABILITIES (CC-4) (specified in §A.2.3.11.3)
10		
11		
12	LSB	
13	MSB	TERMINAL AREA OPERATIONAL CAPABILITIES (CC-3) (specified in §A.2.3.11.4)
14		
15		
16	LSB	
17	MSB	APPROACH/LANDING OPERATIONAL CAPABILITIES (CC-2) (specified in §A.2.3.11.5)
18		
19		
20	LSB	
21	MSB	SURFACE OPERATIONAL CAPABILITIES (CC-1) (specified in §A.2.3.11.6)
22		
23		
24	LSB	
25	MSB	EN-ROUTE OPERATIONAL CAPABILITY STATUS (OM-4) (specified in §A.2.3.11.7)
26		
27		
28	LSB	
29	MSB	TERMINAL AREA OPERATIONAL CAPABILITY STATUS (OM-3) (specified in §A.2.3.11.8)
30		
31		
32	LSB	
33	MSB	APPROACH/LANDING OPERATIONAL CAPABILITY STATUS (OM-2) (specified in §A.2.3.11.9)
34		
35		
36	LSB	
37	MSB	SURFACE OPERATIONAL CAPABILITY STATUS (OM-1) (specified in §A.2.3.11.10)
38		
39		
40	LSB	
41		RESERVED
42		
43		
44		
45		
46		
47		
48		
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-2-227. BDS code E,3 — Transponder type / part 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 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 transponder type.

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

Table A-2-228. BDS code E,4 — Transponder software revision number

MB FIELD

Bit		
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 3-9 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-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 3-9 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-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 3-9 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-2-241. BDS code F,1 — Military applications

MB FIELD

1	STATUS
2	Character Field (see 1)
3	C1
4	A1
5	C2
6	A2
7	C4
8	A 4 MODE 1 CODE
9	X
10	B1
11	D1
12	B2
13	D2
14	B4
15	D4
16	STATUS
17	C1
18	A1
19	C2
20	A2
21	C4
22	A 4 MODE 2 CODE
23	X
24	B1
25	D1
26	B2
27	D2
28	B4
29	D4
30–56	RESERVED

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-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

A.3. FORMATS FOR MODE S SPECIFIC PROTOCOLS (MSP)

A.3.1 MSP CHANNEL NUMBER ALLOCATIONS

The details of protocols and data transfers shall be as specified in the following paragraphs.

Note.— Some MSP channel numbers have been assigned (see Annex 10, Volume III, Part I, Chapter 5, Table 5-25).

A.3.2 UPLINK MSP CHANNELS

The following sections are numbered §A.3.2.X, where 'X' is the decimal equivalent of the uplink MSP channel number. This shall be done to allow definitions of the hitherto undefined formats to be inserted without affecting the paragraph numbers.

For MSP packet formats refer to Annex 10, Volume III, Part I, Chapter 5.

A.3.2.1 UPLINK MSP CHANNEL 1

(Reserved for specific services management)

The description of this channel has not yet been developed.

A.3.2.2 UPLINK MSP CHANNEL 2: TRAFFIC INFORMATION SERVICE (TIS)

A.3.2.2.1 PURPOSE

The TIS shall have the capability to generate automatic alert information on any aircraft that carries an operating transponder (Mode A/C or Mode S). Aircraft that are under primary radar tracking can also be used to generate reports.

Note.— The traffic information service (TIS) is intended to improve the safety and efficiency of "see and avoid" flight by providing the pilot with an automatic display of nearby traffic and warnings of any potentially threatening traffic conditions. The TIS is functionally equivalent to ACAS I, providing traffic advisories but no resolution advisory information. By utilizing the surveillance database maintained by Mode S ground interrogators and its data link, the TIS can provide airborne traffic alerting with a minimum airborne equipage requirement. The TIS is provided without any ATC involvement.

A.3.2.2.2 TIS UPLINK MESSAGE FORMATS

All TIS uplink messages shall be structured as shown below. Each TIS uplink message shall be 56 bits. TIS traffic data messages shall consist of one or more short-form MSP packets. There shall be three types of TIS uplink messages as follows:

1) "Keep-alive"

2) "Goodbye"

3) "Traffic data"

Header	*Message type*	*Traffic block 1*	*Traffic block 2*
8 bits	6 bits	21 bits	21 bits

Note.— The formats of TIS downlink messages are defined in §A.4 of this appendix under broadcast identifier 02_{16}.

A.3.2.2.2.1 Message header

The 8-bit header shall be present in all TIS messages. The message header for TIS shall have the value 02 (hexadecimal), since all TIS messages utilize the short-form MSP protocol and TIS is assigned MSP channel 2.

A.3.2.2.2.2 Message type

The 6-bit message type field shall be used to differentiate the different types of uplink messages:

Message type value	*TIS message uplink type*
0 to 59	Traffic data, first segment (own-heading)
60	Traffic data, intermediate segment(s)
61	Traffic data, final segment
62	Goodbye
63	Keep-alive

In the case of “first segment” traffic data messages, the 6-bit message type field shall contain the Mode S interrogator-derived tracked own-heading of the aircraft receiving the TIS message. This heading shall be quantized in 6 degree increments and shall be expressed with reference to magnetic north at the interrogator. The own-heading value in traffic data messages shall be provided to permit display heading correction on board the TIS-equipped aircraft by using an airborne heading sensor.

Note.— Such a heading correction may be necessary when the aircraft is manoeuvring or crabbing due to wind.

Since there may be several TIS traffic data messages to a given aircraft during a given scan, TIS processing shall be able to group the TIS traffic data uplinks together correctly. The “first”, “intermediate”, and “final” segment type values shall provide the necessary information to perform this grouping process. The mechanism for this shall be as specified below. Buffer space for at least 4 TIS traffic data messages (eight aircraft) shall be provided.

A.3.2.2.2.2.1 Keep-alive message

The TIS keep-alive message shall contain the message header and the message type fields as described above. The message type field shall be set to 63 decimal. The remaining bits of the message shall be unused.

A.3.2.2.2.2.2 Goodbye message

The TIS goodbye message shall contain the message header and the message type fields as described above. The message type field shall be set to 62 decimal. The remaining bits of the message shall be unused.

A.3.2.2.2.3 Traffic information block

Each TIS traffic data message shall contain two 21-bit traffic information blocks whose structure is shown below. The six fields in a traffic information block shall describe one TIS alert aircraft. One TIS traffic data message shall be able to define one or two alert aircraft.

Note.— A number 'n' of TIS traffic data messages may be uplinked in a given scan to convey information on up to 2n alert aircraft.

Traffic bearing	*Traffic range*	*Relative altitude*	*Altitude rate*	*Traffic heading*	*Traffic status*
6 bits	4 bits	5 bits	2 bits	3 bits	1 bit

A.3.2.2.2.3.1 Traffic bearing

The 6-bit traffic bearing field shall contain the bearing angle from the own-aircraft heading to the alert aircraft, quantized in 6 degree increments. The valid range for the traffic bearing field shall be 0 to 59 (with the exception described below).

Note.— Since this bearing angle is defined by TIS with respect to its measured own-aircraft heading, corrections from an airborne heading source can be applied.

If there is only one alert aircraft in a given TIS traffic data message, the traffic bearing field in the unused traffic information block shall be set to the value 63 (a bearing angle greater than 360 degrees) and the remainder of the bits in the traffic information block shall be ignored. This shall be termed as a "null alert" block.

A.3.2.2.2.3.2 Traffic range

The 4-bit traffic range field shall contain the distance between own-aircraft and the alert aircraft. A non-linear range encoding shall be used to minimize the number of bits required for this field as follows:

Traffic range value (r)	*Range (in increments of 230 m (0.125 NM))*
0	0 < r ≤ 1
1	1 < r ≤ 3
2	3 < r ≤ 5
3	5 < r ≤ 7
4	7 < r ≤ 9
5	9 < r ≤ 11
6	11 < r ≤ 13
7	13 < r ≤ 15
8	15 < r ≤ 18
9	18 < r ≤ 22
10	22 < r ≤ 28
11	28 < r ≤ 36
12	36 < r ≤ 44
13	44 < r ≤ 52
14	52 < r ≤ 56
15	r > 56

A.3.2.2.2.3.3 Relative altitude

The 5-bit relative altitude field shall contain the difference in altitude between the own-aircraft and the alert aircraft. A non-linear encoding shall be used to minimize the number of bits required for this field. A special encoding value shall be used to indicate that the alert aircraft has no reported altitude. By convention, a positive value in the relative altitude field shall indicate that the alert aircraft is above the own-aircraft.

Relative altitude shall be given by:

$$\text{Relative altitude} = \text{Altitude}_{\text{Alert aircraft}} - \text{Altitude}_{\text{Own-aircraft}}$$

where altitudes are indicated in feet.

The TIS encoding for relative altitude shall be:

Relative altitude value (alt)	*Relative altitude (feet)*
0	0 ≤ alt ≤ +100
1	+100 < alt ≤ +200
2	+200 < alt ≤ +300
3	+300 < alt ≤ +400
4	+400 < alt ≤ +500
5	+500 < alt ≤ +600
6	+600 < alt ≤ +700
7	+700 < alt ≤ +800
8	+800 < alt ≤ +900
9	+900 < alt ≤ +1 000
10	+1 000 < alt ≤ +1 500
11	+1 500 < alt ≤ +2 000
12	+2 000 < alt ≤ +2 500
13	+2 500 < alt ≤ +3 000
14	+3 000 < alt ≤ +3 500
15	+3 500 < alt
16	No reported altitude
17	–100 ≤ alt < 0
18	–200 ≤ alt < –100
19	–300 ≤ alt < –200
20	–400 ≤ alt < –300
21	–500 ≤ alt < –400
22	–600 ≤ alt < –500
23	–700 ≤ alt < –600
24	–800 ≤ alt < –700
25	–900 ≤ alt < –800
26	–1 000 ≤ alt < –900
27	–1 500 ≤ alt < –1 000
28	–2 000 ≤ alt < –1 500
29	–2 500 ≤ alt < –2 000
30	–3 000 ≤ alt < –2 500
31	alt < –3 000

A.3.2.2.2.3.4 Altitude rate

The 2-bit altitude rate field shall indicate whether the alert aircraft is climbing, descending, or level. An altitude rate of 500 ft/min shall be used as a threshold. The encoding of the TIS altitude rate field shall be:

Altitude rate field value	*Altitude rate*
0	Unused
1	Climbing (>500 ft/min)
2	Descending (>500 ft/min)
3	Level

A.3.2.2.2.3.5 Traffic heading

The 3-bit traffic heading field shall contain the heading of the alert aircraft quantized to 45-degree increments. This heading shall be based on the Mode S ground interrogator track for the alert aircraft.

Note.— The coarse quantization of traffic heading is sufficient to aid the pilot receiving the TIS alert message to visually acquire the traffic alert aircraft.

A.3.2.2.2.3.6 Traffic status

The 1-bit traffic status field shall identify the type of alert represented by this traffic information block. A status value of "ZERO" shall indicate a "proximity" alert and a status value of "ONE" shall indicate a "threat" alert.

A.3.2.2.2.4 Handling multiple TIS alerts

As described above, the traffic data information for a given scan shall consist of one or more TIS traffic data messages. The last traffic information block of the last TIS uplink message for this scan shall be a null-alert block if there is an odd number of alert aircraft in this message. The null-alert condition shall be indicated by the value 63 decimal in the traffic bearing field of the traffic information block.

A.3.2.2.2.4.1 The TIS traffic information blocks within a given TIS traffic data message shall be arranged with the highest priority alerts first. All traffic information blocks with the status "threat" shall precede traffic information blocks with the status "proximity". Within a status class, the traffic information blocks shall be put in order of increasing traffic range.

Note.— This ordering ensures that the most critical traffic alerts will be at the head of the list of traffic information blocks. Therefore, TIS will report on the most significant aircraft up to the limit of the number of messages transferable in one scan.

A.3.2.2.3 TIS TRAFFIC DATA MESSAGES GROUPING MECHANISM

A.3.2.2.3.1 The mechanism for grouping TIS traffic data messages for a given scan shall be based on the message type field in each message as described in §3.2.2.2.

A.3.2.2.3.2 Since the Mode S Comm-A protocol can deliver multiple copies of the same message, the initial step in message grouping shall be a check to eliminate duplicate messages. This shall be accomplished by a bit comparison of successive messages received with the same message type.

A.3.2.2.3.3 After duplicate elimination, the TIS traffic data for a given grouping shall always begin with a “first” segment message. This message shall contain the own-heading value for the group. Additional TIS traffic data messages in the grouping (if present) shall be structured as indicated in the table below:

Number of traffic aircraft	*Structure of group*
1	First
2	First
3	First and final
4	First and final
5	First, 1 intermediate, and final
6	First, 1 intermediate, and final
7	First, 2 intermediates, and final
8	First, 2 intermediates, and final
etc.	First, intermediates, and final

A.3.2.2.3.4 The receipt of a “first” segment shall start the formation of a message group. Subsequent TIS traffic data uplink messages shall be added to the group until one of the following conditions occurs:

a) a TIS uplink of type “final” is received (the final is part of the group);

b) a TIS uplink of type “first” segment, “keep-alive”, or “goodbye” is received; or

c) more than 6 seconds have elapsed since the start of the group.

A.3.2.2.3.5 All the traffic blocks in the TIS traffic data message group (1 to n) shall form the display for the current time. A new group shall then be initiated by the receipt of another TIS traffic data uplink “first” segment message. TIS traffic data uplink messages of type “intermediate” or “final” shall be ignored if a new group has not been initiated by receipt of a “first” segment.

A.3.2.2.4 TIS ESTABLISHMENT/DISCONNECTION PROTOCOLS

The processing required to establish/disconnect TIS with Mode S ground interrogators when coverage boundaries are crossed shall be based upon information contained in the capability registers within the aircraft’s Mode S transponder as well as two specific TIS uplink messages.

A.3.2.2.4.1 Mode S capability report

Transponder register 10_{16} within the Mode S transponder shall contain bits that indicate the capability level of the aircraft with respect to Mode S functions. This register shall be read by each Mode S ground interrogator that acquires the aircraft. Bit 25 of this register shall be set to “ONE” if the aircraft carries any MSP data link services (i.e. TIS).

Note.— This bit merely indicates the presence of MSP data link services on board the aircraft — it does NOT indicate whether any of these services are in use by the aircrew at a given time.

A.3.2.2.4.2 MSP capability report

Transponder registers $1D_{16}$ to $1F_{16}$ within the Mode S transponder contain bits which indicate the dynamic state of certain MSP data services on board the aircraft (where defined in applications, e.g. TIS). These registers shall be read by each Mode S ground interrogator that acquires the aircraft if the Mode S capability report indicates that the aircraft carries MSP data link services. Bit 2 of the MSP capability report register $1D_{16}$ shall be set to “ONE” if TIS support is desired; otherwise, the bit shall be set to “ZERO”. Setting and resetting this bit shall be done in conjunction with the generation of TIS “service connect requests” (TSCR) and “service disconnect requests” (TSDR) downlink messages as specified in section §A.4.3.2 for downlink broadcast identifier 02_{16}.

A.3.2.2.4.3 Keep-alive timer

In the absence of TIS traffic data messages, TIS keep-alive messages shall be uplinked by the Mode S ground interrogator. The TIS airborne processor shall keep a timer that measures the time interval between TIS uplink messages received. The timer shall be reset each time a TIS uplink message is received. If this “keep-alive” timer reaches 60 seconds (the “keep-alive” time parameter for TIS), the TIS ground-to-air service shall be declared to have failed and TIS support is no longer available from the Mode S ground interrogator.

Note.— The data link service processing for TIS must receive periodic uplink messages from the Mode S ground interrogator in order to ensure that the ground-to-air link is maintained and that the ground TIS support is continuing.

A.3.2.2.4.4 TIS principal interrogator code protocol

Note.— Each TIS uplink message is accompanied by a 4-bit interrogator identifier (II) code or a 6-bit surveillance identifier (SI) code (contained in the SD field) that identifies which Mode S ground interrogator (or interrogator cluster) generated it.

The II or SI code shall be used to generate a 7-bit ILAB code. If the Mode S ground interrogator is identified via a 4-bit II code, then the high-order three bits of the ILAB shall be cleared to zero and the II code shall be contained in the low-order 4 bits of the ILAB. Otherwise, if the Mode S ground interrogator is identified via a 6-bit SI code, then the high-order bit of the ILAB shall be set to one and the SI code shall be contained in the low-order 6 bits of the ILAB. At any given moment, only one Mode S ground interrogator shall be declared as the “principal interrogator” (PI). In areas having overlapping Mode S coverage by interrogators with different ILAB codes, an “alternate interrogator” (AI) shall also be declared. The TIS protocol for handling ILAB codes shall be as defined below.

A.3.2.2.4.5 TIS display generation

If TIS messages are received from more than one interrogator at a time, only those TIS messages from the interrogator currently declared as the PI shall be displayed to the pilot. TIS messages from interrogators other than the PI shall be discarded, except for the AI processing described below.

A.3.2.2.4.6 Alternate interrogator (AI) identification

The ILAB code of the most recently received TIS message not from the PI shall be retained as the AI. In the case that no TIS messages have been received from interrogators other than the PI (as described below), no current AI shall be defined. The AI definition shall be initialized to the “none state” when TIS is enabled (TSCR) or disabled (TSDR) by the pilot.

A.3.2.2.4.7 Principal interrogator (PI) identification

The ILAB code of the first Mode S ground interrogator to respond to the TSCR downlink message with a TIS uplink message becomes the PI. The PI shall be retained until either:

a) the PI sends a TIS "goodbye" uplink message; or

b) there is a TIS "keep-alive" time-out on the PI.

In either case, the AI (if one is present) shall be promoted to PI and its TIS messages shall now be displayed. A new AI shall now be identified. If there was no available AI, no PI is now available and the airborne TIS processor shall be in the "no TIS supported" state. This state shall continue until a TIS message (either traffic or keep-alive) is received from a Mode S ground interrogator. When such an uplink message is received, the ILAB code associated with the message shall become the PI and the airborne processing shall resume the display of TIS. The PI definition shall be initialized to the "none" state when TIS is enabled (TSCR) or disabled (TSDR) by the pilot.

A.3.2.3 UPLINK MSP CHANNEL 3

(Reserved for ground-to-air alert)

The description of this channel has not yet been developed.

A.3.2.4 UPLINK MSP CHANNEL 4

(Reserved for ground-derived position)

The description of this channel has not yet been developed.

A.3.2.5 UPLINK MSP CHANNEL 5: ACAS SENSITIVITY LEVEL CONTROL

The description of this channel has not yet been developed.

A.3.2.6 UPLINK MSP CHANNEL 6: DATAFLASH

A.3.2.6.1 PURPOSE

This service shall provide a means of requesting access to services supported by the aircraft. When implemented, bit 6 of the register accessed by BDS code 1,D shall be set to a 1.

A.3.2.6.2 FORMAT

The request shall be transferred in an uplink MSP packet with the channel number set to 6 and, in the case of a long form MSP packet, with SP set to "ZERO". The first byte of the user data field shall contain a service request (SR) header. The contents and format of the service request are specified by the application.

A.3.2.6.3 SR HEADER ASSIGNMENTS

Decimal value of SR	
0	Unassigned
1	Dataflash
2	Local system management
3 to 255	Unassigned

A.3.2.6.3.1 Dataflash

A.3.2.6.3.1.1 Dataflash request format

The format of the user data field shall be as specified in Table A-3-1. The user data field of the requesting MSP packet shall contain the decimal value of “ONE” in the first byte (SR header), followed by one or more requests for dataflash services. Each request shall contain a 2-byte dataflash request header (DH), followed by a 1-byte field to define the minimum time interval permitted between reports (MT field), a 4-bit field to determine the event criterion (EC field), a 4-bit field to determine stable time (ST field), and if indicated in EC, a change quanta field (CQ) and a change threshold (CT) field. The 4-bit ST field shall indicate the decimal value in seconds and how long the changed data has been stable before a message shall be initiated. All zeros in the dataflash header (DH) shall indicate that there are no more dataflash requests in the packet. When an MSP packet is completely filled with dataflash requests, or when there is not sufficient room in the packet for another dataflash request header, it shall be assumed that the dataflash request sequence is complete.

A.3.2.6.3.1.1.1 All aircraft dataflash equipment and installations shall support 16 dataflash contracts. Aircraft equipment and installations originally certified after 1 January 2001 shall support 64 dataflash contracts.

Note 1.— A single dataflash contract relates to a single contract number (see §A.3.2.6.3.1.2.1) for a single register for a particular II code. Therefore, dataflash services, with different DH values for each II code, can be established simultaneously with the same aircraft. These may be modified or discontinued independently of each other.

A.3.2.6.3.1.1.2 **Recommendation. —** *When a request has been accepted by the aircraft system, a dataflash response should be triggered immediately regardless of thresholds or event criteria. If no response is received in 30 seconds then a check should be made that the aircraft is still available on roll call and, if so, a new request should be generated. In order to avoid repeated dataflash requests that produce no response, the number of such requests (N) should be limited (N=3).*

A.3.2.6.3.1.1.3 When a new contract request is received for a contract already in existence, the old contract shall be discontinued and replaced immediately by the latest one.

A.3.2.6.3.1.2 Dataflash header (DH) 16 bits

The 16-bit DH field is divided into four subfields separated by 3 reserved bits (14 through 16) see Table A-3-1.

A.3.2.6.3.1.2.1 *Contract number subfield (CNS) 4 bits (Bits 9 to 12 of the uplink MSP 6 user data field when SR = 1)*

This subfield shall be interpreted as a contract number permitting 16 different contracts to be associated with the register specified by the BDS1 and BDS2 codes of this contract request. Contract numbers available are 0 to 15 and shall be associated with the II code of the contract request.

A.3.2.6.3.1.2.2 *Request data subfield (RDS) 1 bit (Bit 13 of the uplink MSP 6 user data field when SR = 1)*

This subfield shall indicate whether or not the contents of the register being monitored by the requested contract must be sent in the MSP packets on downlink channel 3 that are sent each time the criterion for the contract is met. The subfield shall be interpreted as follows:

RDS = 0 Send only bits 1 to 40 of the user data field on downlink MSP 3 when the contract criterion is met.

RDS = 1 Send bits 1 to 96 of the user data field on downlink MSP 3 when the contract criterion is met.

Note.— RDS only indicates the length of the user data field in downlink MSP 3 when responding with a value zero in the CI field (see §A.3.3.3.4.3.1).

A.3.2.6.3.1.2.3 *BDS1 and BDS2 codes 8 bits (Bits 17 to 24 of the uplink MSP6 user data field)*

BDS1 and BDS2 codes of the register for which the contract is required shall be as specified in Annex 10, Volume IV.

A.3.2.6.3.1.3 Minimum time (MT) 8 bits

The decimal value of the 8-bit MT field shall represent the minimum time in seconds that shall elapse after a report has been event-triggered and sent to the transponder, before a new report can be initiated. The report sent to the transponder shall always be the most current data available.

A.3.2.6.3.1.4 Event initiation

Event initiation shall be controlled by the two following fields.

A.3.2.6.3.1.4.1 *Event criterion subfield (EC) 4 bits*

The EC field shall be the four most significant bits following the MT field. If multiple events occur within a single register being monitored by a dataflash contract, (e.g. if more than one parameter shows a significant change) only one message shall be triggered. The decimal value of the EC field shall be interpreted as follows:

EC field value	*Meaning*
0	No report required, discontinue service for the contract specified in the DH field.
1	Report any change.
2	56-bit change field (CQ) follows ST. Only report changes to bits indicated by a “ONE” in CQ.
3	56-bit field CQ follows ST. For each parameter report all status changes and all changes of the parameter greater than the quantum value indicated in the same units and resolution of the field in CQ corresponding to that parameter. A zero in the field in CQ corresponding to the parameter indicates that no reports are required.
4	112 bits of CQ plus CT follow ST. The first 56 bits are as for the EC value 3 above. The second 56 bits are the CT field indicating a threshold value in the field corresponding to the parameter. Report all changes above the threshold where the value in CQ gives the change quantum.
5	112 bits of CQ plus CT follow ST. Same as for the EC value 4 above except: report all changes below the threshold.
6	112 bits of CQ plus CT follows ST. Same as for EC values 4 and 5 above except: report only when the threshold is crossed (in either direction).
7 to 14	Not assigned
15	Cancel all contracts for the II code in this request.

A.3.2.6.3.1.4.2 *Stable time field (ST) 4 bits*

The ST field shall be the 4 bits following the EC field. The decimal value of ST shall indicate in seconds how long the changed data have been stable, to within the change quanta specified in the CQ field, before a message shall be initiated. A value of “ZERO” in this subfield shall indicate that there is no minimum stable time and any change immediately initiates a message. The significance of the ST shall be dependent on which EC mode is being used. For EC Modes 4 and 5, regarding stability whilst above/below a threshold, if a parameter value remains above/below the defined threshold for greater than the ST time then a dataflash message shall be generated even if the value does not remain stable to within one quantum. Subsequent quantum changes which are stable for greater than the ST time shall generate further dataflash messages until the value falls below/rises above the threshold.

A.3.2.6.3.1.5 Change fields — change quanta (CQ) and change threshold (CT)

These fields shall be present when indicated in EC. For a transponder register service (i.e. for BDS1 and BDS2 from 1 to 255 inclusive), CQ shall be contained in bits 41 to 96 of the MSP 6 user data field. CT, when required, shall be contained in bits 97 to 152 of the MSP 6 user data field. The quantum value in the CQ field shall be indicated in the same units and resolution as those specified for the register being monitored. It shall specify the amount by which the parameter must change, from its value at the initialization of the contract, and thereafter from the value last reported by a dataflash response, in order to trigger a new dataflash response on downlink MSP channel 3 (see Table A-3-1).

A.3.2.6.3.2 Local system management

The purpose of the local system management is to provide a particular ground-air service request that can be defined locally to meet particular requirements (such as for ground station “remote setting” of parameters at the far-field monitor).

A.3.2.7 UPLINK MSP CHANNEL 7

(Reserved for response to air-to-ground service request)

The description of this channel has not yet been developed.

A.3.2.8 UPLINK MSP CHANNEL 8

(Reserved for trajectory negotiation)

The description of this channel has not yet been developed.

A.3.2.9 UPLINK MSP CHANNELS 9 TO 63

These channels have not been assigned.

A.3.3 DOWNLINK MSP CHANNELS

The following sections are numbered A.3.3.X, where “X” is the decimal number equivalent to the downlink MSP channel number. This is done to allow definitions of the hitherto undefined formats to be inserted without affecting paragraph numbers.

A.3.3.1 DOWNLINK MSP CHANNEL 1

(Reserved for specific services management)

The description of this channel has not yet been developed.

A.3.3.2 DOWNLINK MSP CHANNEL 2

This channel has not been assigned.

A.3.3.3 DOWNLINK MSP CHANNEL 3

A.3.3.3.1 PURPOSE

Dataflash is a service which announces the availability of information from air-to-ground on an event-triggered basis. When implemented, bit 31 of the register accessed by BDS code 1,D shall be set to a 1.

Note.— This is an efficient means of downlinking information which changes occasionally and unpredictably.

A.3.3.3.2 SERVICE INITIATION AND TERMINATION

A.3.3.3.2.1 The dataflash service shall be initiated or discontinued by a service request and is received on uplink MSP channel 6 with a decimal value of ONE in the service request (SR) header, which is contained in the first byte of the user data field. This indicates that the rest of the user data field shall contain a dataflash request. On the receipt of such a request, a dataflash message from the register concerned with the request shall immediately be made available and announced to the ground regardless of the setting of the RDS field in the contract request and of any event criteria. The response shall be as follows.

A.3.3.3.2.2 When the requested register is being serviced, the contract shall be established and an MSP packet as specified in Table A-3-2 shall be announced to the ground on MSP channel 3. The CI field must be set to a value of 1. The message shall be used by the ground system to confirm that the service has been initiated.

A.3.3.3.2.3 If the requested register is not being serviced, the contract shall not be established. This shall be indicated by announcing the MSP packet on downlink MSP channel 3 to the ground containing only bits 1 to 40 as specified in Table A-3-2, and with a value of 2 in the CI field.

A.3.3.3.2.4 If the maximum number of contracts that can be supported is already established, then the new contract shall be refused. This shall be indicated by announcing to the ground an MSP packet on downlink channel 3, as specified in Table A-3-2, and with a value of 3 in the CI field.

A.3.3.3.2.5 In the case of a request from the ground to terminate the service for a particular register, the termination of the service shall be confirmed by announcing to the ground an MSP packet on downlink channel 3, as shown in Table A-3-2, and with a value of 4 in the CI field.

A.3.3.3.2.6 In the case of a request from the ground to terminate the service for all contracts to a particular II code, the termination of the service shall be confirmed by announcing to the ground an MSP packet on downlink channel 3, as shown in Table A-3-2, and with a value of 5 in the CI field.

A.3.3.3.2.7 When the transponder register service fails for an established contract, the contract shall be terminated by the airborne application. This will be indicated by announcing to the ground an MSP packet on the downlink channel 3, as shown in Table A-3-2, and with a value of 7 in the CI field. Transponder register service shall be deemed to have failed when any of the parameters specified to be monitored in the negotiation of the contract are not being updated at the specified minimum rate.

A.3.3.3.2.8 When a contract is refused due to an invalid value of the EC field in the contract request, this shall be indicated by announcing to the ground an MSP packet on downlink channel 3, as shown in Table A-3-2, and with a value of 15 in the CI field.

A.3.3.3.2.9 If any message is not extracted from the transponder by a ground interrogator within 30 seconds, the aircraft subnetwork shall cancel the message and generate a delivery failure notice (i.e. the T_Z timer expires), which shall be delivered to the aircraft MSP service provider. When a delivery failure notice is received the service shall be automatically terminated by the dataflash function with no indication to the ground system.

Note.— This is to prevent the transponder message queues being blocked when the ground interrogator stops supplying the message extraction service, either due to a fault or loss of cover. It is the responsibility of the ground application to monitor the dataflash service taking this into account.

A.3.3.3.2.10 When the transponder has not been selectively interrogated by a Mode S interrogator with a particular II code for 60 seconds (determined by monitoring the IIS subfield in all accepted Mode S interrogations), all dataflash contracts related to that II code shall be cancelled with no indication to the ground system.

A.3.3.3.3 SERVICE PROVISION

On the receipt of a dataflash request, the requested parameters shall be monitored and transferred to the ground using the Mode S air-initiated protocols directed to the II code that was contained in the requesting interrogation. In order to prevent the flooding of the transponder with dataflash messages, an upper limit of ten messages in a six-second period shall be imposed. When the limit of ten messages within a six-second period is reached, further messages shall be queued until they can be sent. Messages queued in this way shall respond with a CI field value of 6. If, after initiating a dataflash message to the ground, the change criterion is met again prior to the message being entered into the transponder for announcement, the message is considered stale and shall be replaced by the most up-to-date information.

A.3.3.3.4 DOWNLINK MESSAGE STRUCTURE

The information shall be transferred in a downlink MSP packet with the channel number M/CH = 3. The format is shown in Table A-3-2. The first two bytes of the user data (UD) field shall contain a dataflash header (DH) which shall be identical to the DH field that was contained in the request for service.

A.3.3.3.4.1 Bits 17 to 31 of UD form the II code contract report (CR) field in which each bit shall indicate that at least one contract is active with the II code, which the bit represents when it is set to a ONE; otherwise, there are no active contracts with that II code.

A.3.3.3.4.2 Bits 32 to 36 of UD are not assigned.

A.3.3.3.4.3 Bits 37 to 40 of UD form the contract information (CI) field which shall be interpreted as follows:

CI field value	*Meaning*
0	Response to existing contract
1	New contract established

CI field value	*Meaning*
2	New contract not accepted, or existing contract terminated, due to no transponder register data service
3	New contract not accepted due to maximum number of contracts already being serviced
4	Contract terminated for the DH in this response due to a request from the ground
5	All contracts terminated for the II code that delivered the MSP packet having an EC value of 15 that requested this response
6	Response has been queued due to the limit of six dataflash messages in a ten second period
7	Contract terminated due to failure of the register data service
8 to 14	Unassigned
15	New contract not accepted due to invalid number in EC field of requested uplink MSP packet

A.3.3.3.4.3.1 When the CI field is equal to ZERO, the response shall be as requested by the RDS field in the dataflash header of the contract (see §A.3.2.6.3.1.2.2). When the CI field is not equal to ZERO, the response shall only contain bits 1 to 40 of the user data field on downlink MSP 3 (see Table A-3-2).

A.3.3.3.5 DATA EXTRACTION BY MODE S GROUND STATIONS

The dataflash transaction shall be announced as a downlink frame in response to interrogations UF 4, 5, 20, or 21. The transaction announced shall be either a single segment Comm-B frame or a two segment Comm-B frame, as requested by the contract negotiations. The air-directed Comm-B first segment shall contain the MSP header, dataflash header, and control information for that particular contract. In the case of a contract for a single segment response, if the data is required, it is acquired directly by the ground station extracting the register in question.

A.3.3.4 DOWNLINK MSP CHANNEL 4

(Reserved for position request)

The description of this channel has not yet been developed.

A.3.3.5 DOWNLINK MSP CHANNEL 5

This channel has not been assigned.

A.3.3.6 DOWNLINK MSP CHANNEL 6

(Reserved for response to ground-to-air service request.) (See Table A-3-3.)

The first byte of the user data (UD) field in the downlink MSP channel 6 shall be used to define a response type (RT) field as follows:

RT = 0 Unassigned

RT = 1 (Reserved)

RT = 2 Local system management

RT = 3 to 255 Unassigned

When implemented, bit 34 of register $1D_{16}$ is set to a 1.

Note.— The response to a ground-air service request can be used to transfer information resulting from such a service.

A.3.3.7 DOWNLINK MSP CHANNEL 7

(Reserved for air-to-ground request)

The description of this channel has not yet been developed.

A.3.3.8 DOWNLINK MSP CHANNEL 8

(Reserved for trajectory negotiation)

The description of this channel has not yet been developed.

A.3.3.9 DOWNLINK MSP CHANNELS 9 TO 63

These channels have not been assigned.

TABLES FOR SECTION A.3

Table A-3-1. Request for dataflash monitoring service

Mode S SLM frame containing uplink MSP packet on channel 6 when SR = 1

MSP 6 USER DATA FIELD

Bits 1 to 40

	DP = 0 (1 BIT)	MSB
	MP = 0 (1 BIT)	
	MSB	
		UPLINK MSP
	M/CH = 6 (6 BITS)	HEADER
		(1 BYTE)
	LSB	LSB
1	MSB	
2		
3		
4	SERVICE REQUEST (SR) = 1	
5		
6		
7		
8	LSB	
9	MSB CONTRACT	MSB
10	NUMBER	
11	SUBFIELD	
12	LSB (CNS)	
13	REQUEST DATA (RDS)	
14		
15	RESERVED	DATAFLASH
16		HEADER
17	MSB	
18	BDS1	
19	CODE	
20	LSB	
21	MSB	
22	BDS2	
23	CODE	
24	LSB	LSB
25	MSB	
26		
27	MINIMUM	
28	TIME (MT)	
29	INTERVAL	
30		
31		
32	LSB = 1 second	
33	MSB	
34	EVENT	
35	CRITERION (EC)	
36	LSB	
37	MSB	
38	STABLE TIME (ST)	
39		
40		

The last byte of the final MA field shall always be unassigned

Bits 41 — 96 (if required)

41	MSB
42	
43	
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	
57	
58	
59	
60	CHANGE
61	QUANTA
62	FIELD (CQ)
63	
64	
65	
66	
67	
68	
69	
70	
71	
72	
73	
74	
75	
76	
77	
78	
79	
80	
81	
82	
83	
84	
85	
86	
87	
88	
89	
90	
91	
92	
93	
94	
95	
96	LSB

Bits 97-152 (if required)

97	MSB
98	
99	
100	
101	
102	
103	
104	
105	
106	
107	
108	
109	
110	
111	
112	
113	
114	
115	
116	CHANGE
117	THRESHOLD
118	FIELD (CT)
119	
120	
121	
122	
123	
124	
125	
126	
127	
128	
129	
130	
131	
132	
133	
134	
135	
136	
137	
138	
139	
140	
141	
142	
143	
144	
145	
146	
147	
148	
149	
150	
151	
152	LSB

Table A-3-2. Dataflash for register monitoring service

Mode S frame containing downlink MSP packet on Channel 3

MSP 3 USER DATA FIELD

Bits 1 to 40			Bits 41 to 96	
	MSB LINKED COMM B SUBFIELD (LBS) (2 BITS)		41	MSB
	LSB		42	
	DP = 1 (1 BIT)	MSB	43	
	MP = 0 (1 BIT)		44	
	MSB		45	
			46	
	M/CH = 3 (6 BITS)		47	
		MSP	48	
		HEADER	49	
	LSB		50	
	MSB		51	
			52	
	FILL 1 = 0 (6 BITS)		53	
			54	
			55	
	LSB	LSB	56	
1	MSB CONTRACT	MSB	57	
2	NUMBER		58	
3	SUBFIELD		59	
4	LSB (CNS)		60	
5	REQUEST DATA SUBFIELD (RDS)		61	
6			62	
7	RESERVED		63	
8		DATAFLASH	64	REGISTER
9	MSB	HEADER (DH)	65	MESSAGE
10	BDS1		66	CONTENT
11	CODE		67	
12	LSB		68	
13	MSB		69	
14	BDS2		70	
15	CODE		71	
16	LSB	LSB	72	
17	II=1		73	
18	II=2		74	
19	II=3		75	
20	II=4		76	
21	II=5		77	
22	II=6		78	
23	II= 7 II CODE		79	
24	II= 8 CONTRACT		80	
25	II= 9 REPORT (CR)		81	
26	II=10		82	
27	II=11		83	
28	II=12		84	
29	II=13		85	
30	II=14		86	
31	II=15		87	
32			88	
33			89	
34	NOT ASSIGNED		90	
35			91	
36			92	
37	MSB		93	
38	CONTRACT		94	
39	INFORMATION (CI)		95	
40	LSB		96	LSB

Note.— See Annex 10, Volume III, Part I, §5.2.7.3 for specification of MSP Packets

Table A-3-3 Response to ground-to-air service request

Mode S frame containing downlink MSP packet on channel 6

MSP 6 USER DATA FIELD

Bits 1 to 40			Bits 41 to 96		
	MSB LINKED COMM B SUB FIELD (LBS)		41	MSB	
	LSB (2 BITS)		42		This packet shall always be sent as a linked Comm-B. The second segment being a direct copy of the relevant register.
	DP = 0 (1 BIT)	MSB	43		
	MP = 0 (1 BIT)		44		
	MSB		45		
			46		
	M/CH = 6 (6 BITS)		47		
			48		
		MSP	49		
	LSB	HEADER	50		
	MSB		51		
			52		
	FILL 1 = 0 (6 BITS)		53		
			54		
			55		
	LSB	LSB	56		
1	MSB		57		
2			58		
3			59	REGISTER	
4			60	MESSAGE	
5			61	CONTENT	
6			62		
7			63		
8	RESPONSE		64		
9	TYPE		65		
10			66		
11			67		
12			68		
13			69		
14			70		
15			71		
16	LSB		72		
17			73		
18			74		
19			75		
20			76		
21			77		
22			78		
23			79		
24			80		
25			81		
26			82		
27			83		
28			84		
29	USER		85		
30	DEFINED		86		
31			87		
32			88		
33			89		
34			90		
35			91		
36			92		
37			93		
38			94		
39			95		
40			96	LSB	

A.4. MODE S BROADCAST PROTOCOLS

A.4.1 BROADCAST CHANNEL NUMBER ALLOCATIONS

The broadcast identifiers shall be represented as a two-digit hexadecimal number, e.g. "XX_{16}".

Note.— There are 255 broadcast identifiers available on both the uplink and downlink. Broadcast identifier numbers have been assigned for some applications (see Annex 10, Volume III, Part 1, Chapter 5, Table 5-23).

The data formats for the data link capability report and for aircraft identification together with the assignment of the broadcast identifiers shall be as defined in this document and Annex 10, Volumes III and IV, respectively.

A.4.2 UPLINK BROADCAST IDENTIFIERS

The following sections are numbered A.4.2.X, where "X" is the decimal equivalent of the uplink broadcast identifier number. This is done to allow definitions of the hitherto undefined formats to be inserted without affecting the paragraph numbering.

A.4.2.1 UPLINK BROADCAST IDENTIFIER 01_{16}

(Reserved for differential GNSS correction)

The description of this identifier has not yet been developed.

A.4.2.2 TO A.4.2.47 UPLINK BROADCAST IDENTIFIERS 02_{16} TO $2F_{16}$

These identifiers have not been assigned.

A.4.2.48 UPLINK BROADCAST IDENTIFIER 30_{16}

(Not valid)

A.4.2.49 UPLINK BROADCAST IDENTIFIERS 31_{16}

(Reserved for RA broadcast (see Annex 10, Volume IV, §4.3.8.4.2.3.4)).

A.4.2.50 UPLINK BROADCAST IDENTIFIERS 32_{16}

(Reserved for ACAS (see Annex 10, Volume IV, §4.3.8.4.2.3.3)).

A.4.2.51 TO A.4.2.255 UPLINK BROADCAST IDENTIFIERS 33_{16} TO FF_{16}

These identifiers have not been assigned.

A.4.3 DOWNLINK BROADCAST IDENTIFIER

The following sections are numbered A.4.3.X, where "X" is the decimal equivalent of the downlink broadcast identifier number. This is done to allow definitions of the hitherto undefined formats to be inserted without affecting the paragraph numbering.

A.4.3.1 DOWNLINK BROADCAST IDENTIFIER 01_{16}

This identifier has not been assigned.

A.4.3.2 DOWNLINK BROADCAST IDENTIFIER 02_{16} : TRAFFIC INFORMATION SERVICE

A.4.3.2.1 INTRODUCTION

The traffic information service shall be provided by uplinking information on proximate aircraft that may be of interest to own-aircraft by a Mode S interrogator on uplink MSP channel 2.

Note.— The service and uplink messages are specified in §A.3.2.2 under "Uplink MSP Channel 2".

It shall be possible for the aircraft to request to be either connected to or disconnected from the TIS service. These requests shall be made using the Mode S broadcast protocol using broadcast identifier 02_{16}. These requests shall be the only downlink messages used by the TIS.

A.4.3.2.2 TIS DOWNLINK MESSAGES

The TIS airborne data link service shall be able to generate two types of Mode S downlink messages:

a) TIS service connect request (TSCR); and

b) TIS service disconnect request (TSDR).

Both the TSCR and the TSDR shall be sent as Comm-B broadcast messages using the broadcast identifier 02_{16}.

Note.— The use of the Mode S Comm-B broadcast protocol deals with the case of multiple Mode S interrogators with overlapping coverage, which are in contact with a given TIS aircraft at the same time.

The format of a TIS downlink message (either TSCR or TSDR) shall be as specified below:

Header	DIN 1	DIN 2	DIN 3	DIN 4	DIN 5	DIN 6
8 bits	8 bits	8 bits	8 bits	8 bits	8 bits	8 bits

The message header shall be the standard message header for TIS described in uplink MSP channel 2 (see §A.3.2.2). The 8-bit data link service identifier numbers (DIN) shall be read and processed sequentially from the TCSR or TSDR message until either:

a) DIN i = 0; or

b) all bits of the downlink message have been processed.

Note 1.— This structure and protocol for MSP downlink service requests allow for future expansion and use by other MSP data link services.

Note 2.— The principal and alternate TIS II codes in the TIS process (see §A.3.2.2) are set to the "none" state when either a TSCR or TSDR is generated.

A.4.3.2.2.1 TCSR format

This TIS Comm-B downlink message shall be generated when the pilot requests the initiation of TIS service. The TSCR message shall be generated at the same time as the MSP capability report bit for TIS is set to "ONE". A TSCR shall be identified by a DIN value of 1. The TSCR shall be defined as a Comm-B broadcast message so that any Mode S ground interrogator capable of supporting TIS can respond to it.

A.4.3.2.2.2 TSDR format

This TIS Comm-B broadcast downlink message shall be generated when the pilot requests termination of TIS service. The TSDR message shall be generated at the same time as the MSP capability report bit for TIS is set to "ZERO". A TSDR shall be identified by a DIN value of 2. The TSDR shall be defined as a Comm-B broadcast message so that any Mode S interrogator supporting TIS can respond to it.

A.4.3.3 TO A.4.3.15 DOWNLINK BROADCAST IDENTIFIERS 03_{16} TO $0F_{16}$

These identifiers have not been assigned.

A.4.3.16 DOWNLINK BROADCAST IDENTIFIER 10_{16} : DATA LINK CAPABILITY REPORT

See Table A-2-16.

A.4.3.17 TO A.4.3.31 DOWNLINK BROADCAST IDENTIFIERS 11_{16} TO $1F_{16}$

These identifiers have not been assigned.

A.4.3.32 DOWNLINK BROADCAST IDENTIFIER 20_{16} : AIRCRAFT IDENTIFICATION

See Table A-2-32.

A.4.3.33 TO A.4.3.253 DOWNLINK BROADCAST IDENTIFIERS 21_{16} TO FD_{16}

These identifiers have not been assigned.

A.4.3.254 DOWNLINK BROADCAST IDENTIFIER FE_{16}

(Reserved for update request)

See Annex 10, Volume III, Part I, Chapter 5.

A.4.3.255 DOWNLINK BROADCAST IDENTIFIER FF_{16}

(Reserved for search request)

See Annex 10, Volume III, Part I, Chapter 5.

Appendix B

PROVISIONS FOR EXTENDED SQUITTER VERSION 1

B.1. INTRODUCTION

B.1.1 Appendix B defines data formats and protocols that shall be used for implementations of extended squitter Version 1.

Note 1.— Appendix B is arranged in the following manner:

Section B.1 Introduction

Section B.2 Data formats for transponder registers

Section B.3 Traffic information service — broadcast (TIS-B) formats and coding

Section B.4 ADS-B Rebroadcast (ADS-R) formats and coding

Note 2.— Implementation guidelines on possible data sources, the use of control parameters, and the protocols involved is given in Appendix C.

B.2. DATA FORMATS FOR TRANSPONDER REGISTERS

B.2.1 REGISTER ALLOCATION

The register allocation shall be as specified in §A.2.1, except that the name of register 61_{16} is changed to aircraft status.

B.2.2 GENERAL CONVENTIONS ON DATA FORMATS

General conventions on data formats shall be as specified in §A.2.2.

B.2.3 EXTENDED SQUITTER FORMATS

This section defines the formats and coding that shall be used for extended squitter ADS-B messages. When the extended squitter capability is implemented as an extended squitter/non-transponder device (ES/NT, Annex 10, Volume IV, §3.1.2.8.7), the convention for register numbering shall not be required. However, the data content and the transmit times for any ES/NT device shall be the same as specified for the transponder case.

B.2.3.1 FORMAT TYPE CODES

The first 5-bit ("ME" bits 1–5, Message bits 33–37) field in every Mode S extended squitter message shall contain the format TYPE. The format TYPE shall differentiate the messages into several classes: Airborne Position, Airborne Velocity, Surface Position, Identification, Aircraft Intent, Aircraft State, etc. In addition, the format TYPE shall also encode the Navigation Integrity Category (NIC) of the source used for the position report. The format TYPE shall also differentiate the Airborne Messages as to the TYPE of their altitude measurements: barometric pressure-altitude or GNSS height (HAE). The 5-bit encoding for format TYPE shall conform to the definition contained in the following table:

TYPE code	*Subtype code*	*NIC supplement*	*Format (message type)*	*Horizontal containment radius limit (R_C)*	*Navigation integrity category (NIC)*	*Altitude type*	*Notes*
0	Not present	Not applicable	No position information(airborne or surface position)	R_C unknown	NIC = 0	Barometric altitude *or* no altitude information	1, 2, 3
1	Not present	Not applicable	Aircraft identification and category(§B.2.3.4)	Not applicable	Not applicable	Not applicable	Category set D
2							Category set C
3							Category set B
4							Category set A
5	Not present	0	Surface position(§B.2.3.3)	R_C < 7.5 m	NIC = 11	No altitude information	
6		0		R_C < 25 m	NIC = 10		
7		1		R_C < 75 m	NIC = 9		6
		0		R_C < 0.1 NM (185.2 m)	NIC = 8		
8		0		R_C ≥ 0.1 NM (185.2 m) or unknown	NIC = 0		
9	Not present	0	Airborne position (§B.2.3.2)	R_C < 7.5 m *and* VPL < 11 m	NIC = 11	Barometric altitude	5
10		0		R_C < 25 m *and* VPL < 37.5 m	NIC = 10		5
11		1		R_C < 75 m and VPL < 112 m	NIC = 9		5, 6
		0		R_C < 0.1 NM (185.2 m)	NIC = 8		
12		0		R_C < 0.2 NM (370.4 m)	NIC = 7		
13		1		R_C < 0.6 NM (1111.2 m)	NIC = 6		
		0		R_C < 0.5 NM (926 m)			
14		0		R_C < 1.0 NM (1852 m)	NIC = 5		
15		0		R_C < 2 NM (3.704 km)	NIC = 4		
16		1		R_C < 4 NM (7.408 km)	NIC = 3		7
		0		R_C < 8 NM (14.816 km)	NIC = 2		
17		0		R_C < 20 NM (37.04 km)	NIC = 1		
18		0		R_C ≥ 20 NM (37.04 km) or unknown	NIC = 0		
19	0	Not applicable	Reserved	Not applicable	Not applicable	Difference between "barometric altitude" and "GNSS height (HAE)"	
	1 — 4		Airborne velocity (§B.2.3.5)				
	5 — 7		Reserved				
20	Not present	0	Airborne position(§B.2.3.2)	R_C < 7.5 m *and* VPL < 11 m	NIC = 11	GNSS height (HAE)	2, 5
21		0		R_C < 25 m *and* VPL < 37.5 m	NIC = 10		2, 5
22		0		R_C ≥ 25 m *or* VPL ≥ 37.5 m *or* R_C *or* VPL are unknown	NIC = 0		2
23	0	Not applicable	Test message				
	1 — 6		Reserved				
	7		Allocated for national use				
24			Reserved for surface system status				
25 26			Reserved				
27			Reserved for trajectory change				
28	0		Reserved				
	1		Emergency/priority status (§B.2.3.8)				
	2		ACAS RA broadcast				
	3 — 7		Reserved				

TYPE code	*Subtype code*	*NIC supplement*	*Format (message type)*	*Horizontal containment radius limit (R_C)*	*Navigation integrity category (NIC)*	*Altitude type*	*Notes*
29	0		Target state and status information (§B.2.3.9)				
	1 — 3		Reserved				
30	0 — 7		Reserved				
31	0 — 1		Aircraft operational status (§B.2.3.10)				
	2 — 7		Reserved				

Note 1.— "Barometric altitude" refers to barometric pressure-altitude, relative to a standard pressure of 1 013.25 hectopascals (29.92 in Hg). It does not refer to barometric corrected altitude.

Note 2.— TYPE Codes 20 to 22 or TYPE Code 0 are to be used when valid "Barometric altitude" is not available.

Note 3.— After initialization, when horizontal position information is not available but altitude information is available, the airborne position message is transmitted with a TYPE Code of ZERO in bits 1-5, the barometric pressure-altitude in bits 9 to 20, and bits 22 to 56 set to ZERO. If neither horizontal position nor barometric altitude information is available, then all 56 bits of Register 05 {HEX} are set to ZERO. The ZERO (binary 00000) TYPE Code field indicates that latitude and longitude information is not available, while the ZERO altitude field indicates that altitude information is not available.

Note 4.— If the position source is an ARINC 743A GNSS receiver, then the ARINC 429 data "label 130" data word from that receiver is a suitable source of information for R_C, the horizontal integrity containment radius. (The label 130 data word is variously called HPL (Horizontal Protection Limit) or HIL (Autonomous Horizontal Integrity Limit) in different documents).

Note 5.— This TYPE Code value implies limits for both R_C (horizontal containment limit) and VPL (Vertical Protection Limit). If either of these limits is not satisfied, then a different value for the TYPE Code is selected.

Note 6.— The "NIC supplement" field in the Aircraft Operational Status Message (see §B.2.3.10) enables the Report Assembly Function in ADS-B Receiving Subsystems to determine whether the ADS-B Transmitting Subsystem is announcing NIC = 8 (R_C < 0.1 NM) or NIC = 9 (R_C < 75 m).

Note 7.— The "NIC supplement" field in the Aircraft Operational Status Message (see §B.2.3.10) enables the Report Assembly Function in ADS-B Receiving Subsystems to determine whether the ADS-B Transmitting Subsystem is announcing NIC = 2 (R_C < 8 NM) or NIC = 3 (R_C < 4 NM).

Note 8.— The term "broadcast" as used in this appendix, refers to a spontaneous transmission by the transponder. This is distinct from the Comm-B broadcast protocol.

B.2.3.1.1 AIRBORNE POSITION MESSAGE TYPE CODE

B.2.3.1.1.1 Airborne position message TYPE Code if containment radius is available

Note.— If the position information comes from a GNSS receiver that conforms to the ARINC 743A Characteristic, a suitable source of information for the containment radius (R_C), is ARINC 429 label 130 from that GNSS receiver.

If R_C (containment radius) information is available from the navigation data source, then the transmitting ADS-B subsystem shall determine the TYPE Code (the value of the TYPE subfield) of airborne position messages as follows.

a) If current valid horizontal position information is not available to the ADS-B Transmitting Subsystem, then the TYPE subfield of Airborne Position Messages shall be set to ZERO (0).

b) If valid horizontal position and barometric pressure-altitude information are both available to the ADS-B Transmitting Subsystem, then the ADS-B Transmitting Subsystem shall set the TYPE subfield of Airborne Position Messages to a value in the range from 9 to 18 in accordance with the table of §B.2.3.1.

c) If valid horizontal position information is available to the ADS-B Transmitting Subsystem, but valid barometric pressure-altitude information is not available, and valid geometric altitude information is available, the ADS-B Transmitting Subsystem shall set the TYPE subfield of Airborne Position Messages to a value in the range from 20 to 22 depending on the containment radius R_C and vertical protection limit VPL in accordance with the table of §B.2.3.1.

d) If valid horizontal position information is available to the ADS-B Transmitting Subsystem, but neither valid barometric altitude information nor valid geometric altitude information is available, the ADS-B Transmitting Subsystem shall set the TYPE subfield in Airborne Position Messages to a value in the range from 9 to 18 depending on the containment radius R_C in accordance with the table of §B.2.3.1. (In that case, the ALTITUDE subfield of the Airborne Position Messages would be set to all ZEROs in order to indicate that valid altitude information is not available.)

B.2.3.1.1.2 Airborne position message TYPE Code if containment radius is not available

If R_C (containment radius) information is NOT available from the navigation data source, then the ADS-B Transmitting Subsystem shall indicate NIC = 0 by selecting a TYPE Code of 0, 18, or 22 in the Airborne Position Messages, as follows:

a) the ADS-B Transmitting Subsystem shall set the TYPE subfield to ZERO (0) if valid horizontal position information is not available; and

b) the ADS-B Transmitting Subsystem shall set the TYPE subfield to 18 if valid pressure-altitude information is available, or if neither valid pressure-altitude nor valid geometric altitude information is available.

If valid pressure-altitude is not available, but valid geometric altitude information is available, the ADS-B Transmitting Subsystem shall set the TYPE subfield to 22.

B.2.3.1.2 SURFACE POSITION MESSAGE TYPE CODE

B.2.3.1.2.1 Surface position message TYPE Code if containment radius is available

If R_C (horizontal containment radius) information is available from the navigation data source, then the ADS-B Transmitting Subsystem shall use R_C to determine the TYPE Code used in the Surface Position Message in accordance with the table of B.2.3.1.

Note.— If the position information comes from a GNSS receiver that conforms to the ARINC 743A characteristic, a suitable source of information for the containment radius (R_C), is ARINC 429 label 130 from that GNSS receiver.

B.2.3.1.2.2 Surface position message TYPE Code if containment radius is not available

If R_C (horizontal containment radius) information is not available from the navigation data source, then the ADS-B Transmitting Subsystem shall indicate NIC = 0 by selecting a TYPE Code of 0 or 8 in the Surface Position Messages, as follows:

a) the ADS-B Transmitting Subsystem shall set the TYPE subfield to ZERO if valid horizontal position information is not available; and

b) the ADS-B Transmitting Subsystem shall set the TYPE subfield to 8 if valid horizontal position information is available. (This TYPE code indicates that containment radius, R_C, is either unknown or greater than or equal to 0.1 NM.)

B.2.3.1.3 TYPE CODE BASED ON HORIZONTAL PROTECTION LEVEL

If valid horizontal position information is available, then the "TYPE" code in the Surface Position Message shall be set in the range from "5" to "8."

a) If R_C (Horizontal Containment Radius) information is available from the navigation data source, the "TYPE" coding shall be selected according to the R_C value, in accordance with the table of §B.2.3.1.

b) If R_C is not available from the navigation data source, then the "TYPE" coding shall be set to 8.

B.2.3.2 AIRBORNE POSITION FORMAT

The airborne position squitter shall be formatted as specified in §A.2.3.2.

B.2.3.3 SURFACE POSITION FORMAT

The surface position squitter shall be formatted as specified in the definition of register number 06_{16} and in the following paragraphs.

B.2.3.3.1 MOVEMENT

The movement field shall be formatted as specified in §A.2.3.3.1.

B.2.3.3.2 HEADING/GROUND TRACK

B.2.3.3.2.1 Heading/ground track status

This 1-bit field shall define the validity of the ground track value. Coding for this field shall be as follows: 0=invalid and 1=valid.

Note.— If a source of A/V heading is not available to the ADS-B transmitting subsystem, but a source of ground track angle is available, then ground track angle may be used instead of heading, provided that the status bit for heading subfield is set to ZERO (0) whenever the ground track angle is not a reliable indication of the A/V's Heading. (The ground track angle is not a reliable indication of the A/V's heading when the A/V's ground speed is low.)

B.2.3.3.2.2 Heading/ground track value

This 7-bit (14-20) field shall define the direction (in degrees clockwise from true or magnetic north) of aircraft motion on the surface. The value shall be encoded as an unsigned angular weighted binary numeral, with an MSB of 180 degrees and an LSB of 360/128 degrees, with zero indicating true north. The data in the field shall be rounded to the nearest multiple of 360/128 degrees.

Note.— The reference direction for heading (whether true north or magnetic north) is indicated in the horizontal reference direction (HRD) field of the aircraft operational status message (see §B.2.3.10.13).

B.2.3.3.3 Compact position reporting (CPR) format (F)

The CPR format field shall be formatted as specified in §A.2.3.3.3.

B.2.3.3.4 Time synchronization (T)

The time synchronization field shall be formatted as specified in §A.2.3.3.4.

B.2.3.3.5 Latitude/longitude

The latitude/longitude field shall be formatted as specified in §A.2.3.3.5.

B.2.3.4 IDENTIFICATION AND CATEGORY FORMAT

The identification and category squitter shall be formatted as specified in §A.2.3.4.

B.2.3.5 AIRBORNE VELOCITY FORMAT

The airborne velocity squitter shall be formatted as specified in the definition of register number 09_{16} and in the following paragraphs.

B.2.3.5.1 Subtypes 1 and 2

Subtypes 1 and 2 shall be used as specified in §A.2.3.5.1.

B.2.3.5.2 Subtypes 3 and 4

Subtypes 3 and 4 shall be used as specified in §A.2.3.5.2.

B.2.3.5.3 Intent change flag in airborne velocity messages

The intent change flag shall be formatted as specified in §A.2.3.5.3.

B.2.3.5.4 IFR capability flag (IFR) in airborne velocity messages

The IFR capability flag shall be formatted as specified in §A.2.3.5.4.

B.2.3.5.5 Navigation accuracy category for velocity (NAC_V)

This 3-bit (ME bits 11-13, Message bits 43-45) subfield shall indicate the navigation accuracy category for velocity (NAC_V).

The ADS-B transmitting subsystem shall accept, via an appropriate data interface, data from which the own-vehicle navigation accuracy category for velocity (NAC_V) may be determined, and it shall use such data to establish the NAC_V subfields in transmitted ADS-B airborne velocity messages.

B.2.3.5.5.1 If the external data source provides 95 per cent accuracy figures of merit for horizontal and vertical velocity [$HFOM_R$ (horizontal figure of merit for velocity) and $VFOM_R$ (vertical figure of merit for velocity)], then the ADS-B transmitting subsystem shall determine the value of the NAC_V field in the airborne velocity messages, subtypes 1, 2, 3 and 4 as specified in the following table.

NAC_V value (Decimal)	*$HFOM_R$ value*		*$VFOM_R$ value*
4	$HFOM_R$ < 0.3 m/s (0.984 fps)	AND	$VFOM_R$ < 0.46 m/s (1.5 fps)
3	$HFOM_R$ < 1 m/s (3.28 fps)	AND	$VFOM_R$ < 1.52 m/s (5.0 fps)
2	$HFOM_R$ < 3 m/s (9.84 fps)	AND	$VFOM_R$ < 4.57 m/s (15.0 fps)
1	$HFOM_R$ < 10 m/s (32.8 fps)	AND	$VFOM_R$ < 15.24 m/s (50 fps)
0	$HFOM_R$ unknown or $HFOM_R$ ≥ 10 m/s (32.8 fps)	OR	$VFOM_R$ unknown or $VFOM_R$ ≥ 15.24 m/s (50 fps)

Note.— The tests in the table are to be applied in the order shown, from the most stringent test (for NAC_V = 4) to the least stringent (for NAC_V = 0). That is, if $HFOM_R$ and $VFOM_R$ do not satisfy the conditions for NAC_V = 4, then they are tested against the conditions for NAC_V = 3. If they do not satisfy the conditions for NAC_V = 3, they are tested against the conditions for NAC_V = 2, and so on.

B.2.3.5.5.2 If the external data source does not provide $HFOM_R$ and $VFOM_R$, the 95 per cent accuracy figures of merit for horizontal and vertical velocity, but it does provide 95 per cent accuracy figures of merit for the horizontal and vertical positions [HFOM, horizontal figure of merit for position, and VFOM, vertical figure of merit for position], then the following tables shall be used to determine the NAC_V value to be inserted in the Airborne Velocity message. The following table shall be used if the position and velocity are obtained from a GNSS/GBAS or GNSS/SBAS receiver (Global Navigation Satellite System with Ground Based Augmentation System or with Satellite Based Augmentation System) when that receiver is operating in GBAS or SBAS mode.

NAC_V value (Decimal)	*HFOM and VFOM values*
4	HFOM ≤ 1 m and VFOM ≤ 5.85 ft
3	(HFOM > 1 m or VFOM > 5.85 ft) and HFOM ≤ 4.5 m, and VFOM ≤ 23.3 ft
2	(HFOM > 4.5 m or VFOM > 23.3 ft) and HFOM ≤ 14.5 m, and VFOM ≤ 73.3 ft
1	(HFOM > 14.5 m or VFOM > 73.3 ft) and HFOM ≤ 49.5 m, and VFOM ≤ 248 ft
0	HFOM > 49.5 m or VFOM > 248 ft

B.2.3.5.5.3 The following table shall be used if the position and velocity are obtained from a GNSS receiver operating in autonomous mode (that is, without GBAS or SBAS differential corrections).

NAC_V value (Decimal)	*HFOM and VFOM values*
2	HFOM ≤ 125 m, and VFOM ≤ 585 ft
0	HFOM > 475 m or VFOM > 2 335 ft
1	(HFOM > 125 m or VFOM > 585 ft) and HFOM ≤ 475 m, and VFOM ≤ 2 335 ft

B.2.3.5.5.4 If the external source of position and velocity data provides neither 95 per cent bounds on the accuracy of the velocity data ($HFOM_R$ and $VFOM_R$) nor 95 per cent bounds on the accuracy of the position data (HFOM and VFOM), then the transmitting ADS-B device shall set the value of the NAC_V field in the Airborne Velocity Messages to zero.

B.2.3.5.6 HEADING IN AIRBORNE VELOCITY MESSAGES

The heading in the airborne velocity message shall be formatted as specified in §A.2.3.5.6.

Note.— The reference direction for heading (whether True North or Magnetic North) is indicated in the Horizontal Reference Direction (HRD) field of the Aircraft Operational Status Message (see §B.2.3.10.13).

B.2.3.5.7 DIFFERENCE FROM BAROMETRIC ALTITUDE IN AIRBORNE VELOCITY MESSAGES

The difference from barometric altitude field shall be formatted as specified in §A.2.3.5.7.

B.2.3.6 STATUS REGISTER FORMAT

The status register shall be formatted as specified in §A.2.3.6.

B.2.3.7 EVENT-DRIVEN PROTOCOL

The event-driven protocol register shall be as specified in §A.2.3.7.

B.2.3.8 AIRCRAFT STATUS

B.2.3.8.1 EMERGENCY/PRIORITY STATUS

B.2.3.8.1.1 Format

The aircraft status squitter that conveys emergency/priority status information shall be formatted as specified in the definition of transponder register 61_{16}, Table B-2-97a.

B.2.3.8.1.2 Transmission rate

This message shall be broadcast at random intervals that are uniformly distributed between 0.7 and 0.9 seconds for the duration of the emergency.

B.2.3.8.1.3 Message delivery

Message delivery shall be accomplished using the event-driven protocol (see §A.2.3.7). The broadcast of this message shall not take priority over the ACAS RA broadcast but shall take priority over all other event-driven message types, as specified in §B.2.5.5.3.

B.2.3.8.2 ACAS RA BROADCAST

B.2.3.8.2.1 Format

The aircraft status squitter that conveys ACAS RA broadcast information shall be formatted as specified in the definition of transponder register 61_{16}, Table B-2-97b.

B.2.3.8.2.2 Transmission rate

This message shall be broadcast at random intervals that are uniformly distributed between 0.7 and 0.9 seconds for the duration of the emergency.

B.2.3.8.2.3 Message delivery

Message delivery shall be accomplished using the event-driven protocol (see §A.2.3.7). The broadcast of this message shall take priority over the emergency/priority status broadcast and all other event-driven message types, as specified in §B.2.5.5.3.

B.2.3.9 RESERVED FOR TARGET STATE AND STATUS INFORMATION

B.2.3.10 AIRCRAFT OPERATIONAL STATUS

The aircraft operational status message squitter shall be formatted as specified in the definition of register number 65_{16} and in the following paragraphs.

B.2.3.10.1 TRANSMISSION RATE

The aircraft operational status (type = 31 and subtype = 0, for airborne participants) ADS-B message shall be broadcast at random intervals that are uniformly distributed over the range of 0.7 to 0.9 seconds when the target state and status message (type = 29 and subtype = 0) is not being broadcast and there has been a change within the past 24 ±1 seconds for the value of any of the following message parameters:

a) ACAS operational;

b) ACAS resolution advisory active;

c) NAC_P;

d) SIL.

Otherwise the aircraft operational status (type = 31 and subtype = 0, for airborne participants) ADS-B message shall be broadcast at random intervals that are uniformly distributed over the range of 2.4 to 2.6 seconds.

B.2.3.10.2 MESSAGE DELIVERY

Message delivery shall be accomplished using the event-driven protocol (see §B.2.3.7).

B.2.3.10.3 CAPABILITY CLASS (CC) CODES

This 16-bit (ME bits 9–24, Message bits 41–56) subfield in the airborne aircraft operational status message (subtype=0) or 12-bit (ME bits 9–20, message bits 41–52) subfield in the surface aircraft operational status message (subtype=1) shall be used to report the operational capability of the aircraft. Encoding of the CC subfield shall be defined as specified in the following tables.

For an ADS-B transmitting subsystem compliant with this appendix, if an update has not been received from an on-board data source within the past 5 seconds for any data element of the capability class codes subfield, then the data associated with that data element shall be considered invalid and so reflected in the encoding of that message element to reflect no capability or unknown capability.

Airborne Capability Class (CC) Code for Version 1 Systems

Msg Bit #	41	42	43	44	45	46	47	48	49	50	51 – 56
“ME” Bit #	9	10	11	12	13	14	15	16	17	18	19 – 24
Content	Service level MSBs = 0 0		Not-ACAS	CDTI	Service level LSBs = 0 0		ARV	TS	TC		Reserved

Subfield Coding:

1. Not-ACAS (Airborne Collision Avoidance System Status)
   0 = ACAS operational or unknown
   1 = ACAS not installed or not operational

2. CDTI (Cockpit Display of Traffic Information Status)
   0 = Traffic display not operational
   1 = Traffic display operational

3. ARV (Air-Referenced Velocity Report Capability)
   0 = No capability for sending messages to support Air-Referenced Velocity Reports
   1 = Capability of sending messages to support Air-Referenced Velocity Reports

4. TS (Target State Report Capability)
   0 = No capability for sending messages to support Target State Reports
   1 = Capability of sending messages to support Target State Reports

5. TC (Target Change Report Capability)
   0 = No capability for sending messages to support Trajectory Change Reports
   1 = Capability of sending messages to support TC+0 Report only
   2 = Capability of sending information for multiple TC Reports
   3 = Reserved

Surface Capability Class (CC) Code for Version 1 Systems

Msg Bit #	41	42	43	44	45	46	47	48	49	50	51	52
“ME” Bit #	9	10	11	12	13	14	15	16	17	18	19	20
Content	Service level MSBs = 0 0		POA	CDTI	Service level LSBs = 0 0		B2 Low	Reserved				

Subfield Coding:

1. CDTI (Cockpit Display of Traffic Information)
   0 = Traffic display not operational
   1 = Traffic display operational

2. POA (Position Offset Applied)
   0 = Position transmitted is not the ADS-B position reference point
   1 = Position transmitted is the ADS-B position reference point

3. B2 Low (Class B2 transmit power less than 70 Watts)
   0 = Greater than or equal to 70 Watts transmit power
   1 = Less than 70 Watts transmit power

B.2.3.10.4 OPERATIONAL MODE (OM)

This 16-bit (ME bits 25–40, message bits 57–72) subfield shall be used to indicate the operational modes that are active on board the aircraft. Encoding of the subfield shall be as specified in the following table.

Msg Bit #	57	58	59	60	61	62-72
“ME” Bit #	25	26	27	28	29	30-40
OM format	0 0		ACAS RA active	IDENT switch active	Receiving ATC services	Reserved
	0 1		Reserved			
	1 0		Reserved			
	1 1		Reserved			

Subfield Coding:

1. ACAS Resolution Advisory (RA) active
   0 = ACAS II or ACAS RA not active
   1 = ACAS RA is active

2. IDENT switch active
   0 = Ident switch not active
   1 = Ident switch active — retained for 18 ±1 seconds

3. Receiving ATC services
   0 = Aircraft not receiving ATC services
   1 = Aircraft receiving ATC services

B.2.3.10.5 EXTENDED SQUITTER VERSION NUMBER

This 3-bit (ME bits 41–43, message bits 73–75) subfield shall be used to indicate the version number of the formats and protocols in use on the aircraft installation. Encoding of the subfield shall be as specified in the following table.

Extended squitter version number subfield		
Coding		*Meaning*
(Binary)	*(Decimal)*	
000	0	Conformant to Doc 9871, 1st Edition, Appendix A
001	1	Conformant to Doc 9871, 1st Edition, Appendix B
010 – 111	2 – 7	Reserved

B.2.3.10.6 NAVIGATION INTEGRITY CATEGORY (NIC) SUPPLEMENT

This 1-bit (ME bit 44, message bit 76) subfield shall be used with the TYPE Code to encode the navigation integrity category (NIC) of the transmitting ADS-B participant to allow surveillance applications to determine whether the reported geometric position has an acceptable integrity containment region for the intended use. Encoding of the NIC Supplement subfield shall be as specified in the following table. If an update has not been received from an on-board data source for the NIC Supplement subfield within the past 5 seconds, then the NIC Supplement subfield shall be encoded to indicate that R_C is "Unknown."

NIC value	*Containment Radius (R_C) and Vertical Protection Limit (VPL)*	*Airborne*		*Surface*	
		Airborne position TYPE Code	*NIC supplement Code*	*Surface position TYPE Code*	*NIC supplement Code*
0	R_C unknown	0, 18 or 22	0	0, 8	0
1	R_C < 20 NM (37.04 km)	17	0	N/A	N/A
2	R_C < 8 NM (14.816 km)	16	0	N/A	N/A
3	R_C < 4 NM (7.408 km)	16	1	N/A	N/A
4	R_C < 2 NM (3.704 km)	15	0	N/A	N/A
5	R_C < 1 NM (1 852 m)	14	0	N/A	N/A
6	R_C < 0.6 NM (1 111.2 m)	13	1	N/A	N/A
	R_C < 0.5 NM (926 m)	13	0		
7	R_C < 0.2 NM (370.4 m)	12	0	N/A	N/A
8	R_C < 0.1 NM (185.2 m)	11	0	7	0
9	R_C < 75 m *and* VPL < 112 m	11	1	7	1
10	R_C < 25 m *and* VPL < 37.5 m	10 or 21	0	6	0
11	R_C < 7.5 m *and* VPL < 11 m	9 or 20	0	5	0

Note 1.— "N/A" means "This NIC value is not available in the ADS-B surface position message formats."

Note 2.— The NIC parameter is broadcast partly in the TYPE subfield of airborne position and surface position messages, and partly in the NIC Supplement subfield of the aircraft operational status message. The NIC integrity containment region is described horizontally and vertically using the two parameters, R_C and VPL.

B.2.3.10.7 NAVIGATION ACCURACY CATEGORY FOR POSITION (NAC_P)

This 4-bit (ME bits 45–48, message bits 77–80) subfield shall be used to announce 95 per cent accuracy limits for the horizontal position (and for some NAC_P values, the vertical position) that is being currently broadcast in Airborne Position and Surface Position Messages. Encoding of the subfield shall be as specified in the following table. If an update has not been received from an on-board data source for NAC_P within the past 5 seconds, then the NAC_P subfield shall be encoded as a value indicating unknown accuracy.

Coding		*Meaning = 95% horizontal and vertical accuracy bounds (EPU and VEPU)*
(Binary)	*(Decimal)*	
0000	0	EPU ≥ 18.52 km (10 NM) — Unknown accuracy
0001	1	EPU < 18.52 km (10 NM) — RNP-10 accuracy
0010	2	EPU < 7.408 km (4 NM) — RNP-4 accuracy
0011	3	EPU < 3.704 km (2 NM) — RNP-2 accuracy
0100	4	EPU < 1 852 m (1 NM) — RNP-1 accuracy
0101	5	EPU < 926 m (0.5 NM) — RNP-0.5 accuracy
0110	6	EPU < 555.6 m (0.3 NM) — RNP-0.3 accuracy
0111	7	EPU < 185.2 m (0.1 NM) — RNP-0.1 accuracy
1000	8	EPU < 92.6 m (0.05 NM) — e.g. GPS (with SA)
1001	9	EPU < 30 m and VEPU < 45 m — e.g. GPS (SA off)
1010	10	EPU < 10 m and VEPU < 15 m — e.g. WAAS
1011	11	EPU < 3 m and VEPU < 4 m — e.g. LAAS
1100 – 1111	12 – 15	Reserved

Note 1.— The Estimated Position Uncertainty (EPU) used in the table is a 95 per cent accuracy bound on horizontal position. EPU is defined as the radius of a circle, centered on the reported position, such that the probability of the actual position lying outside the circle is 0.05. When reported by a GNSS system, EPU is commonly called HFOM (Horizontal Figure of Merit).

Note 2.— Vertical Estimated Position Uncertainty (VEPU) is a 95 per cent accuracy limit on the vertical position (geometric altitude). VEPU is defined as a vertical position limit, such that the probability of the actual geometric altitude differing from the reported geometric altitude by more than that limit is 0.05. When reported by a GNSS system, VEPU is commonly called VFOM (Vertical Figure of Merit).

Note 3.— RNP accuracy includes error sources other than sensor error, whereas horizontal error for NAC_P only refers to horizontal position error uncertainty.

Note 4.— If geometric altitude is not being reported, then the VEPU tests are not assessed.

B.2.3.10.8 BAROMETRIC ALTITUDE QUALITY (BAQ)

This 2-bit (ME bits 49–50, message bits 81–82) subfield in the airborne operational status message (subtype=0) shall be set to zero (0) by ADS-B transmitting subsystems.

B.2.3.10.9 SURVEILLANCE INTEGRITY LEVEL (SIL)

This 2-bit (ME bits 51–52, Message bits 83–84) subfield shall be used to define the probability of the integrity containment region described by the NIC parameter being exceeded for the selected position source, including any external signals used by the source. Encoding of the subfield shall be as shown in the following table. For installations where the SIL value is being dynamically updated, if an update has not been received from an on-board data source for SIL within the past 5 seconds, then the SIL subfield shall be encoded as a value indicating "Unknown."

The probability specified by the SIL subfield shall be 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) the per sample probability of a position source error larger than the horizontal or vertical integrity containment region 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 an indication (see note 1 below the table), within a time period determined by the positioning source, as indicated in the table.

Coding		*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*
(Binary)	*(Decimal)*		
00	0	Unknown	Unknown
01	1	$\leq 1 \times 10^{-3}$ per flight hour or per sample	$\leq 1 \times 10^{-3}$ per flight hour or per sample
10	2	$\leq 1 \times 10^{-5}$ per flight hour or per sample	$\leq 1 \times 10^{-5}$ per flight hour or per sample
11	3	$\leq 1 \times 10^{-7}$ per flight hour or per sample	$\leq 2 \times 10^{-7}$ per 150 seconds or per sample

Note 1.— "An Indication" may include, for example, a flag for invalid position report, or a change in NIC, or switching to another data source.

Note 2.— A problem for installations that include currently available GNSS receivers and FMS systems is that SIL is not output by these systems. Most implementers are expected to determine SIL by off-line analysis of the installed configuration. This off-line analysis can be performed on the various primary and alternate means of determining the reported position. SIL is a static value for each of these configurations.

Note 3.— The vertical integrity containment column applies to NIC values greater than 8.

Note 4.— The SIL code value is the lower of the horizontal or vertical coding values.

Note 5.— It is recognized that there are three possible derivations of SIL: (a) the integrity value provided by navigation sensors with self-monitoring capability (e.g. GPS), (b) the reliability of aircraft systems given as indicated by a failure rate commensurate with the equipment design assurance, and (c) the integrity of other navigation systems, (e.g. RNP) that rely on ground-based self-monitoring equipment for integrity assurance, and for which no specific hourly *integrity value can be ascribed. These three values are not readily interchangeable. Selection of the largest of the values as specified in the table above is felt to provide a reasonable bound on the order of magnitude of the probability of possible failures affecting ADS-B applications.*

Note 6.— GNSS systems report integrity in terms of flight hours and FMS systems report in terms of per measurement sample (derived from a number of position measurements). While these are not equivalent measures of integrity, the difference is not considered to be critical for initial applications.

B.2.3.10.9.1 ***Recommendations***.—

1. *SIL is intended to reflect the integrity of the navigation source of the position information broadcast, therefore the SIL value transmitted should be indicative of the true integrity of the ADS-B position data.*

2. *If SIL information is not provided by the navigation source, implementers should not arbitrarily set an SIL value of zero indicating unknown integrity.*

3. *Unless there is a tightly coupled navigation source where SIL can be unambiguously determined and set dynamically, the ADS-B Transmitting Subsystem should provision for the static setting of SIL as part of the installation procedure.*

B.2.3.10.10 BAROMETRIC ALTITUDE INTEGRITY CODE (NIC_{BARO})

This 1-bit (ME bit 53, message bit 85) subfield shall be used to indicate whether or not the barometric pressure-altitude being reported in the airborne position message has been crosschecked against another source of pressure-altitude. The NIC_{BARO} subfield shall be encoded as shown in the following table. If an update has not been received from an on-board data source for NIC_{BARO} within the past 5 seconds, then the NIC_{BARO} subfield shall be encoded as a value of ZERO (0).

Coding	*Meaning*
0	The barometric altitude that is being reported in the Airborne Position Message is based on a Gilham coded input that has not been cross-checked against another source of pressure-altitude
1	The barometric altitude that is being reported in the Airborne Position Message is either based on a Gilham code input that has been cross-checked against another source of pressure-altitude and verified as being consistent, or is based on a non-Gilham coded source

Note 1.— The barometric altitude value itself is conveyed within the ADS-B Position Message.

B.2.3.10.10.1 The NIC_{BARO} subfield provides a method of indicating a level of data integrity for aircraft installed with Gilham encoding barometric altitude sources. Because of the potential of an undetected error when using a Gilham encoded altitude source, a comparison shall be performed with a second source and only if the two sources agree shall the NIC_{BARO} subfield be set to a value of “1”. For other barometric altitude sources (Synchro or DADS) the integrity of the data is indicated with a validity flag or SSM. No additional checks or comparisons are necessary. For these sources the NIC_{BARO} subfield shall be set to a value of “1” whenever the barometric altitude is valid.

B.2.3.10.11 AIRCRAFT LENGTH AND WIDTH CODES

This 4-bit (ME bits 21–24, message bits 53–56) subfield shall be used in the surface aircraft operational status message (subtype=1) to describe the amount of space that an Aircraft or Ground Vehicle occupies. The A/V length and width code shall be based on the actual dimensions of the transmitting Aircraft or Surface Vehicle as specified in the following table. Each aircraft or vehicle shall be assigned the smallest A/V length and width code consistent with its actual dimensions. Each A/V shall be assigned the smallest A/V length and width codes from the following table for which the actual length and width is less than or equal to specified upper bounds.

A/V — L/W code (Decimal)	*Length code*			*Width code*	*Upper-bound length and width for each length/width code*	
	ME bit 49	*ME bit 50*	*ME bit 51*	*ME bit 52*	*Length (metres)*	*Width (metres)*
0	0	0	0	0	15	11.5
1				1		23
2	0	0	1	0	25	28.5
3				1		34
4	0	1	0	0	35	33
5				1		38
6	0	1	1	0	45	39.5
7				1		45
8	1	0	0	0	55	45
9				1		52
10	1	0	1	0	65	59.5
11				1		67
12	1	1	0	0	75	72.5
13				1		80
14	1	1	1	0	85	80
15				1		90

If the aircraft is longer than 85 m or wider than 90 m, L/W Code 15 shall be used.

B.2.3.10.12 TRACK ANGLE/HEADING

The track angle/heading shall be a 1-bit (“ME” bit 53, Message bit 85) subfield of the ADS-B aircraft operational status message (subtype=1, for surface participants) that allows correct interpretation of the data contained in the heading/ground track subfield of the ADS-B surface position message. The bit values shall be interpreted as follows:

0 = Target heading angle is being reported.
1 = Track angle is being reported.

B.2.3.10.13 HORIZONTAL REFERENCE DIRECTION (HRD)

This 1-bit (ME bit 54, Message bit 86) subfield shall be used to indicate the reference direction (True North or Magnetic North) for horizontal directions such as heading, track angle, selected heading, selected track angle, etc. The horizontal reference direction subfield shall be encoded as specified in the following table:

HRD value	*Meaning*
0	True North
1	Magnetic North

B.2.4 EXTENDED SQUITTER INITIALIZATION AND TIMEOUT

Initialization and timeout functions for extended squitter broadcast shall be performed by the transponder and are specified in Annex 10, Volume IV, 3.1.2.

Note.— A description of these functions is presented in the following paragraphs to serve as reference material for the section on the general formatter/manager (GFM) (see §B.2.5).

B.2.4.1 INITIATION OF EXTENDED SQUITTER BROADCAST

Initialization of extended squitter broadcast shall be performed by the transponder as specified in §A.2.4.1.

B.2.4.2 REGISTER TIME-OUT

Register time-out processing shall be performed by the transponder as specified in §A.2.4.2.

B.2.4.3 TERMINATION OF EXTENDED SQUITTER BROADCAST

Termination of extended squitter broadcast shall be performed by the transponder as specified in §A.2.4.3.

B.2.4.4 REQUIREMENTS FOR NON-TRANSPONDER DEVICES

Non-transponder devices shall provide the same functionality for initialization; register time-out and broadcast termination as specified for the transponder case in §B.2.4.1 to §B.2.4.3, except that a non-transponder device operating on the surface shall continue to broadcast DF=18 with message TYPE Code=0 at a rate specified for the surface position message even though it has lost its navigation input.

Note.— Continued broadcast of the surface position message is needed to support the operation of surface multilateration systems.

B.2.5 GENERAL FORMATTER/MANAGER (GFM)

The general formatter/manager (GFM) shall format messages for insertion in the transponder registers.

Note.— In addition to data formatting, there are other tasks that are performed by this function.

B.2.5.1 NAVIGATION SOURCE SELECTION

The GFM shall perform navigation source selection as specified in §A.2.5.1.

B.2.5.2 LOSS OF INPUT DATA

The GFM shall handle loss of input data as specified in §A.2.5.2.

B.2.5.3 SPECIAL PROCESSING FOR FORMAT TYPE CODE ZERO

Special processing for format TYPE Code zero shall be performed as specified in §A.2.5.3.

B.2.5.4 TRANSPONDER CAPABILITY REPORTING

Transponder capability reporting shall be performed as specified in §A.2.5.4.

B.2.5.5 HANDLING OF EVENT-DRIVEN PROTOCOL

The event-driven interface protocol provides a general purpose interface into the transponder function for messages beyond those that are regularly transmitted all the time (provided input data are available). This protocol shall operate by having the transponder broadcast a message once each time the event-driven register is loaded by the GFM.

Note.— This gives the GFM complete freedom in setting the update rate (up to a maximum) and duration of broadcast for applications such as emergency status and intent reporting.

In addition to formatting, the GFM shall control the timing of message insertion so that it provides the necessary pseudo-random timing variation and does not exceed the maximum transponder broadcast rate for the event-driven protocol.

B.2.5.5.1 TRANSPONDER SUPPORT FOR EVENT-DRIVEN MESSAGES

Transponder support for event-driven messages shall be as specified in §A.2.5.5.1.

B.2.5.5.2 GFM USE OF EVENT-DRIVEN PROTOCOL

GFM use of the event-driven protocol shall be as specified in §A.2.5.5.2.

B.2.5.5.3 EVENT-DRIVEN MESSAGE TRANSMISSION SCHEDULING FUNCTION

The event-driven message scheduling function shall ensure that the total event-driven message rate does not exceed 2 transmitted messages per second.

The event-driven message scheduling function shall apply the following rules as a means of prioritizing the event-driven message transmissions and limiting the transmission rates:

a) the event-driven message scheduling function shall reorder, as necessary, pending event-driven messages according to the following message priorities, listed below in descending order from highest to lowest priority.

1) When an extended squitter aircraft status message is active for the broadcast of an emergency/priority condition (type=28 and subtype=1), or an ACAS RA broadcast (type=28, subtype=2), that message shall continue to be transmitted at random intervals that are uniformly distributed over the range of 0.7 to 0.9 seconds, relative to the previous aircraft status message for the duration of the emergency or RA condition if the target state and status message is not being broadcast. If the target state and status message with subtype=zero (0) is being broadcast, then the aircraft status shall be broadcast at random intervals that are uniformly distributed over the range of 2.4 to 2.6 seconds relative to the previous aircraft status message for the duration of the emergency conditions established in accordance with Tables B-2-97a and B-2-97b.

2) Reserved for future use.

3) Reserved for future use.

4) When an aircraft operational status message is active (type=31 and subtype=0) and there has been a change in one or more of the message parameters within the past 24 seconds that results in a higher update rate-reporting requirement, the aircraft operational status message shall be transmitted at the rate specified in §B.2.3.10.1.

5) When a target state and status message is active for the broadcast of target state information (message type=29 and subtype=0) the target state and status message shall be transmitted at random intervals that are uniformly distributed over the range of 1.2 to 1.3 seconds relative to the previous target state and status message for as long as target state information is available and valid.

6) Reserved for future use.

7) When an aircraft operational status message is active (type=31 and subtype=0) and there has been no change in the message parameters that would require an increased broadcast rate, the aircraft operational status message shall be transmitted at the rate specified in §B.2.3.10.1.

8) This priority level applies as a default to any event-driven message type and subtype combination not specifically identified at a higher priority level above. Event-driven messages of this default priority level shall be delivered to the transponder on a first-in-first-out basis at equal priority.

b) the event-driven message scheduling function shall limit the number of event-driven messages provided to the transponder to two (2) messages per second.

c) if (b) results in a queue of messages awaiting delivery to the transponder, the higher priority pending messages, according to (a) above shall be delivered to the transponder for transmission before lower priority messages.

d) if (b) results in a queue of messages awaiting delivery to the transponder, new Event-Driven messages shall directly replace older messages of the same exact type and subtype (where a subtype is defined) that are already in the pending message queue. The updated message shall maintain the same position in the message queue as the pending message that is being replaced.

e) if (b) above results in a queue of messages awaiting delivery to the transponder, then pending message(s) shall be deleted from the message transmission queue if not delivered to the transponder for transmission, or not replaced with a newer message of the same message Type and Subtype, within the Message Lifetime value specified in the following table.

Message type	*Message subtype*	*Message lifetime*
23	0	5.0 seconds (±0.2 s)
	> 0	Reserved
24		Reserved
25		Reserved
26		Reserved
27		Reserved
28	= 1	5.0 seconds (±0.2 s)
	= 2	10 seconds after RAT transitions from 0 to 1
	0, > 2	Reserved
29	= 0	2.5 seconds (±0.2 s)
	> 0	Reserved
30		Reserved
31	= 0, 1	5.0 seconds (±0.2 s)
	> 1	Reserved

B.2.5.5.4 A default message lifetime of 20 seconds shall be used for queue management unless otherwise specified.

B.2.5.6 DERIVATION OF MODE FIELD BITS FOR AIRCRAFT INTENTION PARAMETERS

Derivation of mode field bits for aircraft intention parameters shall be performed as specified in §A.2.5.6.

B.2.6 LATITUDE/LONGITUDE CODING USING COMPACT POSITION REPORTING (CPR)

CPR coding shall be performed as specified in §A.2.6.

TABLES FOR SECTION B.2

Formats that shall be used for the following tables are presented in this section:

Table B-2-6.	BDS code 0,6 — Extended squitter surface position
Table B-2-8.	BDS code 0,8 — Extended squitter aircraft identification and category
Table B-2-9a.	BDS code 0,9 — Extended squitter airborne velocity (Subtypes 1 and 2: Velocity over ground)
Table B-2-9b.	BDS code 0,9 — Extended squitter airborne velocity (Subtypes 3 and 4: Airspeed and heading)
Table B-2-97a.	BDS code 6,1 — Aircraft status (Subtype 1: Emergency/priority status)
Table B-2-97b.	BDS code 6,1 — Aircraft status (Subtype 2: Extended squitter ACAS RA broadcast)
Table B-2-101.	BDS code 6,5 — Aircraft operational status

All other tables shall be formatted as specified in Appendix A.

Table B-2-6. BDS code 0,6 — Extended squitter surface position

MB FIELD

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

PURPOSE: To provide accurate surface position information.

Table B-2-8. BDS code 0,8 — Extended squitter aircraft identification and category

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 aircraft 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:

<u>Set A:</u>

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 (> 400 kts)
7 = Rotorcraft

<u>Set B:</u>

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

<u>Set C:</u>

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

<u>Set D:</u> Reserved

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

As specified in Annex 10, Volume IV, Table 3-9.

Table B-2-9a. BDS code 0,9 — Extended squitter airborne velocity (Subtypes 1 and 2: Velocity over ground)

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 B-2-9b. BDS code 0,9 — Extended squitter airborne velocity (Subtypes 3 and 4: Airspeed and heading)

MB FIELD

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 (NACV) (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 B-2-97a. BDS code 6,1 — Aircraft status (Subtype 1: Emergency/priority status)

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
12–56	RESERVED

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 B-2-97b. BDS code 6,1 — Aircraft status (Subtype 2: Extended squitter ACAS RA Broadcast)

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 B-2-101. BDS code 6,5 — Extended squitter aircraft operational status

MB FIELD

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.

B.3. CF FIELD CODE DEFINITIONS IN DF=18 ADS-B AND TIS-B MESSAGES

B.3.1 INTRODUCTION

Note 1.— This section defines the formats and coding for a traffic information service broadcast (TIS-B) service based on the same 112-bit 1 090 MHz signal transmission that is used for ADS-B on 1 090 MHz.

Note 2.— TIS-B complements the operation of ADS-B by providing ground-to-air broadcast of surveillance data on aircraft that are not equipped for 1 090 MHz ADS-B as an aid to transition to a full ADS-B environment. The basis for this ground surveillance data may be ATC Mode S radar, a surface or approach multilateration system or a multi-sensor data processing system. The TIS-B ground-to-air transmissions use the same signal formats as 1 090 MHz ADS-B and can therefore be accepted by a 1 090 MHz ADS-B receiver.

Note 3.— TIS-B service is intended to provide a complete surveillance picture to 1 090 MHz ADS-B users during a transition period. After transition, it also provides a means to cope with a user that has lost its 1 090 MHz ADS-B capability, or is broadcasting incorrect information.

B.3.2 TIS-B FORMAT DEFINITION

TIS-B information shall be broadcast using the 112-bit Mode S DF=18 format as shown below in the following table.

<table>
<tr><th colspan="6">TIS-B Format Definition</th></tr>
<tr><td>Bit #</td><td>1 ---- 5</td><td>6 --- 8</td><td>9 ----- 32</td><td>33 ------------------------- 88</td><td>89 ---- 112</td></tr>
<tr><td rowspan="2">DF=18Field Names</td><td>DF[5]</td><td>CF[3]</td><td>AA[24]</td><td>ME[56]</td><td>PI[24]</td></tr>
<tr><td>10010</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>MSB</td><td>MSB</td><td>MSB</td><td>MSB</td><td>MSB</td></tr>
<tr><td></td><td>LSB</td><td>LSB</td><td>LSB</td><td>LSB</td><td>LSB</td></tr>
</table>

B.3.3 CONTROL FIELD ALLOCATION

The content of the DF=18 transmission shall be defined by the value of the control field, as specified in the following table.

CF Field Code Definitions in DF=18 ADS-B and TIS-B Messages

CF value	*ICAO/Mode A Flag (IMF)*	*Meaning*
2	0	Fine TIS-B message, AA field contains the 24-bit ICAO aircraft address
	1	Fine TIS-B message, AA field contains the 12-bit Mode A code followed by a 12-bit track file number
3	0	Coarse TIS-B airborne position and velocity message, AA field contains the 24-bit ICAO aircraft address
	1	Coarse TIS-B airborne position and velocity message, AA field contains the 12-bit Mode A code followed by a 12-bit track file number.

CF value	*ICAO/Mode A Flag (IMF)*	*Meaning*
4	N/A	Reserved for TIS-B management message AA field contains TIS-B/ADS-R management information
5	0	TIS-B messages that relay ADS-B Messages using anonymous 24-bit addresses
	1	Reserved
6	0	ADS-B rebroadcast using the same TYPE Codes and message formats as defined for DF=17 ADS-B messages AA field contains the 24-bit ICAO aircraft address
	1	ADS-B rebroadcast using the same TYPE Codes and message formats as defined for DF=17 ADS-B messages AA field contains a 24-bit anonymous aircraft address

B.3.4 TIS-B SURVEILLANCE MESSAGE DEFINITION

B.3.4.1 TIS-B FINE AIRBORNE POSITION MESSAGE

The TIS-B fine airborne position ME field shall be formatted as specified in Table B-3-1.

B.3.4.1.1 ICAO/MODE A FLAG (IMF) FOR THE AIRBORNE POSITION MESSAGE

This one-bit field (bit 8) shall indicate the type of identity associated with the aircraft data reported in the TIS-B message. IMF equal to ZERO (0) shall indicate that the TIS-B data is identified by an ICAO 24-bit address. IMF equal to ONE (1) shall indicate that the TIS-B data is identified by a “Mode A” code. A TIS-B report on a primary radar target shall indicate a “Mode A” code of all ZEROs.

Note.— The AA field is coded differently for 24-bit addresses and Mode A codes as specified in §B.3.3.

B.3.4.1.2 PRESSURE-ALTITUDE

This 12-bit field shall provide the aircraft pressure-altitude. This field shall contain barometric altitude encoded in 25- or 100-foot increments (as indicated by the Q Bit).

Note.— All zeros in this field indicate that there is no altitude data.

B.3.4.1.3 COMPACT POSITION REPORTING (CPR) FORMAT (F)

This field shall be set as specified in 2.3.2.1 of Appendix A.

B.3.4.1.4 LATITUDE/LONGITUDE

The Latitude/Longitude fields in the TIS-B fine Airborne Position Message shall be set as specified in §A.2.3.2.3.

B.3.4.2 TIS-B SURFACE POSITION MESSAGE

The TIS-B surface position ME field shall be formatted as specified in Table B-3-2.

B.3.4.2.1 MOVEMENT

This field shall be set as specified in §B.2.3.3.1

B.3.4.2.2 GROUND TRACK (TRUE)

B.3.4.2.2.1 Ground track status

This field shall be set as specified in §B.2.3.3.2.1.

B.3.4.2.2.2 Ground track angle

This field shall be set as specified in §B.2.3.3.2.2.

B.3.4.2.3 ICAO/MODE A FLAG (IMF) FOR THE SURFACE POSITION MESSAGE

This one-bit field (bit 21) shall indicate the type of identity associated with the aircraft data reported in the TIS-B message. Coding is specified in §B.3.4.1.1.

B.3.4.2.4 COMPACT POSITION REPORTING (CPR) FORMAT (F)

This field shall be set as specified in §A.2.3.3.3.

B.3.4.2.5 LATITUDE/LONGITUDE

The Latitude/Longitude fields in the TIS-B fine Surface Position Message shall be set as specified in §A.2.3.3.5.

B.3.4.3 IDENTIFICATION AND CATEGORY MESSAGE

The TIS-B identification and category ME field shall be formatted as specified in Table B-3-3. This message shall only be used for aircraft identified with an ICAO 24-bit address.

B.3.4.3.1 AIRCRAFT IDENTIFICATION CODING

This field shall be set as specified in the definition of BDS 0,8.

B.3.4.4 VELOCITY MESSAGE

The TIS-B Velocity ME field shall be formatted as specified in Tables B-3-4a and B-3-4b.

B.3.4.4.1 SUBTYPE FIELD

Subtypes 1 and 2 shall be used for the velocity message when velocity over ground is reported. Subtypes 3 and 4 shall be used when airspeed and heading are reported.

Subtype 2 (the supersonic version of the velocity coding) shall be used if either the east-west OR north-south velocities exceed 1 022 knots. A switch to subtype 1 (the normal velocity coding) shall be made if both the east-west AND north-south velocities drop below 1 000 knots.

Subtype 4 (the supersonic version of the airspeed coding) shall be used if airspeed exceeds 1 022 knots. A switch to subtype 3 (the normal airspeed coding) shall be made if the airspeed drops below 1 000 knots.

B.3.4.4.2 ICAO/MODE A FLAG (IMF) FOR THE VELOCITY MESSAGE

This one-bit field (bit 9) shall indicate the type of identity associated with the aircraft data reported in the TIS-B message. Coding is specified in §B.3.4.1.1.

B.3.4.5 COARSE AIRBORNE POSITION MESSAGE

The TIS-B coarse airborne position ME field shall be formatted as specified in Table B-3-5.

Note.— This message is used if the surveillance source for TIS-B is not of high enough quality to justify the use of the fine formats. An example of such a source is a scanning beam Mode S interrogator.

B.3.4.5.1 ICAO/MODE A FLAG (IMF) FOR THE COARSE AIRBORNE POSITION MESSAGE

This one-bit field (bit 1) shall indicate the type of identity associated with the aircraft data reported in the TIS-B message in §B.3.4.1.1.

B.3.4.5.2 SERVICE VOLUME ID (SVID)

The 4-bit SVID field shall identify the TIS-B site that delivered the surveillance data.

Note 1.— In the case where TIS-B messages are being received from more than one TIS-B service, the Service ID can be used to select coarse messages from a single service. This will prevent the TIS-B track from wandering due to the different error characteristics associated with the different services.

Note 2.— The SVID is defined by the service provider.

B.3.4.5.3 PRESSURE-ALTITUDE

This 12-bit field shall provide the aircraft pressure-altitude. This field shall contain barometric altitude encoded in 25- or 100-foot increments (as indicated by the Q Bit).

B.3.4.5.4 GROUND TRACK STATUS

This one bit (ME bit 20) field shall define the validity of the ground track value. Coding for this field shall be as follows: 0=not valid and 1=valid.

B.3.4.5.5 GROUND TRACK ANGLE

This 5-bit (ME bits 21-25) field shall define the direction (in degrees clockwise from true north) of aircraft motion. The ground track shall be encoded as an unsigned angular weighted binary numeral, with an MSB of 180 degrees and an LSB of 360/32 degrees, with ZERO (0) indicating true north. The data in the field shall be rounded to the nearest multiple of 360/32 degrees.

B.3.4.5.6 GROUND SPEED

This 6-bit (ME bits 26-31) field shall define the aircraft speed over the ground. Coding of this field shall be as specified in the following table:

Coding	*Ground speed (GS) in knots*
0	No ground speed information
1	GS $\leq$ 16
2	16 $\leq$ GS < 48
3	48 < GS < 80
*****	*****
62	1936 $\leq$ GS < 1968
63	GS $\geq$ 1968

B.3.4.5.7 LATITUDE/LONGITUDE

The Latitude/Longitude fields in the TIS-B Coarse Airborne Position Message shall be set as specified in §A.2.3.2.3 except that the 12-bit form of CPR coding shall be used.

B.3.4.6 RESERVED FOR TIS-B/ADS-R MANAGEMENT MESSAGES

Note.— TIS-B/ADS-R Management Messages could announce information such as location and the service of the TIS-B ground station. There is no requirement for Management Messages. Format DF=18 with CF=4 has been reserved for the future use of such messages.

Table B-3-1. TIS-B fine airborne position message

MB FIELD

1–5	MSB … LSB FORMAT TYPE CODE (see §B.2.3.1)
6–7	MSB … LSB SURVEILLANCE STATUS
8	IMF (see §B.3.4.1.1)
9–20	MSB … LSB PRESSURE-ALTITUDE This is the altitude code (AC) as specified in §3.1.2.6.5.4 of Annex 10, Volume IV, but with the M-bit removed
21	RESERVED
22	CPR FORMAT (F) (see §A.2.3.2.1)
23–39	MSB … LSB CPR ENCODED LATITUDE (CPR airborne format specified in §B.2.6)
40–56	MSB … LSB CPR ENCODED LONGITUDE (CPR airborne format specified in §B.2.6)

PURPOSE: To provide airborne position information for aircraft that are not equipped with 1 090 MHz ADS-B when the TIS-B service is based on high quality surveillance data.

Surveillance Status coding:

0 = no condition information

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 take precedence over code 3.

Table B-3-2. TIS-B fine surface position message

MB FIELD

1	MSB
2	
3	FORMAT TYPE CODE
4	(see §B.2.3.1)
5	LSB
6	MSB
7	
8	
9	MOVEMENT
10	(see §B.2.3.3.1)
11	
12	LSB
13	STATUS for Heading/Ground Track (1 = valid, 0 = not valid)
14	MSB
15	
16	HEADING/GROUND TRACK
17	(Referenced to true north)
18	
19	
20	LSB = 360/128 degrees
21	IMF (see §B.3.4.2.3)
22	CPR FORMAT (F) (see §A.2.3.3.3)
23	MSB
24	
25	
26	
27	
28	
29	
30	CPR ENCODED LATITUDE
31	
32	CPR Surface Format
33	(specified in §B.2.6)
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	
47	CPR ENCODED LONGITUDE
48	
49	CPR Surface Format
50	(specified in §B.2.6)
51	
52	
53	
54	
55	
56	LSB

PURPOSE: To provide surface position information for aircraft that are not equipped with 1 090 MHz ADS-B.

Table B-3-3. TIS-B identification and category message

	MSB	
2		FORMAT TYPE CODE
3		(see §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 aircraft that are not equipped with 1 090 MHz ADS-B.

Type coding:

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

ADS-B Emitter Category coding:

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 (> 400 kts)
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:

As specified in Annex 10, Volume IV, Table 3-9.

Table B-3-4a. TIS-B velocity messages (Subtypes 1 and 2: Velocity over ground)

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	IMF (specified in §B.3.4.4.2)			
10	MSB			
11	NAVIGATION ACCURACY CATEGORY FOR POSITION			
12	(NAC_P) (specified in §B.2.3.10.7)			
13	LSB			
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	GEO FLAG (GEO = 0)			
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	NIC SUPPLEMENT (see §B.2.3.10.6)			
48	MSB			
49	NAVIGATION ACCURACY CATEGORY FOR VELOCITY			
50	LSB (NAC_V) (see §B.2.3.5.5)			
51	MSB SURVEILLANCE INTEGRITY LEVEL			
52	LSB (SIL) (see §B.2.3.10.9)			
53				
54	RESERVED			
55				
56				

PURPOSE: To provide velocity information for aircraft that are not equipped with 1 090 MHz ADS-B when the TIS-B service is based on high quality surveillance data.

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	

Note 1.— The "vertical rate" and "geometric height difference from barometric altitude" fields for surface aircraft do not need to be processed by TIS-B receivers.

Note 2.— When bit 36 = 0, then bits 37 – 56 contain the fields shown in the left hand side of this page. When bit 36 = 1, then bits 37 – 56 contain the fields shown below.

Bit		
36	GEO FLAG (GEO = 1)	
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	NIC SUPPLEMENT (see §B.2.3.10.6)	
48	RESERVED	
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

Table B-3-4b. TIS-B velocity messages (Subtypes 3 and 4: Air Referenced Velocity)

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	IMF (specified in §B.3.4.4.2)			
10	MSB			
11	NAVIGATION ACCURACY CATEGORY FOR POSITION			
12	(NAC_P) (specified in §B.2.3.10.7)			
13	LSB			
14	HEADING STATUS BIT: 0 = Not Available, 1 = Available			
15	MSB = 180 degrees			
16				
17				
18	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	GEO FLAG (GEO = 0)			
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	NIC SUPPLEMENT (see §B.2.3.10.6)			
48	MSB			
49	NAVIGATIONAL ACCURACY CATEGORY FOR VELOCITY			
50	LSB (NAC_V) (see §B.2.3.5.5)			
51	MSB SURVEILLANCE INTEGRITY LEVEL (SIL)			
52	LSB (see §B.2.3.10.9)			
53	RESERVED			
54				
55	TRUE/MAGNETIC HEADING (0 = True, 1 = Magnetic)			
56	RESERVED			

PURPOSE: To provide velocity information for aircraft that are not equipped with 1 090 MHz ADS-B when the TIS-B service is based on high quality surveillance data.

Subtype shall be coded as follows:

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

Note 1.— The "vertical rate" and "geometric height difference from barometric altitude" fields for surface aircraft do not need to be processed by TIS-B receivers

Note 2.— When bit 36 = 0, then bits 37 – 56 contain the fields shown in the left hand side of this page. When bit 36 = 1, then bits 37 – 56 contain the fields shown below.

Bit		
36	GEO FLAG (GEO = 1)	
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	NIC SUPPLEMENT (see §B.2.3.10.6)	
48	RESERVED	
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

Table B-3-5. TIS-B coarse airborne position message

MB FIELD

1	IMF (see §B.3.4.1.1)
2	MSB SURVEILLANCE STATUS
3	LSB (see Annex 10, Volume IV, §3.1.2.8.6.3.1.1)
4	MSB
5	SERVICE VOLUME ID (SVID)
6	(see §B.3.4.5.2)
7	LSB
8	MSB
9	
10	
11	
12	PRESSURE-ALTITUDE
13	
14	(This is the altitude code (AC) as specified in §3.1.2.6.5.4
15	of Annex 10, Volume IV, but with the M-bit removed)
16	
17	
18	
19	LSB
20	GROUND TRACK STATUS (1 = valid, 0 = invalid)
21	MSB
22	
23	GROUND TRACK ANGLE
24	(see §B.3.4.5.5)
25	LSB
26	MSB
27	
28	GROUND SPEED
29	(see §B.3.4.5.6)
30	
31	LSB
32	CPR FORMAT (F) (0 = even, 1 = odd)
33	MSB
34	
35	
36	
37	
38	CPR ENCODED LATITUDE
39	
40	(see §B.3.4.5.7)
41	
42	
43	
44	LSB
45	MSB
46	
47	
48	
49	
50	CPR ENCODED LONGITUDE
51	
52	(see §B.3.4.5.7)
53	
54	
55	
56	LSB

PURPOSE: To provide airborne position information for aircraft that are not equipped with 1 090 MHz ADS-B when the TIS-B service is based on moderate quality surveillance data.

Surveillance status shall be coded as follows:

0 = No condition information
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.

B.4. ADS-B REBROADCAST (ADS-R) FORMATS AND CODING

B.4.1 INTRODUCTION

Notes. —

1.— This section defines the formats and coding for an ADS-B Rebroadcast (ADS-R) Service based on the same 112-bit 1 090 MHz extended squitter signal transmission that is used for ADS-B messages on 1 090 MHz.

2.— ADS-R complements the operation of ADS-B and TIS-B by providing ground-to-air rebroadcast of ADS-B data about aircraft that are not equipped for 1 090 MHz extended squitter ADS-B, but are equipped with an alternate form of ADS-B (e.g. universal access transceiver (UAT)). The basis for the ADS-R transmission is the ADS-B report received at the ground station using a receiver compatible with the alternate ADS-B data link.

3.— The ADS-R ground-to-air transmissions use the same signal formats as the 1 090 MHz extended squitter ADS-B and can therefore be accepted by a 1 090 MHz ADS-B receiving subsystem, with the exceptions identified in the following sections.

B.4.2 ADS-B REBROADCAST FORMAT DEFINITIONS

ADS-B rebroadcast information shall be transmitted using the 112-bit Mode S DF=18 format.

B.4.3 CONTROL FIELD ALLOCATION

The content of the DF=18 transmission shall be defined by the value of the control field (CF). ADS-B rebroadcast transmissions shall use CF=6.

B.4.4 ADS-B REBROADCAST SURVEILLANCE MESSAGE DEFINITIONS

Note.— The rebroadcast of ADS-B information on the 1 090 MHz extended squitter data link is accomplished by utilizing the same ADS-B message formats defined in the tables in Section 2 of this appendix, with the exception of the need to transmit an indication to the 1 090 MHz receiving subsystem as to the type of identity associated with the aircraft data being reported in the ADS-B rebroadcast message. This identification is performed using the ICAO/Mode A flag (IMF), which is defined in §B.3.3.1.

B.4.4.1 REBROADCAST AIRBORNE POSITION MESSAGE

The ME Field of the rebroadcast airborne position message shall be formatted as specified in Table A-2-5, except that ME bit 8 shall be redefined to be the ICAO/Mode A flag (IMF). This bit shall be defined as follows:

IMF = 0 shall indicate that the ADS-B rebroadcast data is identified by an ICAO 24-bit address.

IMF = 1 shall indicate that the ADS-B rebroadcast data is identified by an anonymous 24-bit address, or ground vehicle address, or fixed obstruction address.

B.4.4.2 REBROADCAST SURFACE POSITION MESSAGE

The ME field of the rebroadcast surface position message shall be formatted as specified in Table B-2-6, except that ME bit 21 is redefined to be the ICAO/Mode A flag (IMF). Coding of IMF flag shall be as specified in §B.4.4.1.

B.4.4.3 REBROADCAST AIRCRAFT IDENTIFICATION AND CATEGORY MESSAGE

The ME field of the rebroadcast aircraft identification and category message shall be formatted as specified in Table B-2-8.

Note.— A rebroadcast aircraft identification and category message does not contain the IMF bit since aircraft using an anonymous 24-bit address will not provide identity and category information.

B.4.4.4 REBROADCAST AIRBORNE VELOCITY MESSAGE

The ME field of the rebroadcast airborne velocity messages shall be formatted as specified in Table B-2-9a for subtype 1 & 2 messages, and in Table B-2-9b for subtype 3 & 4 messages, except that ME bit 9 is redefined to be the ICAO/Mode A flag (IMF). Coding of IMF flag shall be as specified in §B.4.4.1.

B.4.4.5 REBROADCAST AIRCRAFT STATUS MESSAGE

The ME field of the rebroadcast aircraft status message (subtype=1) shall be formatted as specified in Table B-2-97a, except that ME bit 56 is redefined to be the ICAO/Mode A flag (IMF). Coding of IMF flag shall be as specified in §B.4.4.1.

B.4.4.6 RESERVED FOR THE REBROADCAST TARGET STATE AND STATUS MESSAGE

B.4.4.7 REBROADCAST AIRCRAFT OPERATIONAL STATUS MESSAGE

The ME field of the rebroadcast aircraft operational status message shall be formatted as specified in Table B-2-101, except that ME bit 56 is redefined to be the ICAO/Mode A flag (IMF). Coding of IMF flag shall be as specified in §B.4.4.1.

Appendix C

IMPLEMENTATION GUIDELINES

C.1 INTRODUCTION

C.1.1 GENERAL

C.1.1.1 This appendix provides implementation guidelines on data formats for applications using Mode S specific services and extended squitter contained in Appendices A and B of this document.

C.1.1.2 The appendix contains implementation guidelines for the following:

a) Transponder Comm-B registers and extended squitter;

b) Mode S specific protocols;

c) Mode S broadcast protocols; and

d) Extended squitter ground stations.

C.1.1.3 The appendix is intended for use by the avionics industry and by the developers of air traffic services (ATS) applications.

C.1.2 MODE S SPECIFIC SERVICES OVERVIEW

C.1.2.1 Mode S specific services are data link services that can be accessed by a separate dedicated interface to the Mode S subnetwork. On the ground they can also be accessed via the aeronautical telecommunication network (ATN). They operate with a minimum of overhead and delay and use the link efficiently, which makes them highly suited to ATS applications.

C.1.2.2 There are three categories of service provided:

a) *Ground-initiated Comm-B (GICB) protocol.* This service consists of defined data available on board the aircraft being put into one of the 255 transponder registers (each with a length of 56 bits) in the Mode S transponder at specified intervals by a serving process, e.g. airborne collision avoidance system (ACAS) or the aircraft data link processor (ADLP). A Mode S ground interrogator or an ACAS unit can extract the information from any of these transponder registers at any time and pass it for onward transmission to ground-based or aircraft applications.

b) *Mode S specific protocols (MSPs)*. This service uses one or more of the 63 uplink or downlink channels provided by this protocol to transfer data in either short- or long-form MSP packets from the ground data link processor (GDLP) to the ADLP or vice versa.

c) *Mode S broadcast protocol.* This service permits a limited amount of data to be broadcast from the ground to all aircraft. In the downlink direction, the presence of a broadcast message is indicated by the transponder, and this message can be extracted by all Mode S systems that have the aircraft in coverage at the time. An identifier is included as the first byte of all broadcasts to permit the data content and format to be determined.

C.1.2.3 In the case of an uplink broadcast, the application on board the aircraft will not be able to determine, other than on an interrogator identifier (II) or surveillance identifier (SI) code basis, the source of an interrogation. When necessary, the data source must be identified within the data field. On the downlink, however, the originating aircraft is known due to its aircraft address.

C.1.3 EXTENDED SQUITTER OVERVIEW

Extended squitter is an ADS-B system utilizing the frequencies and formats of the Mode S system for broadcasting ADS-B information. The result is an integrated approach for surveillance that permits aircraft equipped with a Mode S transponder and an acceptable navigations source to participate in both ADS-B and beacon ground environments. This facilitates a smooth transition from a beacon-based to an ADS-B based environment. In addition, extended squitter can support hybrid surveillance. Hybrid surveillance is a technique for allowing ACAS to use passive ADS-B surveillance for non-threatening aircraft to reduce its active interrogation rate.

C.2 DATA FORMATS FOR TRANSPONDER REGISTERS

C.2.1 TRANSPONDER REGISTER ALLOCATION

Applications have been allocated transponder register numbers as specified in §A.2.1.

Note 1.— The transponder register number is equivalent to the Comm-B data selector (BDS) value used to address that transponder register (see §3.1.2.6.11.2.1 of Annex 10, Volume IV).

Note 2.— Data requirements and availability for the data to be entered into transponder registers are shown in §A.2.1.

C.2.2 GENERAL CONVENTIONS ON DATA FORMATS

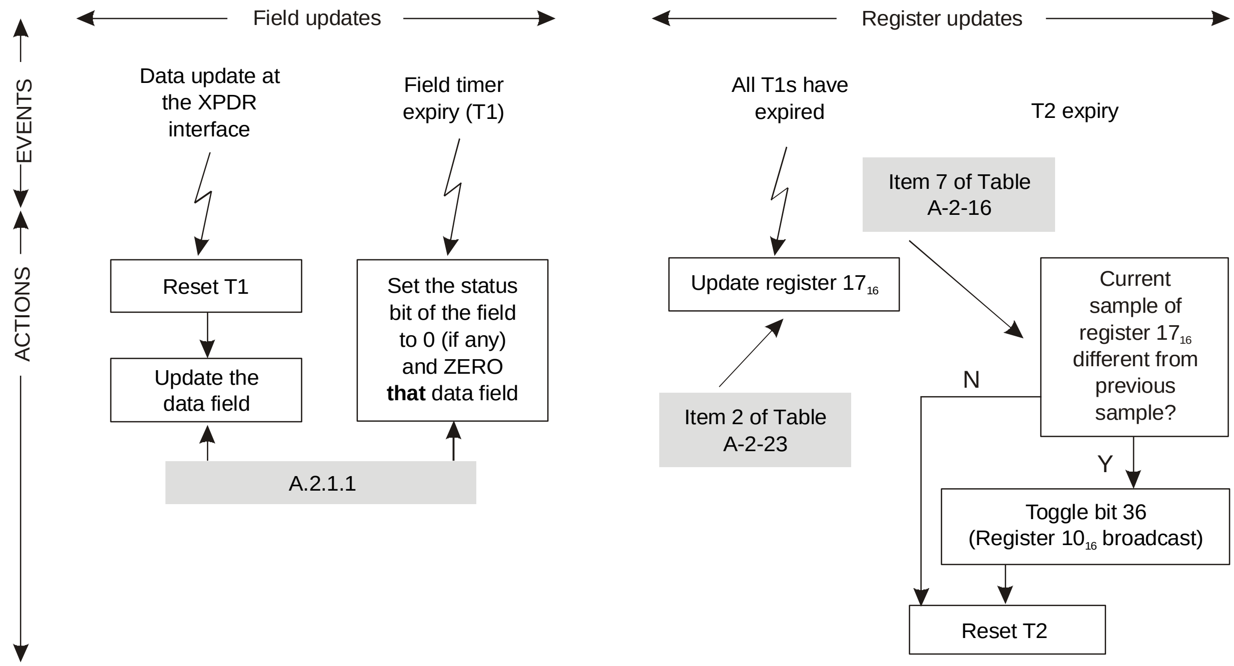
C.2.2.1 VALIDITY OF DATA

The bit patterns contained in the 56-bit transponder registers are considered as valid application data only if they comply with the conditions specified in Appendix A. Figure C-1 is a summary of the provisions contained in Appendix A with respect to the loading and clearing of data into the transponder register.

C.2.2.2 REPRESENTATION OF NUMERICAL DATA

Numerical data are represented as follows:

Whenever applicable, the resolution for data fields has been aligned with ICAO documents or with corresponding ARINC 429 labels. Unless otherwise specified in the individual table, where ARINC 429 labels are given in the tables, they are given as an example for the source of data for that particular field. Other data sources providing equivalent data may be used.



T1 = a time no greater than twice the specified maximum update interval or 2s (whichever is the greater) — T1 is actually the contribution of the transponder to the data age. There are as many T1 timers as data fields in the transponder register.

T2 = approximately 60s — used to control register 17 changes

Shaded boxes show the corresponding sections of Appendix A.

Figure C-1. Detailed process for the clearing and loading of data in the fields of transponder register

C.2.3 DATA SOURCES FOR TRANSPONDER REGISTERS

Tables C-1-1 to C-1-6 show possible ARINC labeled data sources that can be used to derive the required data fields in the transponder registers. Alternatives are given where they have been identified.

C.2.4 FOR TRANSPONDER REGISTER FORMATTING

C.2.4.1 TRANSPONDER REGISTER 10_{16}

The following sections state the requirements and guidance material that apply for the setting of some specific bits of transponder register 10_{16}. These requirements are contained in Table A-2-16 of Appendix A or Annex 10, Volume IV.

C.2.4.1.1 Bit 9 (continuation flag)

This bit should be set as specified in Table A-2-16 of Appendix A.

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 is reserved as a 'continuation flag' to indicate if the subsequent register can be extracted. For example: upon detection of bit 9=1 in register 10_{16} then register 11_{16} can be extracted. If bit 9=1 in register 11_{16} then register 12_{16} can 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.

As long as transponder registers 11_{16} to 16_{16} are undefined, bit 9 should be set to 0.

C.2.4.1.2 Bit 16 and bits 37-40 (ACAS bits)

The setting of these bits is dynamic. They are set by ACAS and possibly overwritten by the transponder.

C.2.4.1.3 Bits 17-23 (Mode S subnetwork version number)

These bits should be set as specified in Table A-2-16 of Appendix A.

17-23 Mode S subnetwork version number.

0 = Mode S subnetwork not available
1 = Version No. 1 (1996)
2 = Version No. 2 (1998)
3 = Version No. 3 (2002)
4 = Version No. 4 (2007), 1st Edition of this document
5-127 = Unassigned

The Mode S subnetwork version number should be set to a non-zero value if at least one DTE or Mode S specific service is installed. For example, if register 40_{16} is loaded with data, it means that the GICB service associated to register 40_{16} is installed. In that case bits 17-23 will be set to a non-zero value, e.g. value 3 if the format of register 40_{16} meets the requirements of Amendment 77 (applicable in 2002).

If the installed DTE or the Mode S specific services meet the requirements of Amendment 71 (applicable in 1996) only, then the Mode S subnetwork number should be set to 1.

If the installed DTE or the Mode S specific services meet the requirements of Amendment 73 (applicable in 1998) only and/or the transponder register formats meet the requirements of Doc 9688 version 1, then the Mode S subnetwork number should be set to 2.

If the installed DTE or the Mode S specific services meet the requirements of Amendment 77, then the Mode S subnetwork number should be set to 3.

The setting of these bits is static.

C.2.4.1.4 Bit 24 (Transponder enhanced protocol indicator)

This bit is set to 1 when the transponder is a level 5 transponder. This bit is set by the transponder itself. It is a static bit.

C.2.4.1.5 BIT 25 (MODE S SPECIFIC SERVICES CAPABILITY)

This bit should be set as specified in Table A-2-16, item 2 of Appendix A.

When bit 25 is set to 1, it indicates that at least one Mode S specific service is supported and the particular capability reports should be checked.

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

This bit actually indicates if the aircraft installation enables the loading of airborne parameters in at least one register not accessed by the BDS codes mentioned above.

The setting of this bit is preferably static.

C.2.4.1.6 BITS 26-32 (UPLINK AND DOWNLINK ELM THROUGHPUT CAPABILITY)

Bits 26-28 indicate the uplink ELM average throughput capability. These bits are set by the transponder and are preferably static.

Bits 29-32 indicate the throughput capability of downlink ELM containing the maximum number of ELM segments that the transponder can deliver in response to an interrogation. These bits are set by the transponder and are preferably static.

C.2.4.1.7 BIT 33 (AIRCRAFT IDENTIFICATION CAPABILITY)

This bit should be set as required in Annex 10, Volume IV, §3.1.2.9.1.3:

Aircraft identification capability report. Transponders which respond to a ground-initiated request for aircraft identification shall report this capability in the data link capability report (Annex 10, Volume IV, §3.1.2.6.10.2.2.2) by setting bit 33 of the MB subfield to 1.

This bit actually indicates whether the aircraft installation supports an interface to load the aircraft identification into the transponder register 20_{16}. It does not take into account the consistency of the data loaded into the register.

The setting of this bit is preferably dynamic. In case it is statically handled it should be forced to 1.

When this bit is dynamic, it is always equal to bit 7 of register 17_{16}. It might be different from bit 25 of register 18_{16} since the bits of registers 18_{16} to $1C_{16}$ are not reset once they are set. If the interface availability changes during the flight, bit 33 of register 10_{16} and bit 7 of register 17_{16} will be updated accordingly whereas bit 25 of register 18_{16} will remain unchanged.

This is explained in notes 1 and 2 of §A.2.2.1.

Note 1.— The intent of the capability bits in register number 17_{16} is to indicate that useful data are contained in the corresponding transponder register. For this reason, each bit for a register is cleared if data becomes unavailable (see §A.2.5.4.1) and set again when data insertion into the register resumes.

Note 2.— A bit set in register numbers 18_{16} to $1C_{16}$ indicates that the application using this register has been installed on the aircraft. These bits are not cleared to reflect the real-time loss of an application, as is done for register number 17_{16} (see §A.2.5.4.2).

It is also to be noted that register 10_{16} will be broadcast twice following the interface availability change. The first time because bit 33 will change, then because bit 36 will also toggle approximately one minute later to indicate that the content of register 17_{16} has changed.

C.2.4.1.8 BIT 34 (SQUITTER CAPABILITY SUBFIELD)

This bit should be set as specified in Table A-2-16 of Appendix A.

The squitter capability subfield (SCS) is interpreted as follows:

0 = squitter registers are not updated
1 = squitter registers are being updated

SCS: This 1-bit squitter capability subfield reports the capability of the transponder to transmit extended squitter position reports. It shall be set to 1 if BDS registers 05 and 06 {HEX} have been updated within the last ten plus or minus one seconds. Otherwise, it shall be set to 0.

Bit 34 is therefore an AND of bits 1 and 2 of transponder register 17_{16} and the setting of this bit is dynamic.

Note that register 10_{16} will be broadcast twice in case bit 34 changes. The first time because bit 34 will change, then because bit 36 will also toggle one minute later to indicate that the content of register 17_{16} has changed.

C.2.4.1.9 BIT 35 (SI CODE CAPABILITY)

This bit should be set as specified in Table A-2-16 of Appendix A, item 6.

The surveillance identifier code (SIC) bit is interpreted as follows:

0 = no surveillance identifier code capability
1 = surveillance identifier code capability

SIC: This 1-bit surveillance identifier capability subfield reports the capability of the transponder to support the surveillance identifier (SI) codes.

The setting of this bit is static. If the transponder software version handles SI codes then this bit should be set to 1.

C.2.4.1.10 BIT 36 (COMMON USAGE GICB CAPABILITY REPORT)

This bit should be set as specified in Table A-2-16 of Appendix A, item 7.

Bit 36 toggles each time the common usage GICB capability report (BDS code 1,7) changes. To avoid the generation of too many broadcast capability report changes, BDS code 1,7 is sampled at approximately one minute intervals to check for changes. The setting of this bit is therefore dynamic.

C.2.4.2 TRANSPONDER REGISTER 18_{16} TO $1c_{16}$

The bits contained in Registers 18_{16} to $1C_{16}$ indicate the capability of the installation and are therefore specific to the platform on which the transponder is installed.

It is accepted that these bits can be set once the corresponding data has been received by the transponder over a period of time. This can happen at any time and not only during the power-on cycle of the transponder as equipment providing expected information could be powered-on later.

Once a bit is set, it remains set until the power-off of the transponder.

C.2.4.3 TRANSPONDER REGISTER 20_{16}

C.2.4.3.1 AIRBORNE FUNCTION

Annex 10, Volume IV requirements (Annex 10, Volume IV, §3.1.2.9.1.1) state the following for data in transponder register 20_{16}:

"AIS, aircraft identification subfield in MB. The transponder shall report the aircraft identification in the 48-bit (41-88) AIS subfield of MB. The aircraft identification transmitted shall be that employed in the flight plan. When no flight plan is available, the registration marking of the aircraft shall be inserted in this subfield.

Note.— When the registration marking of the aircraft is used, it is classified as 'fixed direct data' (3.1.2.10.5.1.1). When another type of aircraft identification is used, it is classified as 'variable direct data' (3.1.2.10.5.1.3)."

When the aircraft installation does not use an external source to provide the aircraft identification (most of the time it will be the call sign used for communications between pilot and controllers), the text above means that the aircraft identification is considered as variable direct data. It also means that such data characterize the flight condition of the aircraft (not the aircraft itself) and are therefore subject to dynamic changes. It further means that variable direct data are also subject to the following requirement when data become unavailable.

Paragraph §A.2.1.1 states:

"If data are not available for a time no greater than twice the specified maximum update interval or 2 seconds (whichever is the greater), the status bit (if specified for that field) shall indicate that the data in that field are invalid and the field shall be zeroed."

Therefore, if the external source providing the aircraft identification fails or delivers corrupted data, transponder register 20_{16} should be zeroed. It should not include the registration marking of the aircraft since the airborne installation has initially been declared as providing variable direct data for the aircraft identification.

The loss of the aircraft identification data will be indicated to the ground since transponder register 20_{16} will be broadcast following its change. If the registration marking of the aircraft was inserted in lieu of the call sign following a failure of the external source, it would not help the ground systems since the registration marking of the aircraft is not the information that was inserted in the aircraft flight plan being used by the ground ATC systems.

In conclusion, the aircraft identification is either fixed (aircraft registration) or variable direct data (call sign). It depends whether the aircraft installation uses a data source providing the call sign; if so, data contained in transponder register 20_{16} should meet the requirement of the SARPs. When data become unavailable because of a data source failure, transponder register 20_{16} should contain all zeros.

C.2.4.3.2 GROUND CONSIDERATIONS

Aircraft identification data can be used to correlate surveillance information with flight plan information. If the data source providing the aircraft identification fails, the aircraft identification information will no longer be available in the surveillance data flow. In this case, the following means could enable the ground system to continue correlating the surveillance and flight plan information of a given target.

If the aircraft identification is used to correlate surveillance and flight plan data, extra information such as the Mode A code, if any, and the ICAO 24-bit aircraft address of the target could be provided to the flight data processing system. This would enable the update of the flight plan of the target with this extra information.

In case the aircraft identification becomes unavailable, it would still be possible to correlate both data flows using (for example) the ICAO 24-bit aircraft address information to perform the correlation. It is therefore recommended that ground systems update the flight plan of a target with extra identification information that is available in the surveillance data flow, e.g. the ICAO 24-bit aircraft address, the Mode A code (if any) or the tail number (if available from transponder register 21_{16}).

This extra identification information might then be used in lieu of the aircraft identification information contained in transponder register 20_{16} in case the data source providing this information fails.

C.2.4.4 TRANSPONDER REGISTER NUMBER 40_{16}

Paragraph §C.2.4.4.1 gives a general example of what are the different selected altitudes and the relationship with the target altitude and introduces the meaning of the different parameters and notions used in this section.

Paragraphs §C.2.4.4.2, §C.2.4.4.3 and §C.2.4.4.4 provide more detailed information for some specific platforms.

C.2.4.4.1 GENERAL EXAMPLE FOR THE LOADING OF DATA IN REGISTER 40_{16}

Figure C-2 provides a general example for the loading of data in Register 40_{16}.
The goal of Figure C-2 is to clarify the differences between the FMS selected altitude and the FCU/MCP selected altitude, and also to clarify how the target altitude of the aircraft and the MCP/FCU mode bits are determined depending on the phase of flight in the vertical profile.

Notions and terms used:

— Cleared flight level: Flight level cleared by the controller, i.e. the flight level aircraft should reach and maintain.

— MCP/FCU selected altitude

- The Autopilot Flight Director System (AFDS) is more commonly known as autopilot (A/P). Its task is to laterally and vertically control the aircraft when selected by the crew. In general in modern aircraft, the AFDS is a system consisting of several individual Flight Control Computers (FCCs) and a single Flight Control Panel (FCP) mounted directly between the pilots just under the windshield. Fundamentally, the autopilot attempts to acquire or maintain target parameters determined either by manual inputs made by the pilot or by computations from the Flight Management System.

- MCP: Mode Control Panel is the usual name given on Boeing platforms to the FCP which provides control of the Autopilot, Flight Director, Altitude Alert and Autothrottle System. The MCP is used to select and activate Autopilot Flight Director System (AFDS) modes and establish altitudes, speeds and climb/descent profiles.

- FCU: Flight Control Unit is similar to MCP but for Airbus platforms.

- MCP/FCU selected altitude: The altitude set by pilots on the MCP/FCU controlling the auto-pilot system. In the great majority of cases pilots set the MCP/FCU altitude to the altitude cleared by Air Traffic Control (ATC) before engaging a vertical mode. The autopilot will try to reach this MCP/FCU selected altitude using different selectable vertical modes: constant vertical rate (e.g. V/S), Flight Level change at a given airspeed (e.g. FL CH), vertical path given by the FMS (VNAV), and maintain it using the altitude hold mode (ALT HOLD).

  Note.— If the aircraft is not equipped with an autopilot this information may be derived from equipment generating an alert when the FL is reached (e.g. altitude alerter system).

— FMS selected altitude

- The Flight Management System (FMS or FMC for Flight Management Computer) is a computer onboard aircraft that controls the navigation, performance, flight planning, and guidance aspects of flight. The FMS navigation component determines where the aircraft is. The FMS performance component calculates necessary performance data. The FMS flight planning component allows for the creation and modification of flight plans. The FMS guidance component issues commands necessary to guide the aircraft along the route programmed into the FMS. The current and programmed paths of the aircraft are monitored three-dimensionally, by flying from waypoint to waypoint and by obeying crossing restrictions.

- The FMS guidance component will therefore compute selected altitude constraints to be reached at different points. This is known as FMS selected altitude. These selected altitudes are used to control the aircraft in specific modes of autopilot, for example, when Vertical Navigation mode (VNAV) is selected on MCP/FCU. VNAV mode is the highest level of vertical profile automation, and maximizes fuel economy.

— Target altitude: this is the next altitude at which the aircraft will level-off if in a climb or descent, or the aircraft current intended altitude if it is intending to hold its altitude.

- The target altitude may be:

  - The MCP/FCU selected altitude when the autopilot is directly controlled by command entered by the crew.

  - The FMS selected altitude when in VNAV or similar modes.

  - The current altitude.

  - Unknown.

— MCP/FCU mode bits:

- VNAV indicates when a VNAV or equivalent mode in which the A/P is controlled by FMS is selected.

- ALT HOLD indicates when A/P Alt Hold mode is selected. It does not correspond to a general altitude capture and does not cover VNAV hold situation.

- Approach indicates that a mode to capture ILS localizer and glide slope is engaged.

— Priority of MCP/FCU selected altitude on FMS selected altitude

The MCP/FCU selected altitude is the altitude that the aircraft shall not violate and therefore it has always priority on FMS selected altitude.

Explanation of the different steps in Figure C-2:

Generally, Figure C-2 shows a theoretical sequence of cases which should not be considered as a real operational sequence. For example, some steps may be more realistic when the aircraft is in descent.

Step 1: The MCP/FCU selected altitude has been set to first cleared flight level (FL100). The Autopilot/Flight Director is engaged and the aircraft is holding the latest MCP/FCU selected altitude which has been reached before step 1. The target altitude is the MCP/FCU selected altitude. VNAV mode is not engaged. The FMS selected altitude is not the target altitude.

Step 2: A new clear flight level has been allocated to the aircraft by ATC. The pilot has entered this value into the MCP/FCU resulting in a new MCP/FCU selected altitude. The pilot has engaged the VNAV mode. The aircraft speed/path is determined by the FMS. The FMS contains a flight path with an altitude restriction at a given waypoint (FL250). The FMS selected altitude corresponds to the associated altitude restriction. This FMS selected altitude is less than the MCP/FCU selected altitude and therefore becomes the target altitude to which the aircraft is climbing.

Step 3: There is an altitude restriction associated with a waypoint. The aircraft has captured and is maintaining the FMS selected altitude until crossing the waypoint. The VNAV mode remains active. In an operational environment, aircrew should also set the MCP/FCU altitude to the intermediate levels on a stepped climb SID if workload permits.

Step 4: The waypoint with restricted altitude is passed. A new FMS selected altitude is now valid. The aircraft resumes its climbing to try to reach this new FMS selected altitude. VNAV mode is still engaged. Although the aircraft is trying to reach the FMS selected altitude (FL350) it will level off at the MCP/FCU selected altitude, which is lower than the FMS selected altitude, therefore the selected altitude is the MCP/FCU selected altitude.

Step 5: The MCP/FCU selected altitude is lower than the FMS selected altitude. The aircraft therefore first approaches this MCP/FCU selected altitude which is a limit to not violate. This MCP/FCU altitude is captured and held by the aircraft. This automatically disengages the VNAV mode.

Step 6: The flight crew has disengaged the autopilot and is flying the aircraft manually. The target altitude is not known. However on an operational point of view it must be noted that such mode would not be allowed in regulated airspace unless the aircrew had declared an emergency or had obtained a new ATC clearance. In the latter case the ATC clearance should be entered in the MCP/FCU. It is more probable that this case may happen on a “descent when ready” profile. In all cases, the MCP/FCU selected altitude may still be useful because it should be the value used in the altitude alerter.

Step 7: The pilot selects altitude hold (Alt Hold or equivalent mode) making the current altitude equivalent to the target altitude. Note that although MCP/FCU selected altitude could become the same (pilot entering the new flight level in the MCP/FCU) this is not mandatory and, therefore, only altitude represents with full confidence the level the aircraft is maintaining.

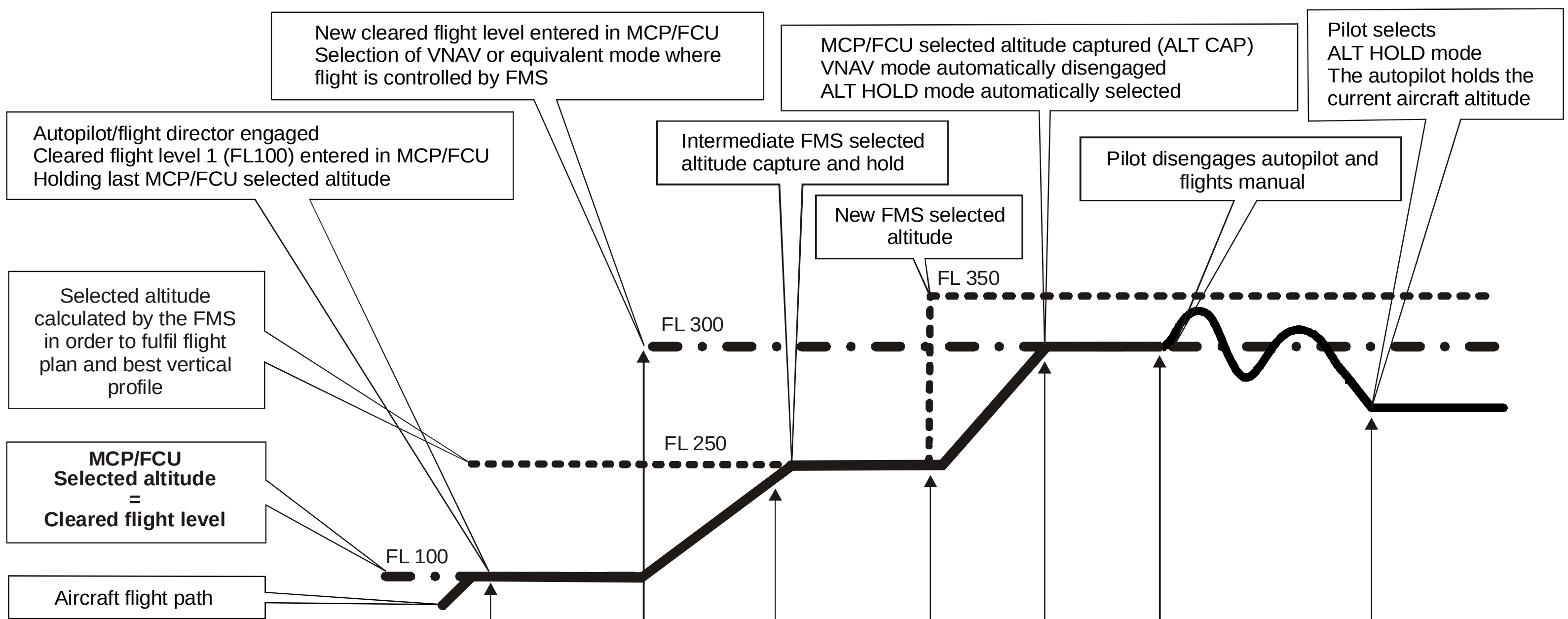
C.2.4.4.1.1 Target Altitude Summary

If MCP/FCU altitude is between your current altitude and FMS Selected Altitude, then the target altitude is MCP/FCU. If VNAV is engaged and the previous case is not in effect, then FMS is the target altitude. If Alt Hold is selected and the current altitude is not equal to either of the selected altitudes, then target altitude is altitude.

General example for the loading of data in register 40_{16}

Hypothesis on information available to transponder

The FMS selected altitude (calculated by the FMS) and the target altitude source information are available on aircraft buses (this is not necessarily the case today) as well as the MCP/FCU mode bits. Bits 48 and 54 are set to 1 all the time with this hypothesis. The reverse hypothesis would require bits 48–51 and bits 54–56 to be all set to 0 and the FMS selected altitude field to be all zeroed.



Register 40_{16} content	MCP/FCU selected altitude		100	300	300	300	300	300	300
	FMS selected altitude		250	250	250	350	350	350	350
	MCP/FCU mode bits	Provided	1	1	1	1	1	1	1
		VNAV	0	1	1	1	0	0	0
		Alt hold	1	0	0	0	1	0	1
		Approach	0	0	0	0	0	0	0
	Target altitude (Unknown, Altitude, FCU/MCP, FMS)		FCU/MCP	FMS	FMS	FCU/MCP	FCU/MCP	Unknown	Altitude
	Step		**1**	**2**	**3**	**4**	**5**	**6**	**7**

Figure C-2. General example for the loading of data in register 40_{16}

C.2.4.4.1.2 Possible uses of selected altitude and target altitude

1. MCP/FCU selected altitude will be downlinked as an additional read-back in order to check that the cleared flight level has been correctly understood and entered in the airborne system by the pilot.

2. Target altitude and associated mode of flight may be of interest to reduce the Short Term Conflict Alert false alarm rate.

C.2.4.4.1.3 Target altitude implementation difficulties

It is recognized that all information to determine which altitude is the target altitude or which mode of flight is currently used may not always be available to the transponder in the current airborne implementation. In addition it may be very dependent on the platform. It is therefore preferable to set to 0 the corresponding bits of register 40_{16} rather than sending wrong information.

C.2.4.4.2 TRANSPONDER REGISTER NUMBER 40_{16} ON AIRBUS AIRCRAFT

C.2.4.4.2.1 Target altitude

In order to clarify how aircraft intention information is reported in transponder register 40_{16} a mapping (Table C-2) has been prepared to illustrate, for a number of conditions:

a) how the altitude data are derived that are loaded into transponder register 40_{16}, and

b) how the corresponding source bits are set.

C.2.4.4.2.1.1 A330/A340 family

Table C-2. Transponder register number 40_{16} on Airbus A330/340 aircraft

Auto pilot or flight director status	*Auto pilot or flight director vertical mode*	*Conditions: vertical status/altitude (FCU, FMS or aircraft)*	*Target altitude used*	*Bit 55*	*Bit 56*
(AP on and FD on/off) or (AP off and FD on)	Vertical speed (V/S)	V/S > (<) 0 with FCU ALT > (<) A/C ALT	FCU ALT	1	0
		V/S > (<) 0 with FCU ALT < (>) A/C ALT	/	0	0
		V/S = 0	A/C ALT	0	1
	Flight path angle (FPA)	FPA > (<) 0 with FCU ALT > (<) A/C ALT	FCU ALT	1	0
		FPA > (<) 0 with FCU ALT < (>) A/C ALT	/	0	0
		FPA = 0	A/C ALT	0	1
	Altitude acquire (ALT CAPT)	Aircraft operating with FCU altitude	FCU ALT	1	0
	Altitude acquire (ALT CAPT)	Aircraft capturing a constrained altitude imposed by the FMS	FMS ALT	1	1

Auto pilot or flight director status	*Auto pilot or flight director vertical mode*	*Conditions: vertical status/altitude (FCU, FMS or aircraft)*	*Target altitude used*	*Bit 55*	*Bit 56*
	Altitude hold (ALT)		A/C ALT	0	1
	Descent (DES)	FCU ALT > next FMS ALT	FCU ALT	1	0
		FCU ALT ≤ next FMS ALT	FMS ALT	1	1
		No next FMS ALT	FCU ALT	1	0
	Open descent (OPEN DES)	Mode used to descend directly to the FCU ALT disregarding the computed descent path and FMS constraints	FCU ALT	1	0
	Climb (CLB)	FCU ALT < next FMS ALT	FCU ALT	1	0
		FCU ALT ≥ next FMS ALT	FMS ALT	1	1
		No next FMS ALT	FCU ALT	1	0
	Open climb (OPEN CLB)	Mode used to climb directly to the FCU ALT disregarding the computed descent path and FMS constraints	FCU ALT	1	0
	Take off (TO)	FCU ALT < next FMS ALT	FCU ALT	1	0
		FCU ALT ≥ next FMS ALT	FMS ALT	1	1
		No next FMS ALT	FCU ALT	1	0
	Go around (GA)	FCU ALT > A/C ALT and FCU ALT < next FMS ALT	FCU ALT	1	0
		FCU ALT > A/C ALT and FCU ALT ≥ next FMS ALT	FMS ALT	1	1
		FCU ALT > A/C ALT and no next FMS ALT	FCU ALT	1	0
		FCU ALT ≤ A/C ALT	/	0	0
	Other vertical modes (final approach, land, glide slope)		/	0	0
AP off and FD off			/	0	0

C.2.4.4.2.1.2 A320 family

Table C-3. Transponder register number 40_{16} on Airbus A320 aircraft

Auto pilot or flight director status	*Auto pilot or flight director vertical mode*	*Conditions: vertical status/altitude (FCU, FMS or aircraft)*	*Target altitude used*	*Bit 55*	*Bit 56*
(AP on and FD on/off) or (AP off and FD on)	Vertical speed (V/S)	V/S > (<) 0 with FCU ALT > (<) A/C ALT	FCU ALT	1	0
		V/S > (<) 0 with FCU ALT < (>) A/C ALT	/	0	0
		V/S = 0	A/C ALT	0	1

Auto pilot or flight director status	*Auto pilot or flight director vertical mode*	*Conditions: vertical status/altitude (FCU, FMS or aircraft)*	*Target altitude used*	*Bit 55*	*Bit 56*
	Flight path angle (FPA)	FPA > (<) 0 with FCU ALT > (<) A/C ALT	FCU ALT	1	0
		FPA > (<) 0 with FCU ALT < (>) A/C ALT	/	0	0
		FPA = 0	A/C ALT	0	1
	Altitude acquire (ALT CAPT)	Aircraft operating with FCU altitude	FCU ALT	1	0
	Altitude acquire (ALT CAPT)	Aircraft capturing a constrained altitude imposed by the FMS	FMS ALT	1	1
	Altitude hold (ALT)		A/C ALT	0	1
	Descent (DES) or immediate descent (IM DES)	FCU ALT > next FMS ALT	FCU ALT	1	0
		FCU ALT ≤ next FMS ALT	FMS ALT	1	1
		No next FMS ALT	FCU ALT	1	0
	Open descent (OPEN DES) or expedite (EXP)	Mode used to descend directly to the FCU ALT disregarding the computed descent path and FMS constraints	FCU ALT	1	0
	Climb (CLB) or immediate climb (IM CLB)	FCU ALT < next FMS ALT	FCU ALT	1	0
		FCU ALT ≥ next FMS ALT	FMS ALT	1	1
		No next FMS ALT	FCU ALT	1	0
	Open climb (OPEN CLB) or expedite (EXP)	Mode used to climb directly to the FCU ALT disregarding the computed descent path and FMS constraints	FCU ALT	1	0
	Take off (TO)	FCU ALT < next FMS ALT	FCU ALT	1	0
		FCU ALT ≥ next FMS ALT	FMS ALT	1	1
		No next FMS ALT	FCU ALT	1	0
	Go around (GA)	FCU ALT > A/C ALT and FCU ALT < next FMS ALT	FCU ALT	1	0
		FCU ALT > A/C ALT and FCU ALT ≥ next FMS ALT	FMS ALT	1	1
		FCU ALT > A/C ALT and no next FMS ALT	FCU ALT	1	0
		FCU ALT ≤ A/C ALT	/	0	0
	Other vertical modes (final approach, land, glide slope)		/	0	0
AP off and FD off			/	0	0

The A320 (see Table C-3) has two additional modes compared to the A330/A340:

- The Expedite Mode: it climbs or descends at, respectively, “green dot” speed or V_{max} speed.

- The Immediate Mode: it climbs or descends immediately while respecting the FMS constraints.

C.2.4.4.2.1.3 Synthesis

Tables C-2 and C-3 show the following:

a) Depending on the AP/FD vertical modes and some conditions, the desired "target" altitude might differ. Therefore a logical software combination should be developed in order to load the appropriate parameter in transponder register 40_{16} with its associated source bit value and status.

b) A large number of parameter values are required to implement the logic: the V/S, the FCU ALT, the A/C ALT, the FPA, the FMS ALT and the AP/FD status and vertical modes. The following labels might provide the necessary information to satisfy this requirement:

1. V/S: label 212 (Vertical Rate) from ADC

2. FCU ALT: label 102 (Selected Altitude) from FCC

3. A/C ALT: label 361 (Inertial Altitude) from IRS/ADIRS

4. FPA: label 322 (Flight Path Angle) from FMC

5. FMS ALT: label 102 (Selected Altitude) from FMC

6. AP/FD: labels 272 (Auto-throttle modes), 273 (Arm modes) and 274 (Pitch modes).

The appropriate "target" altitude should, whatever its nature (A/C, FMS or FCU), be included in a dedicated label (e.g. 271) which would be received by the GFM that will then include it in transponder register 40_{16}. A dedicated label (such as label 271) could then contain the information on the source bits for target altitude. This is demonstrated graphically in Figure C-3.

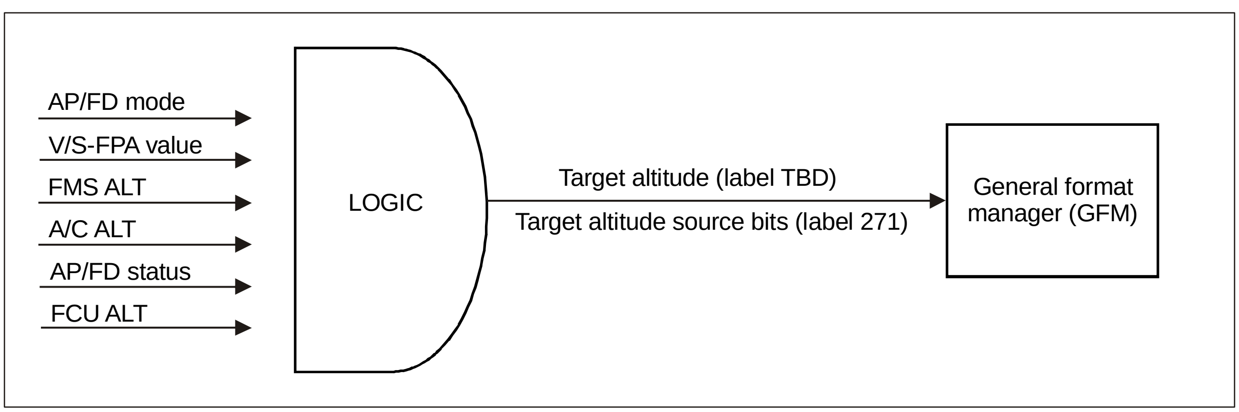


Figure C-3. Logic to derive the target altitude data information

C.2.4.4.2.2 Selected altitude from the altitude control panel

When selected altitude from the altitude control panel is provided in bits 1 to 13, the status and mode bits (48 – 51) may be provided from the following sources:

	A320	*A340*
Status of altitude control panel mode bits (bit 48)	SSM labels 273/274	SSM labels 274/275
Managed vertical mode (bit 49)	Label 274 bit 11 (climb) Label 274 bit 12 (descent) Bus FMGC A	Label 275 bit 11 (climb) Label 275 bit 15 (descent) Bus FMGEC G GE-1
Altitude hold mode (bit 50)	Label 274 bit 19 (Alt mode) Bus FMGC A	Label 275 bit 20 (Alt hold) Bus FMGEC G GE-1
Approach mode (bit 51)	Label 273 bit 23 Bus AFS FCU	Label 273 bit 15 Bus AFS FCU

C.2.4.4.3 TRANSPONDER REGISTER NUMBER 40_{16} ON BOEING 747-400, 757 AND 767 AIRCRAFT

In order to clarify how selected altitude information from the altitude control panel and target altitude is reported in transponder register 40_{16}, a mapping has been prepared to illustrate how the status and mode bits can be derived.

Transponder register bit no.	*Description*	*Label*
48	Status of mode bits	SSM of 272 and 273
49	Managed vertical mode	272 bit 13
50	Altitude hold mode	272 bit 9 / 273 bit 19
51	Approach mode	272 bit 9 / 273 bit 19
54	Status of target altitude source bits	SSM of new label (TBD)
55 56	Target altitude source bits	New label (TBD)

The selected altitude from the mode control panel may be obtained from label 102 (source ID 0A1). The status bit may be derived from the SSM of label 102.

C.2.4.4.4 SETTING OF THE TARGET ALTITUDE SOURCE BITS (BITS 54-56)

These bits should be set as required in Appendix A, Table A-2-64, item 5:

Bit 54 indicates 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, indicate target altitude source:

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

Aircraft which are not equipped with the logic described in §C.2.4.3.1 and §C.2.4.3.2 are not able to determine the target altitude source of the aircraft. In that case bit 54 should be set to 0 (no source information provided) and bits 55 and 56 should be set to 00 (unknown).

C.2.4.5 TRANSPONDER REGISTER 50_{16}

When ARINC 429 data is used an example implementation is the following:

BDS bit no.	Data bit no.	Description
1	STATUS	1 = valid data
2	SIGN	1 = left (left wing down)
3		MSB=45 degrees
4		
5		Roll angle
6		ARINC label 325
7		
8		Range = [-90, +90]
9		
10		
11		LSB = 45/256 degrees
12	STATUS	1 = valid data
13	SIGN	1 = west (e.g. 315°= -45°)
14		MSB = 90 degrees
15		
16		
17		True track angle
18		ARINC label 313
19		
20		Range = [-180, +180]
21		
22		
23		LSB = 90/512 degrees
24	STATUS	1 = valid data
25		MSB = 1 024 kt
26		
27		
28		Ground speed
29		ARINC label 312
30		
31		Range = [0, 2 046]
32		
33		
34		LSB = 1 024/512 = 2kt
35	STATUS	1 = valid data
36	SIGN	1 = minus

BDS bit no.	Data bit no.	Description
37		MSB = 8 degrees/s
38		
39		Track angle rate
40		ARINC label 335
41		
42		Range = [-16, +16]
43		
44		
45		LSB = 8/256 degrees
46	STATUS	1 = valid data
47		MSB = 1 024 kt
48		
49		True air speed
50		ARINC label 210
51		
52		Range = [0, 2 046]
53		
54		
55		
56		LSB = 1 024/512 = 2 kt

The status bits are determined as explained in §A.2.2.2. The data is rounded as specified in §A.2.2.2. The encoding accuracy of the data in the subfield is ±½ LSB by rounding.

For ARINC GAMA configuration, label 335 is not used for the track angle rate but for another parameter. For this particular ARINC configuration the track angle rate field should be loaded with all zeroes. In such cases, ground applications can compute the equivalent of the track angle rate thanks to the true air speed and the roll angle information.

C.2.4.6 TRANSPONDER REGISTER 60_{16}

When ARINC 429 data is used an example, implementation is the following:

BDS bit no.	Data bit no.	Description
1	STATUS	1 = valid data
2	SIGN	1 = West (eg.315 degrees= -45 degrees)
3		MSB = 90 degrees
4		
5		
6		Magnetic heading
7		ARINC label 320
8		
9		Range = [-180, +180]
10		
11		
12		LSB = 90/512 degrees
13	STATUS	1 = valid data
14		MSB = 512 kt
15		
16		
17		Indicated airspeed
18		ARINC label 206
19		
20		Range = [0, 1 023]
21		
22		
23		LSB = 512/512 = 1 kt

BDS bit no.	Data bit no.	Description
24	STATUS	1 = valid data
25		MSB = 2.048
26		
27		Mach
28		ARINC label 205
29		
30		Range = [0, 4.092]
31		
32		
33		
34		LSB = 2.048/512
35	STATUS	1 = valid data
36	SIGN	1 = below
37		MSB = 8 192 ft/min
38		
39		Barometric altitude rate
40		ARINC label 212
41		
42		Range = [-16 384, +16 352]
43		
44		
45		LSB = 8 192/256 = 32 ft/min
46	STATUS	1 = valid data
47	SIGN	1 = below
48		MSB = 8 192 ft/min
49		
50		Inertial vertical velocity
51		ARINC label 365
52		
53		Range = [-16 384, +16 352]
54		
55		
56		LSB = 8 192/256 = 32 ft/min

The status bits are determined as explained in §A.2.2.2. The data is rounded as specified in §A.2.2.2. The encoding accuracy of the data in the subfield is ±½ LSB by rounding.

“Barometric Altitude Rate” contains values that are solely derived from barometric measurement. The Barometric Altitude Rate may be very unsteady and may suffer from barometric instrument inertia.

The “Inertial Vertical Velocity” also provides information on vertical attitude of the aircraft but it comes from equipment (IRS, AHRS) which use different sources used for navigation. The information is a more filtered and smoothed parameter.

C.2.4.7 COMPACT POSITION REPORTING (CPR) TECHNIQUE

C.2.4.7.1 INTRODUCTION TO CPR

CPR is a data compression technique used to reduce the number of bits needed for lat/lon reporting in the airborne and surface position squitters. Data compression is based upon truncation of the high order bits of latitude and longitude.

Airborne lat/lon reports are unambiguous over 666 km (360 NM). Surface reports are unambiguous over 166.5 km (90 NM). In order to maintain this ambiguity distance (and the values of the LSB), longitude must be re-scaled as latitude increases away from the equator to account for the compression of longitude.

C.2.4.7.2 LAT/LON ENCODING CONSIDERATIONS

C.2.4.7.2.1 Unambiguous range

The unambiguous ranges were selected to meet most of the needs of surveillance applications to be supported by ADS-B. To accommodate applications with longer range requirements, a global encoding technique has been included that uses a different encoding framework for alternate position encoding (labeled even and odd). A comparison of a pair of even and odd encoded position reports will permit globally unambiguous position reporting. When global decoding is used, it need only be performed once at acquisition since subsequent position reports can be associated with the correct 666 (or 166.5) km (360 (or 90) NM) patch. Re-establishment of global decoding would only be required if a track were lost for a long enough time to travel 666 km (360 NM) while airborne or 166.5 km (90 NM) while on the surface. Loss of track input for this length of time would lead to a track drop, and global decoding would be performed when the aircraft was required as a new track.

C.2.4.7.2.2 Reported position resolution

Reported resolution is determined by:

a) the needs of the user of this position information; and

b) the accuracy of the available navigation data.

For airborne aircraft, this leads to a resolution requirement of about 5 m. Surface surveillance must be able to support the monitoring of aircraft movement on the airport surface. This requires position reporting with a resolution that is small with respect to the size of an aircraft. A resolution of about 1 m is adequate for this purpose.

C.2.4.7.3 SEAMLESS GLOBAL ENCODING

While the encoding of lat/lon does not have to be globally unambiguous, it must provide consistent performance anywhere in the world including the polar regions. In addition, any encoding technique must not have discontinuities at the boundaries of the unambiguous range cells.

C.2.4.7.4 CPR ENCODING TECHNIQUES

C.2.4.7.4.1 Truncation

The principal technique for obtaining lat/lon coding efficiency is to truncate the high order bits, since these are only required for globally unambiguous coding. The approach is to define a minimum size area cell within which the position is unambiguous. The considerations in 2.4.7.2.1 and 2.4.7.3 have led to the adoption of a minimum cell size as a (nominal) square with a side of 666 km (360 NM) for airborne aircraft and 166.5 km (90 NM) for surface aircraft. This cell size provides an unambiguous range of 333 km (180 NM) and 83 km (45 NM) for airborne and surface aircraft, respectively.

Depending on receiver sensitivity, surveillance of aircraft at very long ranges may require the use of sector beam antennas in order to provide sufficient link reliability for standard transponder transmit power. The area covered by a sector beam provides additional information to resolve ambiguities beyond the 333 km (180 NM) range provided by the coding. In theory, use of a sector beam to resolve ambiguity could provide for an operating range of 666 km (360 NM). In practice, this range will be reduced to about 600 km (325 NM) to provide protection against squitter receptions through the sidelobes of the sector beams.

In any case, this is well in excess of the maximum operating range available with this surveillance technique. It is also well in excess of any operationally useful coverage since an aircraft at 600 km (325 NM) will only be visible to a surface receiver if the aircraft is at an altitude greater than 21 000 m (70 000 ft).

The elements of this coding technique are illustrated in Figure C-4. For ease of explanation, the figure shows four contiguous area cells on a flat earth. The basic encoding provides unambiguous position within the dotted box centered on the receiver, i.e. a minimum of 333 km (180 NM). Beyond this range, ambiguous position reporting can result. For example, an aircraft shown at A would have an ambiguous image at B. However, in this case the information provided by the sector antenna eliminates the ambiguity. This technique will work out to a range shown as the aircraft labeled C. At this range, the image of C (shown as D) is at a range where it could be received through the sidelobes of the sector antenna.

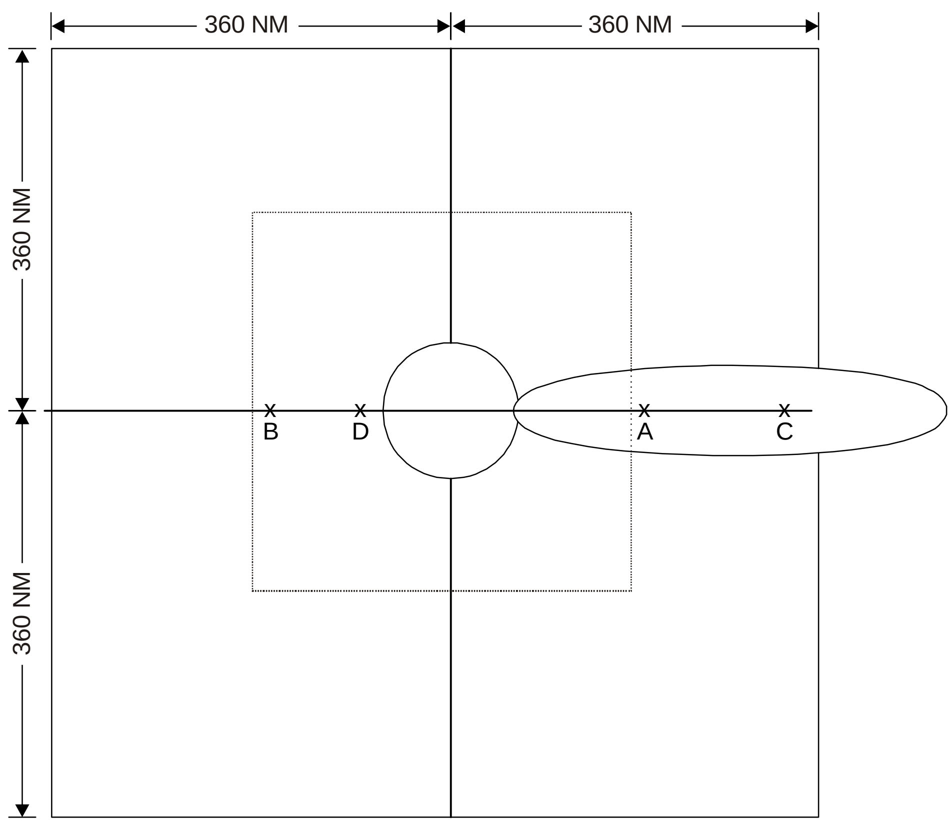


Figure C-4. Maximum range considerations for CPR encoding

C.2.4.7.5 BINARY ENCODING

Note.— For the rest of this appendix, 360 NM is not converted.

Once an area cell has been defined, nominally 360 by 360 NM, the encoding within the cell is expressed as a binary fraction of the aircraft position within the cell. This means that the aircraft latitude and longitude are all zeroes at a point when the aircraft is at the origin of the cell (the south west corner for the proposed encoding) and all ones at point one resolution step away from the diagonally opposite corner.

This provides the seamless transition between cells. This technique for seamless encoding is illustrated in Figure C-5 for the area cells defined above. For simplicity, only two-bit encoding is shown.

C.2.4.7.6 ENCODING

The above techniques would be sufficient for an encoding system if the Earth were a cube. However, to be consistent on a sphere, additional features must be applied to handle the change in longitude extent as latitudes increase away from the equator. The polar regions must also be covered by the coding.

All lines of longitude must have the same nominal radius, so the latitude extent of an area cell is constant. The use of a 360 NM minimum unambiguous range leads to 15 latitude zones from the equator to the poles.

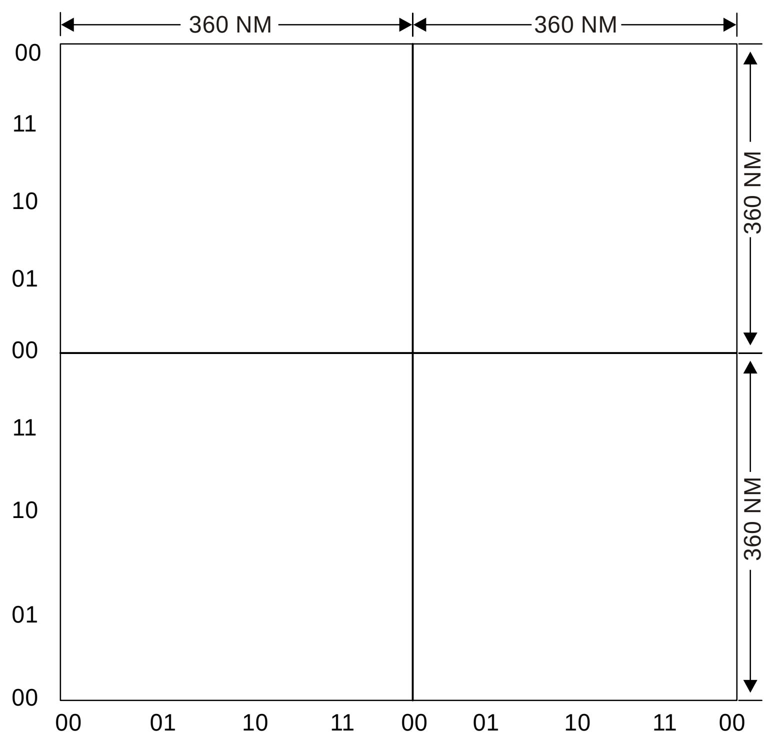


Figure C-5. CPR seamless encoding

Circles of latitude become smaller with increasing latitude away from the equator. This means that the maintenance of 360 NM between ambiguous positions requires that the number of longitude cells at a particular latitude decrease at latitudes away from the equator. In order to maintain minimum unambiguous range and resolution size, the vertical extent of a longitude cell is divided into latitude bands, each with an integral number of zones.

Longitude zone assignment versus latitude is illustrated in Figure C-6 for a simple case showing five of the latitude bands in the northern hemisphere. At the equator, 59 zones are used as required to obtain a minimum longitude dimension of 360 NM at the northern extent of the zone. In fact, it is that precise latitude at which the northern extent of the zone is 360 NM that defines the value of latitude A in the northern hemisphere (it would be the southern extent of the zone for the southern hemisphere). At latitude A, one less longitude zone is used. This number of zones is used until the northern (southern) extent of the longitude zone equals 360 NM, which defines latitude B. The process continues for each of the five bands.

For lines of longitude, 60 zones are used in the CPR system to give the desired cell size of 360 NM. For circles of latitude, only 59 zones can be used at the equator in order to assure that the zone size at the northern latitude limit is at least 360 NM. This process continues through each of 59 latitude bands, each defined by one less zone per latitude band than the previous. Finally, the polar latitude bands are defined as a single zone beyond 87 degrees north and south latitude. A complete definition of the latitude zone structure is given in Table C-4.

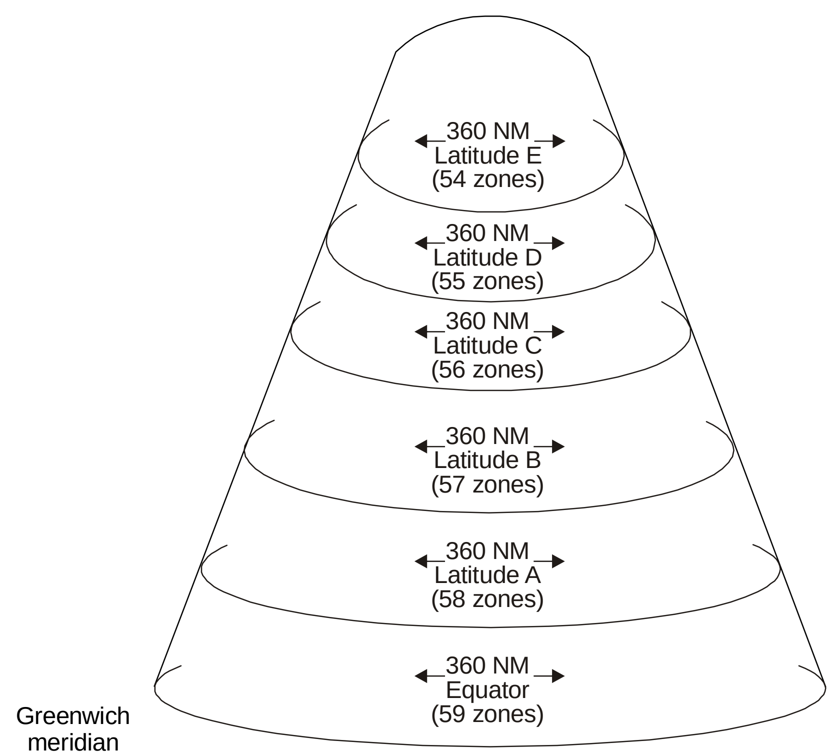


Figure C-6 Longitude zone size assignment versus latitude.

C.2.4.7.7 GLOBALLY UNAMBIGUOUS POSITION

Globally unambiguous position decoding is typically used to initially establish the position of a target. Once the target's position is determined it can be updated using local decoding. Local decoding may be used exclusively only when there is no possibility of message reception from targets farther than the ambiguous range of 180 NM. In applications where ADS-B messages are received more than 180 NM from the receiving station, it will be necessary to use globally unambiguous decoding.

The CPR system includes a technique for globally unambiguous coding. It is based on a technique similar to the use of different pulse repetition intervals (PRI) in radars to eliminate second-time-around targets. In CPR, this takes the form of coding the lat/lon using a different number of zones on alternate reports. Reports labeled T = 0 are coded using 15 latitude zones and a number of longitude zones defined by the CPR coding logic for the position to be encoded (59 at the equator). The reports on the alternate second (T = 1) are encoded using 14 zones for latitude and N – 1 zones for longitude, where N is the number used for T = 0 encoding. An example of this coding structure is illustrated in Figure C-7.

A user receiving reports of each type can directly decode the position within the unambiguous area cell for each report, since each type of report is uniquely identified. In addition, a comparison of the two types of reports will provide the identity of the area cell, since there is only one area cell that would provide consistent position decoding for the two reports. An example of the relative decoded positions for T = 0 and T = 1 is shown in Figure C-8.

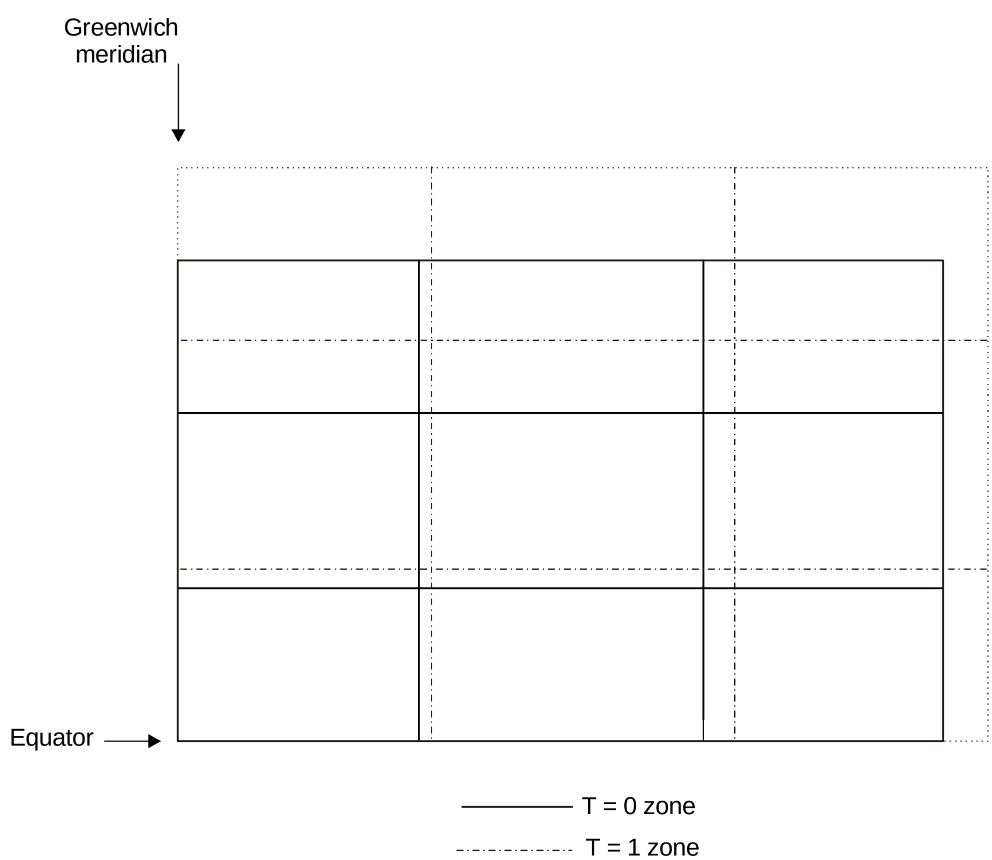


Figure C-7. Zone structure for globally unambiguous reporting.

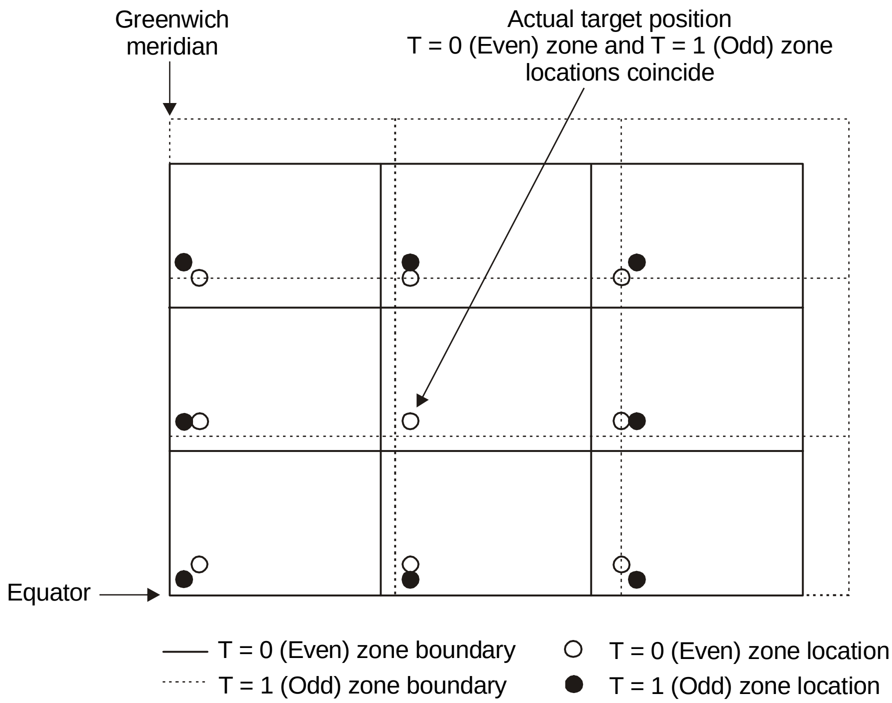


Figure C-8. Determination of globally unambiguous position from a *T* = 0 and *T* = 1 report.

C.2.4.7.8 SUMMARY OF CPR ENCODING CHARACTERISTICS

The CPR encoding characteristics are summarized as follows:

Lat/lon encoding	17 bits for each
Nominal airborne resolution	5.1 metres
Nominal surface resolution	1.2 metres
Maximum unambiguous encoded range, airborne	333 km (180 NM)
Maximum unambiguous encoded range, surface	83 km (45 NM)

Provision for globally unique coding using two reports from a T = 0 and T = 1 report.

Table C-4. Transition latitudes

Zone no.	*Transition latitude (degrees)*	*Zone no.*	*Transition latitude (degrees)*	*Zone no.*	*Transition latitude (degrees)*	*Zone no.*	*Transition latitude (degrees)*
59	10.4704713	44	42.8091401	29	61.0491777	14	76.3968439
58	14.8281744	43	44.1945495	28	62.1321666	13	77.3678946
57	18.1862636	42	45.5462672	27	63.2042748	12	78.3337408
56	21.0293949	41	46.8673325	26	64.2661652	11	79.2942823
55	23.5450449	40	48.1603913	25	65.3184531	10	80.2492321

Zone no.	*Transition latitude (degrees)*	*Zone no.*	*Transition latitude (degrees)*	*Zone no.*	*Transition latitude (degrees)*	*Zone no.*	*Transition latitude (degrees)*
54	25.8292471	39	49.4277644	24	66.3617101	9	81.1980135
53	27.9389871	38	50.6715017	23	67.3964677	8	82.1395698
52	29.9113569	37	51.8934247	22	68.4232202	7	83.0719944
51	31.7720971	36	53.0951615	21	69.4424263	6	83.9917356
50	33.5399344	35	54.2781747	20	70.4545107	5	84.8916619
49	35.2289960	34	55.4437844	19	71.4598647	4	85.7554162
48	36.8502511	33	56.5931876	18	72.4588454	3	86.5353700
47	38.4124189	32	57.7274735	17	73.4517744	2	87.0000000
46	39.9225668	31	58.8476378	16	74.4389342		
45	41.3865183	30	59.9545928	15	75.4205626		

C.3. IMPLEMENTATION GUIDELINES FOR APPLICATIONS

C.3.1 DATAFLASH

C.3.1.1 OVERVIEW

Dataflash is a service which announces the availability of information from air-to-ground on an event-triggered basis. This is an efficient means of downlinking information which changes occasionally and unpredictably.

A contract is sent to the airborne application through the Mode S transponder and the ADLP using an uplink Mode S specific protocol (MSP) (MSP 6, SR = 1) as specified in Annex 10 Volume III, Appendix to Chapter 5. This uplink MSP packet contains information specifying the events which should be monitored regarding the changes of data in a transponder register. When the event occurs, this is announced to the ground installation using the AICB protocol.

The ground installation may then request the downlink information which takes the form of a downlink MSP packet on channel 3 constituted of one or two linked Comm-B segments. The second segment is a direct copy of the relevant transponder register specified in the contract.

The ground system with the embedded dataflash application should determine if an aircraft supports the dataflash protocol as follows:

- if bit 25 of transponder register 10_{16} is set to 1, the system will extract transponder register $1D_{16}$, then,
- if bit 6 and bit 31 of transponder register $1D_{16}$ are set to 1, then the aircraft supports the dataflash service.

C.3.1.2 MINIMUM NUMBER OF CONTRACTS

The minimum number of contracts activated simultaneously that can be supported by the airborne installation should be at least 64. In the case of a software upgrade of existing installations, at least 16 dataflash contracts should be supported.

C.3.1.3 CONTRACT REQUEST FOR A TRANSPONDER REGISTER NOT SERVICED BY THE AIRBORNE INSTALLATION

On the receipt of a dataflash service request, a downlink dataflash message should immediately be announced to the ground regardless of any event criteria. This message is used by the ground system to confirm that the service has been initiated. The message will only consist of one segment. In the case of a service request for an unavailable transponder register, the message sent to the ground should only contain bits 1 to 40 of the downlink message structure with a CI field value of 2. This value will indicate to the ground system that the service request cannot be honored because of the unavailability of the transponder register. The service will then be terminated by the airborne dataflash function, and the ground system should notify the user which has initiated the request that the service request cannot be honored by the airborne installation.

When a transponder register (which was previously supported) becomes unavailable and is currently monitored by a dataflash contract, a downlink dataflash message containing bits 1 to 40 will be sent with a CI field value of 7. This will indicate to the ground that the transponder register is not serviced anymore. The related contract is terminated by the airborne application, and the ground system should notify the user which has initiated the request that the service request has been terminated by the airborne installation. An alternative means for the ground system to detect that the transponder register is not serviced any longer is to analyze the resulting transponder register 10_{16} which will be broadcast by the transponder to indicate to the ground system that transponder register 17_{16} has changed. The Mode S sensor should then extract transponder register 17_{16} and send it to the ground application. The ground application should then analyze the content of this transponder register and should notice that the transponder register monitored by a dataflash contract is no longer supported by the airborne installation.

C.3.1.4 SERVICE CONTINUITY IN OVERLAPPING COVERAGE WITH RADARS USING THE SAME II CODE

Depending on the system configuration the following guidance should be taken into account to ensure service continuity in overlapping coverage of radars working with the same II code.

C.3.1.4.1 RADAR WITH THE DATAFLASH APPLICATION EMBEDDED IN THE RADAR SOFTWARE

For this configuration it is necessary to manage the contract numbers which will be used by each station and to ensure that the same contract number for the same transponder register is not used by another sensor having overlapping coverage and working with the same II code. The reason for this is that a sensor has no means of detecting if a contract it has initialized has been overwritten by another sensor using an identical dataflash header. Also one sensor could terminate a contract because an aircraft is leaving its coverage and no other sensor would know that this contract had been closed. For this reason, no dataflash contract termination should be attempted by either sensor in order to ensure a service continuity.

When two ground stations with overlapping coverage and having the same II code each set up dataflash contracts with the same transponder register for the same aircraft, it is essential to ensure that the contract number is checked by each ground station prior to the closeout of any AICB which is announcing a dataflash message.

C.3.1.4.2 USE OF AN ATC CENTRE-BASED DATAFLASH APPLICATION

The ATC system hosting the dataflash application should manage the distribution of contract numbers for sensors operating with the same II code. This ATC system will also have the global view of the aircraft path within the ATC coverage to either initiate or close dataflash contracts when appropriate. This is the preferred configuration since a central management of the contract numbers is possible which also allows a clean termination of the contracts.

C.3.1.5 GROUND MANAGEMENT OF MULTIPLE CONTRACTS FOR THE SAME TRANSPONDER REGISTER

The ground system managing the dataflash application must ensure that when it receives a request from ground applications for several contracts to monitor different parameters, or different threshold criteria, related to the same transponder register for a particular aircraft/II code pair, it assigns a unique contract number for each contract sent to the aircraft.

C.3.1.6 SERVICE TERMINATION

There are three ways to terminate a dataflash service (one from the ground initiative, two from the airborne installation):

1. The ground can send an MSP with the ECS field set to 0 which means that the service is to be discontinued by the airborne installation.

2. The airborne installation will terminate the service with no indication to the ground system if any message is not extracted from the transponder by a ground interrogator within 30 seconds following the event specified in the dataflash contract (TZ timer).

3. When the transponder has not been selectively interrogated by a Mode S interrogator with a particular II code for 60 seconds (this is determined by monitoring the IIS subfield in all accepted Mode S interrogations), all dataflash contracts related to that II code will be cancelled with no indication to the ground system.

The termination from the ground initiative is the preferable way to terminate the service since both the ground and the airborne systems terminate the service thanks to a mutually understood data link exchange. This termination should nevertheless not be allowed in certain configurations especially with adjacent sensors (with the dataflash application embedded in the sensor software) working with the same II code as explained in §C.2.1. If the termination of the contract by a ground system is to be exercised, it should also be noticed that the ground system should anticipate the exit of the aircraft from its coverage to send the close-out message.

C.3.1.7 DATAFLASH REQUEST CONTAINING MULTIPLE CONTRACTS

It is possible to merge several contracts into one single dataflash request. If multiple events occur which are related to several contracts of the initial dataflash request, one downlink message for each individual event should be triggered containing the associated transponder register. Each of these downlink messages should use the air initiated protocol.

C.3.1.8 TRANSPONDER REGISTER DATA CONTAINED IN THE DOWNLINK MESSAGE

The transponder register data received by the ground system following the extraction of a downlink dataflash message consisting of two segments are the transponder register data at the time of the event. The transponder register data may be up to 1 aerial scan old since the event may occur just after the illumination of the aircraft. Should the end-user need more up-to-date data, the user should use the event announcement to trigger extraction via GICB protocol to get the latest transponder register data.

C.3.2 TRAFFIC INFORMATION SERVICE (TIS)

TBD

C.3.3 EXTENDED SQUITTER

TBD

Table C-1-1. MODE S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY

MODE-S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY																						
DATA REQUIREMENTS												*INPUT DATA SOURCE AVAILABILITY (See Note 1)*										
Register number (HEX)	*Assignment*	*Register field*	*ARINC word (Octal)*	*Parameter description*	*Signal format*	*Units*	*+ Sense*	*Range*	*Sig. Bits/ Dig.*	*Resolution*	*MAX TX INTVL- ms*	*GPS*	*FMC/ GNSS*	*IRS/ FMS*	*FMC GEN*	*ADS*	*Control panel*	*FCC/ MCP*	*DFS/ VHF*	*Weather*	*Maint comp*	*Notes*
00	Not valid		N/A	N/A	N/A							N/A										
01	Unassigned		N/A	N/A	N/A							N/A										
02	Linked Comm-B, Segment 2		N/A	N/A	N/A							N/A										
03	Linked Comm-B, Segment 3		N/A	N/A	N/A							N/A										
04	Linked Comm-B, Segment 4		N/A	N/A	N/A							N/A										
05	Extended Squitter Airborne Position	Type	130	Autonomous Horizontal Integrity Limit	BNR	NM	+	16	17	0.0001221	1200	1	2	3								2
			136	Vertical Figure of Merit	BNR	feet	+	32,768	18	0.125	1200	1	2	3								2
			247	Horizontal Figure of Merit	BNR	NM	+	16	18	6.1035E-5	1200	1	2	3								2
			167	Estimated Position Uncertainty	BNR	NM	+	0-128	16	0.00195	TBD		1	3	2							2
		Surveillance Status	N/A	N/A	N/A							N/A										3
		Single Antenna Flag	N/A	N/A	N/A							N/A										4
		Altitude	370	GNSS Height (HAE)	BNR	feet	UP	+/- 131,072	20	0.125	1200	1	2	3								
			203	Altitude (1013.25 hPa) (barometric)	BNR	feet	UP	+131,072	17	1.0	62.5			2		1						
		Encoded Latitude	110	GNSS Latitude, Coarse	BNR	degrees	N	+/- 180	20	0.00017166	1200	1	2	3								
			120	GNSS Latitude, Fine	BNR	degrees	+	0.000172	11	8.3819E-8	1200	1	2	3								
			010	Latitude, Present Position	BCD	degrees	N	180N — 180S	6	0.1	500		1	3	2							
			310	Latitude, Present Position	BNR	degrees	N	0 — 180N/ 0 — 180S	20	0.00017166	200		1	3	2							
		Encoded Longitude	111	GNSS Longitude, Coarse	BNR	degrees	E	+/- 180	20	0.00017166	1200	1	2	3								
			121	GNSS Longitude, Fine	BNR	degrees	+	0.000172	11	8.3819E-8	1200	1	2	3								
			011	Longitude, Present Position	BCD	degrees	E	180E — 180W	6	0.1	500		1	3	2							
			311	Longitude, Present Position	BNR	degrees	E	0 — 180E/ 0 — 180W	20	0.00017166	200		1	3	2							
		CPR Format	N/A	N/A	N/A								1	3	2							
		Time	150	UTC	BNR	hr:min:s	+	23:59:9	17	1.0 second	1200	1	2	3								5

MODE-S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY																						
DATA REQUIREMENTS												INPUT DATA SOURCE AVAILABILITY (See Note 1)										
Register number (HEX)	Assignment	Register field	ARINC word (Octal)	Parameter description	Signal format	Units	+ Sense	Range	Sig. Bits/ Dig.	Resolution	MAX TX INTVL- ms	GPS	FMC/ GNSS	IRS/ FMS	FMC GEN	ADS	Control panel	FCC/ MCP	DFS/ VHF	Weather	Maint comp	Notes
		Encoded Latitude/ Longitude	103	GNSS Track Angle	BNR	degrees	CW-N	+/- 180	15	0.00549316	1200	1	2	3								5
			112	GNSS Ground Speed	BNR	knots	+	4,096	15	0.125	1200	1	2	3								5
			312	Ground Speed	BNR	knots	+	4,096	15	0.125	50		1	3	2							5
			012	Ground Speed	BCD	knots	+	0 — 7000	4	1.0	500		1	3	2							5
			313	True Track Angle	BNR	deg./180	+	+/- 180	12	0.05	50		1	3	2							5
			013	True Track Angle	BCD	degrees	+	0 — 359.9	4	0.1	500		1	3	2							5
			210	True Airspeed	BNR	knots	+	2,048	15	0.0625	125			2	1							5
			206	Computed Airspeed	BNR	knots	+	1,024	14	0.0625	125			2	1							5
			166	GNSS N/S Velocity	BNR	knots	N	+/- 4,096	15	0.125	1200	1	2	3								6
			174	GNSS E/W Velocity	BNR	knots	E	+/- 4,096	15	0.125	1200	1	2	3								6
			366	N/S Velocity	BNR	knots	N	+/- 4,096	15	0.125	200		1	3	2							6
			367	E/W Velocity	BNR	knots	E	+/- 4,096	15	0.125	200		1	3	2							6

Table C-1-2. MODE S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY (Continued)

MODE-S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY (continued)																						
DATA REQUIREMENTS												*INPUT DATA SOURCE AVAILABILITY (See Note 1)*										
Register number (HEX)	*Assignment*	*Register field*	*ARINC Word (Octal)*	*Parameter description*	*Signal format*	*Units*	*+ Sense*	*Range*	*Sig. Bits/ Dig.*	*Resolution*	*MAX TX INTVL- ms*	*GPS*	*FMC/ GNSS*	*IRS/ FMS/*	*FMC GEN*	*ADS*	*Control panel*	*FCC/ MCP/*	*DFS/ VHF*	*Weather*	*Maint comp*	*Notes*
		Type	130	Autonomous Horizontal Integrity Limit	BNR	NM	+	16	17	0.0001221	1200	1		2								2
			136	Vertical Figure of Merit	BNR	feet	+	32,768	18	0.125	1200	1		2								2
			247	Horizontal Figure of Merit	BNR	NM	+	16	18	6.1035E-5	1200	1		2								2
			167	Estimated Position Uncertainty	BNR	NM	+	0-128	16	0.00195	TBD		1	3	2							2
		Movement	112	GNSS Ground Speed	BNR	knots	+	4,096	15	0.125	1200	1	2	3								5
			312	Ground Speed	BNR	knots	+	4,096	15	0.125	50		1	3	2							5
			012	Ground Speed	BCD	knots	+	0 — 7000	4	1.0	500		1	3	2							5,7
		Ground Track	103	GNSS Track Angle	BNR	degrees	CW-N	+/- 180	15	0.00549316	1200	1	2	3								5,8
			313	True Track Angle	BNR	deg./180	+	+/- 180	12	0.05	50		1	3	2							5,8
			013	True Track Angle	BCD	degrees	+	0 — 359.9	4	0.1	500		1	3	2							5,8
		Encoded Latitude	110	GNSS Latitude, Coarse	BNR	degrees	N	+/- 180	20	0.00017166	1200	1	2	3								
			120	GNSS Latitude, Fine	BNR	degrees	+	0.000172	11	8.3819E-8	1200	1	2	3								
	Extended Squitter		010	Latitude, Present Position	BCD	degrees	N	180N — 180S	6	0.1	500		1	3	2							
06	Surface Position		310	Latitude, Present Position	BNR	degrees	N	0 — 180N/ 0 — 180S	20	0.00017166	200		1	3	2							
		Encoded Longitude	111	GNSS Longitude, Coarse	BNR	degrees	E	+/- 180	20	0.00017166	1200	1	2	3								
			121	GNSS Longitude, Fine	BNR	degrees	+	0.000172	11	8.3819E-8	1200	1	2	3								
			011	Longitude, Present Position	BCD	degrees	E	180E — 180W	6	0.1	500		1	3	2							
			311	Longitude, Present Position	BNR	degrees	E	0 — 180E/ 0 — 180W	20	0.00017166	200		1	3	2							
		CPR Format	N/A	N/A	N/A							N/A										
		Time	150	UTC	BNR	hr:min:s	+	23:59:9	17	1.0 second	1200	1	2	3								
		Encoded Latitude/ Longitude	103	GNSS Track Angle	BNR	degrees	CW-N	+/- 180	15	0.00549316	1200	1	2	3								5
			112	GNSS Ground Speed	BNR	knots	+	4,096	15	0.125	1200	1	2	3								5
			312	Ground Speed	BNR	knots	+	4,096	15	0.125	50		1	3	2							5
			012	Ground Speed	BCD	knots	+	0 — 7000	4	1.0	500		1	3	2							5
			313	True Track Angle	BNR	deg./180	+	+/- 180	12	0.05	50		1	3	2							5
			013	True Track Angle	BCD	degrees	+	0 — 359.9	4	0.1	500		1	3	2							5
			210	True Airspeed	BNR	knots	+	2,048	15	0.0625	125			2		1						5

MODE-S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY (continued)																						
DATA REQUIREMENTS												INPUT DATA SOURCE AVAILABILITY (See Note 1)										
Register number (HEX)	Assignment	Register field	ARINC Word (Octal)	Parameter description	Signal format	Units	+ Sense	Range	Sig. Bits/ Dig.	Resolution	MAX TX INTVL- ms	GPS	FMC/ GNSS	IRS/ FMS/	FMC GEN	ADS	Control panel	FCC/ MCP/	DFS/ VHF	Weather	Maint comp	Notes
			206	Computed Airspeed	BNR	knots	+	1,024	14	0.0625	125			2		1						5
			166	GNSS N/S Velocity	BNR	knots	N	+/- 4,096	15	0.125	1200	1	2	3								6
			174	GNSS E/W Velocity	BNR	knots	E	+/- 4,096	15	0.125	1200	1	2	3								6
			366	N/S Velocity	BNR	knots	N	+/- 4,096	15	0.125	200		1	3	2							6
			367	E/W Velocity	BNR	knots	E	+/- 4,096	15	0.125	200		1	3	2							6
07	Extended Squitter Status	Transmission Rate Type Subfield	N/A	N/A	N/A							N/A										9
			370	GNSS Height (HAE)	BNR	feet	UP	+/- 131,072	20	0.125	1200	1	2	3								
			203	Altitude 1013.25 (hPa) (Barometric)	BNR	feet	UP	+131,072	17	1.0	62.5			2		1						
08	Extended Squitter Aircraft Identification And Category	Characters 1 — 8	233	Flight Identification Word #1	See ARINC 718A Attachment 4A							See Note 17										
			234	Flight Identification Word #2	See ARINC 718A Attachment 4A							See Note 17										
			235	Flight Identification Word #3	See ARINC 718A Attachment 4A							See Note 17										12
			236	Flight Identification Word #4	See ARINC 718A Attachment 4A							See Note 17										
		Characters 9 — 10	237	Flight Identification Word #5	Reserved for Flight Identification Characters 9 and 10							See Note 17										
		Characters 1 — 8	301	Aircraft Identification Word #1	See Note 13 and 14							See Note 13 and 14										
			302	Aircraft Identification Word #2	See Note 13 and 14							See Note 13 and 14										13, 14
			303	Aircraft Identification Word #3	See Note 13 and 14							See Note 13 and 14										
		Characters 1 — 8	360	Flight Number Character 1 — 8	See ARINC 429P1, Attachment 6 Flight Identification							See Note 17										12
		Aircraft Category	TBD	TBD	TBD							TBD										

Table C-1-3. MODE S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY (Continued)

MODE-S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY (continued)																						
DATA REQUIREMENTS												*INPUT DATA SOURCE AVAILABILITY (See Note 1)*										
Register number (HEX)	*Assignment*	*Register field*	*ARINC Word (Octal)*	*Parameter description*	*Signal format*	*Units*	*+ Sense*	*Range*	*Sig. Bits/ Dig.*	*Resolution*	*MAX TX INTVL- ms*	*GPS*	*FMC/ GNSS*	*IRS/ FMS/*	*FMC GEN*	*ADS*	*Control panel*	*FCC/ MCP/*	*DFS/ VHF*	*Weather*	*Maint comp*	*Notes*
09	Extended Squitter Airborne Velocity (Subtype 1 and 2)	Subtype	112	GNSS Ground Speed	BNR	knots	+	4,096	15	0.125	1200	1	2	3								
			312	Ground Speed	BNR	knots	+	4,096	15	0.125	50		1	3	2							
			012	Ground Speed	BCD	knots	+	0 — 7000	4	1.0	500		1	3	2							
		$NUC_{VELOCITY}$	TBD	Navigation Uncertainty Category_Velocity	TBD								1	3	2							
		E/W Velocity	174	GNSS E/W Velocity	BNR	knots	E	+/–4,096	15	0.125	1200	1	2	3								
			367	E/W Velocity	BNR	knots	E	+/–4,096	15	0.125	200		1	3	2							
		N/S Velocity	166	GNSS N/S Velocity	BNR	knots	N	+/–4,096	15	0.125	1200	1	2	3								
			366	N/S Velocity	BNR	knots	N	+/–4,096	15	0.125	200	1	2	3								
		Vertical Rate	165	GNSS Vertical Velocity	BNR	Ft./min.	UP	+/–32,768	15	1.0	1200	1	2	3								
			365	Inertial Vertical Velocity	BNR	Ft./min.	+	+/–32,768	15	1.0	40		1	3	2							
			212	Altitude Rate, Barometric	BNR	Ft./min.	+	+/–32,768	11	16	62.5			2		1						
			232	Altitude Rate	BCD	Ft./min.	UP	+/–20,000	4	10.0	62.5			2		1						
		GNSS Alt Diff from	203	Altitude (1013.25 hPa) (Barometric)	BNR	feet	UP	+131,072	17	1.0	62.5			2		1						
		Baro Alt	370	GNSS Height (HAE)	BNR	feet	UP	+/–131,072	20	0.125	1200	1	2	3								
	Extended Squitter Airborne Velocity (Subtype 3 and 4)	Subtype	210	True Airspeed	BNR	knots	+	2,048	15	0.0625	125			2		1						5
			206	Computed Airspeed	BNR	knots	+	1,024	14	0.0625	125			2		1						5
		$NUC_{VELOCITY}$	TBD	Navigation Uncertainty Category_Velocity	TBD									1								
		E/W Velocity	174	GNSS E/W Velocity	BNR	knots	E	+/–4,096	15	0.125	1200	1	2	3								
			367	E/W Velocity	BNR	knots	E	+/–4,096	15	0.125	200		1	3	2							
		N/S Velocity	166	GNSS N/S Velocity	BNR	knots	N	+/–4,096	15	0.125	1200	1	2	3								
			366	N/S Velocity	BNR	knots	N	+/–4,096	15	0.125	200		1	3	2							
		Airspeed	210	True Airspeed	BNR	knots	+	2,048	15	0.0625	125			2		1						
			206	Computed Airspeed	BNR	knots	+	1,024	14	0.0625	125			2		1						
		Vertical Rate	165	GNSS Vertical Velocity	BNR	Ft./min.	UP	+/–32,768	15	1.0	1200	1	2	3								
			365	Inertial Vertical Velocity	BNR	Ft./min.	+	+/–32,768	15	1.0	40		1	3	2							
			212	Altitude Rate, Barometric	BNR	Ft./min.	+	+/–2,768	11	16	62.5			2		1						
			232	Altitude Rate	BNR	Ft./min.	UP	+/–20,000	4	10.0	62.5			2		1						
		GNSS Alt	203	Altitude (Barometric)	BNR	feet	UP	+131,072	17	1.0	62.5			2		1						

MODE-S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY (continued)																						
DATA REQUIREMENTS												INPUT DATA SOURCE AVAILABILITY (See Note 1)										
Register number (HEX)	Assignment	Register field	ARINC Word (Octal)	Parameter description	Signal format	Units	+ Sense	Range	Sig. Bits/ Dig.	Resolution	MAX TX INTVL- ms	GPS	FMC/ GNSS	IRS/ FMS/	FMC GEN	ADS	Control panel	FCC/ MCP/	DFS/ VHF	Weather	Maint comp	Notes
		Diff From Baro Alt	076	GNSS Alt (MSL)	BNR	feet	UP	+/–31,072	20	0.125	1200	1	2	3								
			370	GNSS Height (HAE)	BNR	feet	UP	+/–131,072	20	0.125	1200	1	2	3								
		Magnetic	320	Magnetic Heading	BNR	Deg./180	+	+/– 180	15	0.00549316	50		1	3	2							
		Heading	014	Magnetic Heading	BCD	degrees	+	359.9	4	0.1	500		1	3	2							
0A	Extended Squitter Event Driven Information	N/A	N/A	N/A	N/A							N/A										
0B	Air/Air State Information 1	True Airspeed	210	True Airspeed	BNR	knots	+	2,048	15	0.0625	125			2		1						
			230	True Airspeed	BCD	knots	+	100 — 599	3	1.0	500			2		1						
		Heading	320	Magnetic Heading	BNR	Deg./180	+	+/– 180	15	0.00549316	50		1	3	2							
			014	Magnetic Heading	BCD	degrees	+	359.9	4	0.1	500		1	3	2							
			314	True Heading	BNR	Deg./180	+	+/– 180	15	0.00549316	50		1	3	2							
			044	True Heading	BCD	degrees	+	359.9	4	0.1	500		1	3	2							
		True Track Angle	103	GNSS Track Angle	BNR	degrees	CW-N	+/– 180	15	0.00549316	1200	1	2	3								
			313	True Track Angle	BNR	deg./180	+	+/– 180	12	0.05	50		1	3	2							20
			013	True Track Angle	BCD	degrees	+	0 — 359.9	4	0.1	500		1	3	2							20
		Ground Speed	112	GNSS Ground Speed	BNR	knots	+	4,096	15	0.125	1200	1	2	3								
			312	Ground Speed	BNR	knots	+	4,096	15	0.125	50		1	3	2							
			012	Ground Speed	BCD	knots	+	0 — 7000	4	1.0	500		1	3	2							

Table C-1-4. MODE S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY (Continued)

MODE-S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY (continued)																						
DATA REQUIREMENTS												*INPUT DATA SOURCE AVAILABILITY (See Note 1)*										
Register number (HEX)	*Assignment*	*Register field*	*ARINC Word (Octal)*	*Parameter description*	*Signal Format*	*Units*	*+ Sense*	*Range*	*Sig. Bits/ Dig.*	*Resolution*	*MAX TX INTVL- ms*	*GPS*	*FMC/ GNSS*	*IRS/ FMS*	*FMC GEN*	*ADS*	*Control panel*	*FCC/ MCP*	*DFS/ VHF*	*Weather*	*Maint comp*	*Notes*
0C	Air/Air State Information 2	Level Off Altitude	025	Selected Altitude	BCD	feet	+	0 – 50,000	5	1.0	200			2				1				
			102	Selected Altitude	BNR	feet	+	65,536	16	1.0	200			2				1				
		Next Course	024	Selected Course	BCD	degrees	+	0 – 359	3	1.0	200			2				1				
			023	Selected Heading	BCD	degrees	+	0 – 359	3	1.0	200			2				1				
			101	Selected Heading	BNR	Deg./180	+	+/– 180	12	0.05	62.5			2				1				
			100	Selected Course	BNR	Deg./180	+	+/– 180	12	0.05	333			2				1				
		Time to Next Waypoint	002	Time to Go (TTG)	BCD	Min.	+	0 – 399.9	4	0.1	200		1	3	2							
		Vertical Velocity	212	Altitude Rate, Barometric	BNR	Ft./min.	+	+/– 32,768	11	16	62.5			2		1						
			365	Inertial Vertical Velocity	BNR	Ft./min.	+	+/– 32,768	15	1.0	40		1	3	2							
			165	GNSS Vertical Velocity	BNR	Ft./min.	UP	+/– 32,768	15	1.0	1200	1	2	3								
		Roll Angle	325	Roll Angle	BNR	Deg./180	Right	+/– 180	14	0.01	20		1	3	2							
0D -to- 0E	Reserved for Air/Air State Info	N/A	N/A	N/A	N/A							N/A										
0F	Reserved for ACAS	N/A	N/A	N/A	N/A							N/A										
10	Data Link Capability Report	N/A	N/A	N/A	N/A							See Note 18										
11 -to- 16	Reserved for Extension to Data Link Capability Report	N/A	N/A	N/A	N/A							N/A										
17	Common Usage GICB Capability Report	N/A	N/A	N/A	N/A							N/A										
18 -to- 1F	Mode S Specific Services Capability Report	N/A	N/A	N/A	N/A							N/A										
20	Aircraft Identification	Characters 1 – 8	233	Flight Identification Word #1	See ARINC 718A Attachment 4A							See Note 17										
			234	Flight Identification Word #2	See ARINC 718A Attachment 4A							See Note 17										
			235	Flight Identification Word #3	See ARINC 718A Attachment 4A							See Note 17										12
			236	Flight Identification Word #4	See ARINC 718A Attachment 4A							See Note 17										
		Characters 9 - 10	237	Flight Identification Word #5	Reserved for Flight Identification Characters 9 and 10																	
		Characters 1 - 8	301	Aircraft Identification Word #1	See Note 13 and 14							See Note 13 and 14										
			302	Aircraft Identification Word #2	See Note 13 and 14							See Note 13 and 14										13, 14

MODE-S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY (continued)																						
DATA REQUIREMENTS												INPUT DATA SOURCE AVAILABILITY (See Note 1)										
Register number (HEX)	Assignment	Register field	ARINC Word (Octal)	Parameter description	Signal Format	Units	+ Sense	Range	Sig. Bits/ Dig.	Resolution	MAX TX INTVL- ms	GPS	FMC/ GNSS	IRS/ FMS	FMC GEN	ADS	Control panel	FCC/ MCP	DFS/ VHF	Weather	Maint comp	Notes
			303	Aircraft Identification Word #3	See Note 13 and 14							See Note 13 and 14										
		Characters 1 - 8	360	Flight Number Character 1 - 8	See ARINC 429P1, Attachment 6 Flight Identification							See Note 17										12
21	Aircraft Registration Number	Characters 1 - 8	301	Aircraft Identification Word #1	See Note 13 and 14							See Note 13 and 14										13, 14
			302	Aircraft Identification Word #2	See Note 13 and 14							See Note 13 and 14										
			303	Aircraft Identification Word #3	See Note 13 and 14							See Note 13 and 14										
		Airline Registration Characters 1 - 2	N/A	Airline Registrations	N/A							N/A										
22	Antenna Position		N/A	Antenna 1 - 4 Position Information	TBD							TBD										
25	Aircraft Type	Model Description	N/A	Aircraft Type / Model Information	TBD							TBD										
26 -to- 2F	Unassigned	N/A	N/A	N/A	N/A							N/A										
30	ACAS Active Resolution Advisory		N/A	N/A	N/A							N/A										
31 -to- 3F	Unassigned	N/A	N/A	N/A	N/A							N/A										
40	SELECTED VERTICAL INTENTION	MCP/FCU Selected Altitude	102	MCP/FCU Selected Altitude	BNR	feet	+	65,536	16	1.0	200			2				1				15
			025	Selected Altitude	BCD	feet	+	0 – 50,000	5	1.0	200			2				1				15
		FMS Selected Altitude	102	Selected Altitude	BNR	feet	+	65,536	16	1.0	200		1	3	2							19
		Barometric pressure setting MINUS 800 mb	234	Barometric Pressure Setting Minus 800 mb	BCD	millibars	+	750-1050	5	0.1	125							1				19
		VNAV MODE	272	From MCP of the FMC System.	DISC			N/A			100 Min			2				1				16
		APPROACH MODE	273	From MCP of the FMC System.	DISC			N/A			100 Min			2				1				16
		ALT HOLD MODE	272	From MCP of the FMC System.	DISC			N/A			100 Min			2				1				16
		Status of Target Altitude Source Bits			N/A							N/A										16
		Target Altitude Source			N/A							N/A										16

Table C-1-5. MODE S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY (Continued)

MODE-S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY (continued)																						
DATA REQUIREMENTS												INPUT DATA SOURCE AVAILABILITY (See Note 1)										
Register number (HEX)	*Assignment*	*Register field*	*ARINC Word (Octal)*	*Parameter description*	*Signal format*	*Units*	*+ Sense*	*Range*	*Sig. Bits/ Dig.*	*Resolution*	*MAX TX INTVL- ms*	*GPS*	*FMC/ GNSS*	*IRS/ FMS*	*FMC GEN*	*ADS*	*Control panel*	*FCC/ MCP*	*DFS/ VHF*	*Weather*	*Maint comp*	*Notes*
41	Next Waypoint Details	Character 1 — 9	TBD	TBD	TBD							TBD										
		Waypoint Latitude	TBD	TBD	TBD							TBD										
42	Next Waypoint Details	Waypoint Longitude	TBD	TBD	TBD							TBD										
		Waypoint Crossing Altitude	TBD	TBD	TBD							TBD										
43	Next Waypoint Details	Bearing to Waypoint	115	Waypoint Bearing	BNR	deg./180	+	+/– 80	12	0.05	200		1	3	2							
		Time to Go (TTG)	002	Time to Go (TTG) to Waypoint	BCD	min.	+	0 — 399.9	4	0.1	200		1	3	2							
		Distance to Go (DTG)	001	Distance to Go (DTG) to Waypoint	BCD	NM	+	+/– 3999.9	5	0.1	200		1	3	2							
44	Meteorological Routine Air Report	Wind Speed	315	Wind	BNR	knots	+	256	8	1.0	100		1	3	2							
		Wind Speed	015	Speed	BCD	knots	+	0 — 399	3	1.0	500		1	3	2							
		True Wind Direction	316	Wind	BNR	deg./180	CW-N	+/–180	8	0.7	100		1	3	2							
		True Wind Direction	016	Direction	BCD	degrees	+	0 — 359	3	1.0	500		1	3	2							
		Static Air Temperature	213	Static Air Temperature	BNR	deg. C	+	512	11	0.25	500			2		1						
		Average Static Pressure	217	Average Static Pressure	BNR	in. Hg.	+	64	16	0.0009765625	62.5			2		1						
			TBD	Turbulence	TBD									3		2				1		
		Humidity	113	Humidity	BNR	%	+	100	9	0.1953125				3		2				1		
45	Meteorological Hazard Report	Turbulence	TBD	Turbulence	TBD							TBD										
		Wind Shear	TBD	Wind Shear	TBD							TBD										
		Microburst	TBD	Microburst	TBD							TBD										
		Icing	TBD	Icing	TBD							TBD										
		Wake Vortex	TBD	Wake Vortex	TBD							TBD										
		Static Air Temperature	213	Static Air Temperature	BNR	deg. C	+	512	11	0.25	500			2		1						
		Average Static Pressure	217	Average Static Pressure	BNR	in. Hg.	+	64	16	0.0009765625	62.5			2		1						
		Radio	164	Radio Height	BNR	feet	+	8,192	16	0.125	50			2						1		
		Height	165	Radio Height	BCD	feet	+	+/– 999.9	5	0.1	200			2						1		
46	Reserved for Flight Management System_Mode 1	TBD	TBD	TBD	TBD							TBD										
47	Reserved for Flight Management System_Mode 2	TBD	TBD	TBD	TBD							TBD										

MODE-S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY (continued)																						
DATA REQUIREMENTS												*INPUT DATA SOURCE AVAILABILITY (See Note 1)*										
Register number (HEX)	*Assignment*	*Register field*	*ARINC Word (Octal)*	*Parameter description*	*Signal format*	*Units*	*+ Sense*	*Range*	*Sig. Bits/ Dig.*	*Resolution*	*MAX TX INTVL- ms*	*GPS*	*FMC/ GNSS*	*IRS/ FMS*	*FMC GEN*	*ADS*	*Control panel*	*FCC/ MCP*	*DFS/ VHF*	*Weather*	*Maint comp*	*Notes*
48	VHF Channel Report	VHF 1 — 3	030	VHF Comm Frequency	See ARINC 429									2					1			
			047	VHF Comm Frequency	See ARINC 429									2					1			
		Audio Status	N/A	Audio Status	N/A							N/A										
49 -to- 4F	Unassigned	N/A	N/A	N/A	N/A							N/A										
50	Track and Turn Report	Roll Angle	325	Roll Angle	BNR	deg./180	Right	+/–80	14	0.01	20		1	3	2							
		True Track	313	True Track Angle	BNR	deg./180	+	+/–180	12	0.05	50		1	3	2							
		Angle	013	True Track Angle	BCD	degrees	+	0 – 359.9	4	0.1	500		1	3	2							
			103	GNSS Track Angle	BNR	degrees	CW-N	+/–180	15	0.00549316	1200	1	2	3								
		Ground	112	GNSS Ground Speed	BNR	knots	+	4,096	15	0.125	1200	1	2	3								
		Speed	312	Ground Speed	BNR	knots	+	4,096	15	0.125	50		1	3	2							
			012	Ground Speed	BCD	knots	+	0 – 7000	4	1.0	500		1	3	2							
		Track Angle Rate	335	Track Angle Rate	BNR	deg./s	CW	+/–32	11	0.015	20		1	3	2							
		True	210	True Airspeed	BNR	knots	+	2,048	15	0.0625	125			2		1						
		Airspeed	230	True Airspeed	BCD	knots	+	100 – 599	3	1.0	500			2		1						
51	Position Report Coarse	Latitude	110	GNSS Latitude, Coarse	BNR	degrees	N	+/–180	20	0.00017166	1200	1	2	3								
			010	Latitude, Present Position	BCD	degrees	N	180N – 180S	6	0.1	500		1	3	2							
			310	Latitude, Present Position	BNR	degrees	N	0 – 180N/ 0 – 180S	20	0.00017166	200		1	3	2							
		Longitude	111	GNSS Longitude, Coarse	BNR	degrees	E	+/–180	20	0.00017166	1200	1	2	3								
			011	Longitude, Present Position	BCD	degrees	E	180E – 180W	6	0.1	500			1								
			311	Longitude, Present Position	BNR	degrees	E	0 – 180E/ 0 – 180W	20	0.00017166	200		1	3	2							
		Pressure-Altitude	203	Altitude (1013.25 hPa) (Barometric)	BNR	feet	UP	+131,072	17	1.0	62.5			2		1						

Table C-1-6. MODE S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY (Continued)

MODE-S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY (continued)																						
DATA REQUIREMENTS												*INPUT DATA SOURCE AVAILABILITY (See Note 1)*										
Register number (HEX)	*Assignment*	*Register field*	*ARINC Word (Octal)*	*Parameter description*	*Signal format*	*Units*	*+ Sense*	*Range*	*Sig. Bits/ Dig.*	*Resolution*	*MAX TX INTVL- ms*	*GPS*	*FMC/ GNSS*	*IRS/ FMS*	*FMC GEN*	*ADS*	*Control panel*	*FCC/ MCP*	*DFS/ VHF*	*Weather*	*Maint comp*	*Notes*
52	Position Report Fine	Latitude, Fine	120	GNSS Latitude, Fine	BNR	degrees	+	0.000172	11	8.3819E-8	1200	1	2	3								
		Longitude, Fine	121	GNSS Longitude, Fine	BNR	degrees	+	0.000172	11	8.3819E-8	1200	1	2	3								
		Pressure / GNSS	203	Altitude (1013.25 hPa) (Barometric)	BNR	feet	UP	+131,072	17	1.0	62.5			2		1						
		Altitude	370	GNSS Height (HAE)	BNR	feet	UP	+/–131,072	20	0.125	1200	1	2	3								
53	Air Referenced State Vector	Magnetic	320	Magnetic Heading	BNR	Deg./180	+	+/–180	15	0.00549316	50		1	3	2							
		Heading	014	Magnetic Heading	BCD	degrees	+	359.9	4	0.1	500		1	3	2							
		IAS	206	Computed Airspeed	BNR	knots	+	1,024	14	0.0625	125			2		1						
		Mach	205	Mach	BNR	mach	+	4,096	16	0.000625	125			2		1						
		True	210	True Airspeed	BNR	knots	+	2,048	15	0.0625	125			2		1						
		Airspeed	230	True Airspeed	BCD	knots	+	100 – 599	3	1.0	500			2		1						
			212	Altitude Rate, Barometric	BNR	Ft./min.	+	+/–32,768	11	16	62.5			2		1						
		Altitude	232	Altitude Rate	BNR	Ft./min.	UP	+/–20,000	4	10.0	62.5			2		1						
		Rate	165	GNSS Vertical Velocity	BNR	Ft./min.	UP	+/–32,768	15	1.0	1200	1	2	3								
			365	Inertial Vertical Velocity	BNR	Ft./min.	+	+/–32,768	15	1.0	40		1	3	2							
54	Waypoint #1	Char 1 — 5	130	TCP Identification	TBD							TBD										
		ETA	056	Estimated Time of Arrival (ETA)	BCD	hr.:min.	+	0 – 23.59.9	5	0.1	500		1	2								
		Estimated Flight Level	TBD	TBD	TBD							TBD										
		Time to Go	002	Time to Go (TTG)	BCD	min.	+	0 – 399.9	4	0.1	200		1	2								
55	Waypoint #2	Char 1 — 5	130	TCP Identification	TBD							TBD										
		ETA	056	Estimated Time of Arrival (ETA)	BCD	hr.:min.	+	0 – 23.59.9	5	0.1	500		1	2								
		Estimated Flight Level	TBD	TBD	TBD							TBD										
		Time to Go	002	Time to Go (TTG)	BCD	min.	+	0 – 399.9	4	0.1	200		1	2								
56	Waypoint #3	Char 1 — 5	130	TCP Identification	TBD							TBD										
		ETA	056	Estimated Time of Arrival (ETA)	BCD	hr.:min.	+	0 – 23.59.9	5	0.1	500		1	2								
		Estimated Flight Level	TBD	TBD	TBD							TBD										
		Time to Go	002	Time to Go (TTG)	BCD	min.	+	0 – 399.9	4	0.1	200		1	2								
57 -to- 5E	Not Assigned	N/A	N/A	N/A	N/A							N/A										

MODE-S TRANSPONDER REGISTER DATA REQUIREMENTS AND INPUT AVAILABILITY (continued)																						
DATA REQUIREMENTS												INPUT DATA SOURCE AVAILABILITY (See Note 1)										
Register number (HEX)	Assignment	Register field	ARINC Word (Octal)	Parameter description	Signal format	Units	+ Sense	Range	Sig. Bits/ Dig.	Resolution	MAX TX INTVL- ms	GPS	FMC/ GNSS	IRS/ FMS	FMC GEN	ADS	Control panel	FCC/ MCP	DFS/ VHF	Weather	Maint comp	Notes
5F	Quasi-Static Parameter Monitoring	MCP/FCU Selected Altitude	102	Selected Altitude	BNR	feet	+	65,536	16	1.0	200							1				
			025	Selected Altitude	BCD	feet	+	0 – 50,000	5	1.0	200			2				1				15
		FMS Selected Altitude	102	Selected Altitude	BNR	feet	+	65,536	16	1.0	200		2	1								
		Next Waypoint		Next Waypoint	See transponder register numbers 41_{16}, 42_{16}, and 43_{16} Above							See transponder register numbers 41_{16}, 42_{16}, and 43_{16} Above										
		FMS Vertical Mode		FMS Vertical Mode	See transponder register number 40_{16} Above							See transponder register number 40_{16} Above										
		VHF Channel Report		VHF Channel Report	See transponder register number 48_{16} Above							See transponder register number 48_{16} Above										
		Met Hazards		Meteorological Report	See transponder register number 45_{16} Above							See transponder register number 45_{16} Above										
60	Heading and Speed Report	Magnetic Heading	320	Magnetic Heading	BNR	Deg./180	+	+/–180	15	0.00549316	50		1	3	2							
			014	Magnetic Heading	BCD	degrees	+	359.9	4	0.1	500		1	3	2							
		IAS	206	Computed Airspeed	BNR	knots	+	1,024	14	0.0625	125			2		1						
		Mach	205	Mach	BNR	mach	+	4,096	16	0.000625	125			2		1						
		Baro Alt Rate	212	Altitude Rate, Barometric	BNR	Ft./min.	+	+/–32,768	11	16	62.5			2		1						
		Inertial Vertical Velocity	365	Inertial Vertical Velocity	BNR	Ft./min.	+	+/–32,768	15	1.0	40		1	3	2							
61	Extended Squitter Emergency/Priority Status		N/A	Emergency / Priority Status	N/A							N/A										

NOTES.—

1. As a universal fit, this table provides many sources of potential data. The designer is to note that duplicate information is not necessary (i.e. once a supply for the needed data is found, no more dedicated inputs are required).

   The preferred priority of the data source to be used for each parameter is indicated by 1, 2, 3, etc., in the appropriate data source columns when such priority is applicable. The highest priority is given by 1 with priority decreasing to 3, etc.

The Data Concentrator input ports should be monitored to determine the presence of an active ATSU Data Concentrator as shown below. If an active ATSU is detected, the transponder should modify the input port priorities such that the Data Concentrator port has the top priority of all data sources. Exceptions to this rule are: the Flight ID priority should remain as stated in Note 17, and the GPS input ports should remain the top priority for the applicable labels as listed in the table.

If an active ATSU is detected, but certain data labels are not present on the ATSU Data Concentrator port, the transponder should default to the input data priority as listed in the table to obtain the missing data.

ATSU Active determination:
label 377 is received with a value of 167Hex,
AND
label 270 is received with bit 16=0 (ATSU in Normal operation) AND bit 20=1
(ATSU is active)

2. The Type field encoding for this transponder register requires information specific to horizontal and/or vertical position accuracy. Information given herein is intended to provide such data.

3. Surveillance Status is a function of the Mode S transponder and Automatic Dependent Surveillance — Broadcast (ADS-B) transmitters. Appropriate definition for setting of the Surveillance Status is provided in the applicable Minimum Operational Performance Standards (MOPS) for these systems, in regards to definitions of transponder register number 05_{16}.

4. The Single Antenna Flag is a function of the Mode S transponder and ADS-B transmitters. Appropriate definition for setting the Single Antenna Flag is provided in the applicable MOPS for these systems, as well as in Annex 10, Volume III in regards to definitions of transponder register number 05_{16}.

5. The Compact Position Reporting (CPR) algorithm requires positional information and velocity information. Information given here is in the form of polar velocity (e.g. label 103 GNSS Track Angle and label 112 GNSS Ground Speed can be used to derive polar velocity).

6. The CPR algorithm requires positional information and velocity information. Information given here is in the form of rectangular velocity (e.g. label 166 GNSS N/S Velocity and label 174 GNSS E/W Velocity can be used to derive rectangular velocity).

7. Utilized for encoding Movement information.

8. Utilized for encoding Ground Track information.

9. The Transmission Rate Subfield is a function of the Mode S transponder and ADS-B transmitters. Appropriate definition for setting the Transmission Rate Subfield is provided in the applicable MOPS for these systems, in regards to definitions of transponder register number 07_{16}.

10. Data received from a Radio Altimeter data source.

11. Data received from a VHF Comm data source.

12. Transponder register numbers 08_{16} and 20_{16} allow for encoding only 8 characters. On certain airframe configurations this information may be provided within ARINC 429 labels 233-237 or label 360. In all cases, encoding of these transponder register subfields should conform to Annex 10, Volume IV, 3.1.2.9 where:

- All characters will be left justified prior to encoding the character fields.
- Characters will be coded consecutively without intervening SPACE codes.
- Any unused character spaces at the end of the subfield should contain a SPACE character code.
- Any extra characters will be truncated.

The sign status matrix of labels 233 through 237 should be treated by the transponder as follows:

SSM 233 — 236		
BIT		MEANING
31	30	
0	0	Normal Operation
0	1	No Computed Data
1	0	Functional Test
1	1	Normal Operation

It is recommended that control panels and other devices supplying these labels do so by setting the sign status matrix of labels 233 through 237 to 1,1 for normal operation in accordance with ARINC 429P1.

Note.— The following information is provided in order to clarify the confusion that has existed in the industry in regards to definition of the status matrix for labels 233 through 236. This document now establishes the status matrix to be consistent with ARINC 429P1 as given below. Implementers should take note that this reflects a change from what was previously defined in ARINC 718 and EUROCAE ED-86.

ARINC 429 P1 Attachment 1 identifies labels 233 through 236 as ACMS data having binary (BNR) format. Word structure for labels 233 through 236 is provided in ARINC 429P1, Attachment 6. ARINC 429P1 Section §2.1.5.2 defines the status matrix for binary words as follows:

BNR SSM		
BIT		MEANING
31	30	
0	0	Failure Warning
0	1	No Computed Data
1	0	Functional Test
1	1	Normal Operation

Previous definitions of labels 233 through 236 provided in ARINC 718 and subsequent documents identified the status matrix for BCD or discrete data. The status matrix in these words was then given by either of the two following tables:

BCD SSM (Old)		
BIT		MEANING
30	31	
0	0	VALID
0	1	No Computed Data
1	0	Functional Test
1	1	Not Defined

DISCRETE SSM		
BIT		MEANING
31	30	
0	0	Normal Operation
0	1	No Computed Data
1	0	Functional Test
1	1	Failure Warning

13. Flight identification or aircraft registration data usage should adhere to the following guidelines:

    a. In accordance with the intent of Annex 10, Volume IV, §3.1.2.9, if flight identification data (labels 233 — 237, respectively, or label 360) are available (i.e. proper labels received and SSM is not set to No Computed Data (NCD)) at any time during unit operation, then flight identification data should be inserted into the character subfields of transponder registers 08_{16} and 20_{16}.
    b. If flight identification data are NOT available (i.e. no labels received or SSM set to NCD) then aircraft registration should be inserted into the character subfields of transponder register numbers 08_{16} and 20_{16}. On certain airframe configurations aircraft registration data may be provided within ARINC-429 labels 301 — 303.
    c. If flight identification data have been entered into transponder register numbers 08_{16} and 20_{16} and then become NOT available, then the character subfields of the transponder registers should be set to all ZEROs.
    Note that Aircraft Registration data must NOT be used to fill the character subfields of the transponder registers once flight identification data have been used during the transponder power-on cycle.
    d. In all of the above cases, encoding of the character subfields in registers 08_{16} and 20_{16} should conform to Annex 10, Volume IV, §3.1.2.9 where:

        - All characters will be left justified prior to encoding the character fields.
        - Characters will be coded consecutively without intervening SPACE codes.
        - Any unused character spaces at the end of the subfield will contain a SPACE character code.
        - Any extra characters will be truncated.

14. Aircraft identification labels 301-303 can be obtained from the Centralized Fault Display System via the CFDIU (Centralized Fault Display Interface Unit) on the aircraft's maintenance bus. This is typically an ARINC 429 low speed bus.

15. Although data are shown to be available from the MCP, it is more probable that they will be available from the FCC Control Panel (ARINC 701). In this case, the FCC Control Panel and the MCP are treated as one and the same.

16. There is at present no clear availability of coding of target altitude source, but with knowledge of the aircraft type on which the transponder is installed, the VNAV, Approach and Alt Hold mode bits can possibly be identified and used in transponder register 40_{16}. It is expected that standardized mode coding labels will be available from the FMC, Autopilot or Data Concentrator on the aircraft. Note that the referenced MCP has an equipment code of $01D_{HEX}$. Availability and coding of autopilot mode status information varies from aircraft type to aircraft type. Note that the designer should take into account the specific aircraft's flight systems when encoding these fields. The following logic is an example of how to set transponder register 40_{16} mode fields:

For the VNAV mode encoding, the following logic applies:

IF label 272 bit 13 = “1” (indicating VNAV is engaged)
THEN set transponder register 40_{16} VNAV mode field to “Active” (indicating that the A/C is in the VNAV state).

For the ALT HOLD mode encoding, the following logic applies:

IF label 273 bit 19 = “0” (indicating that Approach Mode is not engaged) AND
label 272 bit 9 = “1” (indicating that Altitude Hold Mode is engaged)
THEN set transponder register 40_{16} ALT HOLD mode field to “Active” (indicating that the A/C is in the Alt Hold state).

For the APPROACH mode encoding, the following logic applies:

IF label 272 bit 9 = “0” (indicating that Altitude Hold is not engaged) AND
label 273 bit 19 = “1” (indicating that Approach Mode is engaged)
THEN set transponder register 40_{16} APPROACH mode field to “Active” (indicating that the A/C is in the Approach state).

17. To achieve the most satisfactory source of flight identification data, the source is more important than the label that carries the data. Therefore flight identification should be captured using the following priority configuration:

Priority	*Label*	*Source*
1	233-237	Control Panel
2	360	Control Panel
3	233-237	FMC Gen
4	360	FMC Gen
5	233-237	FMC/GNSS
6	360	FMC/GNSS
7	233-237	IRS/FMS/Data Conc.
8	360	IRS/FMS/Data Conc.
9	233-237	Maintenance Data In
10	360	Maintenance Data In
11	301-303	Maintenance Data In (see Note 13)

18. The contents and source for transponder register number 10_{16} are strictly defined in Annex 10, Volume III, Chapter 5.

19. In the definition of transponder register number 40_{16} in Table A-2-64, mode bits 55 and 56 DO NOT indicate the content of any other fields in the register, they DO give to the recipient of the data contained in transponder register 40_{16}, the information as to which altitude source the aircraft is actually using to determine its short term altitude intent. When the target altitude source for aircraft short term altitude intent is unknown, these bits should be set to 00 and the status bit for target altitude source (bit 54) should be set to 1.

The fields in transponder register 40_{16} should contain the following data:

Bits 1 to 13 of transponder register 4016 should only ever contain the ‘MCP/FCU Selected Altitude’ or all zeros.

Bits 14 to 26 of transponder register 4016 should only ever contain the ‘FMS Selected Altitude’ or all zeros.

Bits 27 to 39 of transponder register 4016 should only ever contain the ‘Barometric pressure setting minus 800 mb’ or all zeros.

Bits 48 to 56 of transponder register 4016 should only ever contain the information as specified in paragraph 5 of the text alongside Table A-2-64 in Appendix A.

Target altitude is 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 will be indicated in the altitude source bits (54 to 56).

Note.— This information which represents the real “aircraft intent”, when available, is 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). The current barometric pressure setting is calculated from the value inserted 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) is set to indicate invalid data.

20. The best resolution currently available is 0.05 degrees. Coding space in this field is available for a resolution of 0.01 degrees.

C.4 IMPLEMENTATION GUIDELINES FOR EXTENDED SQUITTER GROUND SYSTEMS

C.4.1 INTRODUCTION

The provisions presented within the following subsections are focused on requirements applicable to specific classes of airborne and ground transmitting systems that support the applications of ADS-B, TIS-B and ADS-R. Airborne systems transmit ADS-B messages. Ground stations may transmit extended squitter messages containing TIS-B and/or the rebroadcast of ADS-B information (referred to as ADS-Rebroadcast or ADS-R). TIS-B uses surveillance data received by a non-ADS-B source (e.g. SSR). ADS-R uses ADS-B information received via other than an extended squitter ADS-B link, to generate and transmit messages, via the extended squitter link, that convey essentially the same information as included in ADS-B messages.

C4.2 SIGNAL-IN-SPACE CHARACTERISTICS

Ground stations supporting TIS-B and/or ADS-R transmit on 1 090 MHz with the same signal-in-space characteristics as defined in Annex 10, Volume IV, Chapter 3 for replies from Mode S transponders, with the exception that only the long format containing 112 information bits are used.

C.4.3 DATA STRUCTURES

Ground stations supporting TIS-B and/or ADS-R transmit using the same data structure as defined in Annex 10, Volume IV, Chapter 3 for Mode S replies containing 112 information bits transmitted by Mode S transponders. This includes the requirements defined under 3.1.2.3.1 for data encoding, under 3.1.2.3.2 and 3.1.2.8.7 for the format of Mode S replies with DF=18, and the requirements defined under 3.1.2.3.3 for error protection of Mode S replies.

C.4.4 GROUND STATION TRANSMISSION CHARACTERISTICS

Ground stations supporting TIS-B and/or ADS-R use an extended squitter transmission capability. The characteristics of such ground stations, in terms of transmitter power, antenna gain, transmission rates, etc., are tailored to provide the required performance of the service over the desired TIS-B/ADS-R service volume of the specific ground station, assuming that airborne users are equipped with (at least) Class A1 receiving systems as defined in Annex 10, Volume IV, Chapter 5.

Specifically:

a. The minimum trigger threshold level (MTL) of a class A1 airborne receiver is specified as –79 dBm (as listed in Annex 10, Volume IV, Chapter 5). When moderate to high levels of interference are expected to exist within the defined TIS-B/ADS-R service volume, increased ground station Effective Isotropic Radiated Power (EIRP) levels and/or increased transmission rates may be necessary to overcome the degraded reception performance (i.e. by the airborne receiver) caused by the interfering signals. The following example shows the maximum ground-to-air line-of-sight range that can reliably be supported versus the ground station's EIRP for the case of a class A1 equipped airborne receiver operating in an environment with a very low level of interference on the 1 090 MHz channel. This represents the minimum EIRP that should be considered and provision of a higher EIRP may be necessary in order to provide RF link margin to accommodate less than ideal performance from the airborne or ground installation. The combination of the ground station's transmitter power, cable losses and antenna gain/pattern are selected such that the EIRP from the ground station is sufficient to ensure that when a class A1 equipped aircraft is located at the extreme edge of the TIS-B/ADS-R service volume (e.g. at the maximum range from the ground station), the received signal strength will be at –79 dBm or greater.

Nominal Reception Range	*Minimum required ground station EIRP*
15 NM	11 dBW
30 NM	17 dBW
60 NM	23 dBW
120 NM	29 dBW

b. It is necessary to limit the average (i.e. longer-term) transmit duty cycle so as not to cause any significant interference to other local users of the 1 090 MHz RF spectrum (i.e. ground SSR interrogators or to nearby ACAS equipped aircraft). The maximum suitable transmit duty cycle, both peak short-term as well as average, needs to be determined based on the local 1 090 MHz RF environment. To accomplish this, the ground station needs to have the ability to limit both the peak short-term and average transmit duty cycles to the maximums authorized for that site. The peak duty cycle should not exceed one extended squitter transmission within a 1 millisecond interval. The average duty cycle should not exceed 500 extended squitter transmissions per second. However, this may be further limited to comply with local RF spectrum authorization.

c. The ground station antenna's radiation pattern in the horizontal plane needs to be consistent with the TIS-B/ADS-R service volume to be supported by that ground station. An omnidirectional radiation pattern is expected to be suitable for most cases.

d. The ground station antenna should be vertically polarized.

e. The ground station's antenna should have a radiation pattern in the vertical plane that provides positive gain at elevation angles above the horizon with a cut-off of gain (i.e. negative gain) at elevation angles below the horizon. This is required to minimize the negative effects of signal reflections from the ground. Antennas with multiple active elements providing vertical aperture are typically used to produce both increased gain at elevation angles above the horizon and a sharp cut-off in gain below the horizon, and are suitable for both transmission and reception of extended squitter signals. Such antennas provide positive gain at elevation angles above the horizon and peak gains within the range from +6 dB to +9 dB are typical at elevation angles of 10 to 15 degrees above the horizon. The implementation should take into account that such antennas usually have a null in the gain in the vertical dimension which causes a cone of silence.

f. Ground stations supporting an ADS-R capability need to incorporate the ADS-R message generation function and the ADS-R message exchange function.

C.4.5 MESSAGE EXCHANGE FUNCTION

The message exchange function includes the 1 090 MHz receiving antenna and the radio equipment (receiver/demodulator/decoder/data buffer) sub-functions.

C.4.5.1 MESSAGE EXCHANGE FUNCTIONAL CHARACTERISTICS

The airborne Mode S extended squitter receiving system supports the reception and decoding of all extended squitter messages as listed in Annex 10, Volume IV, Chapter 5. The ground ADS-B extended squitter receiving system, as a minimum, supports the reception and decoding of all extended squitter message types that convey information needed to support the generation of the ADS-B reports of the types required by the client ATM ground applications.

C.4.5.2 MESSAGE RECEPTION PERFORMANCE

C.4.5.2.1 The airborne Mode S extended squitter receiver/demodulation/decoder employs the reception techniques and has a receiver minimum trigger threshold level (MTL) as listed in Annex 10, Volume IV, Chapter 5 as a function of the airborne receiver class.

C.4.5.2.2 The ground station's antenna characteristics in combination with the extended squitter receiver's reception technique and MTL are selected to provide the reception performance (i.e. range and update rates) as required by the client ATM ground applications throughout the defined ADS-B surveillance volume. The type of messages that must be received and the type of reports that must be generated will depend on the requirements of the client ground ATM applications. The performance required of ADS-B ground station receivers supporting ATM surveillance applications will depend on the individual ground station's required service volume, the associated required reporting rates, and on the interference levels on the 1 090 MHz channel at that location. It is appropriate to derive the characteristics of the ground station's extended squitter receiver, in terms of MTL and reception techniques, based on what has been defined for the airborne extended squitter receivers in Annex 10, Volume IV, Chapter 5. However, when a higher gain ground station antenna is used (i.e. than that of a typical airborne antenna), the resulting air-to-ground reception range can be expected to be greater than for the air-to-air case. The characteristics of the ground station's antenna along with the associated receiver's characteristics need to be consistent with the intended service volume.

C.4.5.2.3 ADS-B ground stations intended for use in locations anticipated to have moderate to high levels of 1 090 MHz co-channel interference need to have an MTL and use reception techniques at least equivalent to those listed in Annex 10, Volume IV, Chapter 5 for a Class A3 airborne receiver.

C.4.5.2.4 The ground station antenna used for reception should have the same characteristics as specified for transmission in C.4.4.

Appendix D

SERVICES UNDER DEVELOPMENT

D.1 INTRODUCTION

Appendix D presents the latest status of Mode S and extended squitter services under development. When these services are mature, they will be proposed as a revision to the technical provisions in Appendix A or B, or the relevant SARPs.

D.2 EXTENDED SQUITTER TARGET STATE AND STATUS MESSAGE

Note.— §B.2.3.9 has been reserved for this material.

TARGET STATE AND STATUS INFORMATION

The target state and status information squitter shall be formatted as specified in the definition of register number 62_{16} and in the following paragraphs:

D.2.1 TRANSMISSION RATE

This message shall be broadcast at random intervals uniformly distributed over the range of 1.2 to 1.3 seconds for the duration of the operation.

D.2.2 MESSAGE DELIVERY

Extended Squitter Message delivery shall be accomplished using the event-driven protocol (see §A.2.3.7).

D.2.3 VERTICAL DATA AVAILABLE/SOURCE INDICATOR

This 2-bit (ME bits 8 — 9, Message bits 40 — 41) subfield shall be used to identify if aircraft vertical state information is available and present as well as the data source for the vertical data when present in the subsequent subfields. Encoding shall be defined as specified in the following table. Any message parameter associated with vertical target state for which an update has not been received from an on-board data source with the past 5 seconds shall be considered invalid and so indicated in the Vertical Data Available/Source Indicator subfield.

Coding		Meaning
(Binary)	*(Decimal)*	
00	0	No valid Vertical Target State data is available
01	1	Autopilot control panel selected value, such as Mode Control Panel (MCP) or Flight Control Unit (FCU)
10	2	Holding altitude
11	3	FMS/RNAV system

D.2.4 TARGET ALTITUDE TYPE

This one bit (ME bit 10, Message bit 42) subfield shall be used to identify whether the altitude reported in the "Target Altitude" subfield is referenced to mean sea level (MSL) or to a flight level (FL). A value of ZERO (0) shall indicate target altitude referenced to pressure-altitude (flight level). A value of ONE (1) shall indicate a target altitude referenced to barometric corrected altitude (mean sea level).

D.2.5 TARGET ALTITUDE CAPABILITY

This 2-bit subfield (ME bits 12 — 13, Message bits 44 — 45) shall be used to describe the aircraft's capabilities for providing the data reported in the target altitude subfield. The target altitude capability subfield shall be encoded as specified in the following table.

Coding		Meaning
(Binary)	*(Decimal)*	
00	0	Capability for reporting holding altitude only
01	1	Capability for reporting either holding altitude or autopilot control panel selected altitude
10	2	Capability for reporting either holding altitude, autopilot control panel selected altitude, or any FMS/RNAV level-off altitude
11	3	Reserved

D.2.6 VERTICAL MODE INDICATOR

This 2-bit (ME bits 14 — 15, Message bits 46 — 47) subfield shall be used to indicate whether the target altitude is in the process of being acquired (i.e. aircraft is climbing or descending toward the target altitude) or whether the target altitude has been acquired/being held. The Vertical Mode Indicator subfield shall be encoded as specified in the following table.

Coding		*Meaning*
(Binary)	*(Decimal)*	
00	0	Unknown mode or information unavailable
01	1	“Acquiring” Mode
10	2	“Capturing” or “Maintaining” Mode
11	3	Reserved

D.2.7 TARGET ALTITUDE

This 10-bit (ME bits 16 — 25, Message bits 48 — 57) subfield shall be used to provide aircraft’s next intended level-off altitude if in a climb or descent, or the aircraft current intended altitude if it is intending to hold its current altitude. The reported target altitude shall be the operational altitude recognized by the aircraft’s guidance system. The target altitude subfield shall be as specified in the following table.

Coding		*Meaning*
(Binary)	*(Decimal)*	
00 0000 0000	0	Target altitude = -1 000 feet
00 0000 0001	1	Target altitude = -900 feet
00 0000 0010	2	Target altitude = -800 feet
***	***	***
00 0000 1011	11	Target altitude = zero (0) feet
00 0000 1100	12	Target altitude = 100 feet
***	***	***
11 1111 0010	1010	Target altitude = 100 000 feet
11 1111 0011 — 11 1111 1111	1011 — 1023	Invalid (out of range)

D.2.8 HORIZONTAL DATA AVAILABLE/SOURCE INDICATOR

This 2-bit (ME bits 26 — 27, message bits 58 — 59) subfield shall be used to identify if aircraft horizontal state information is available and present as well as the data source for the horizontal target data when present in the subsequent subfields. The horizontal data available/source Indicator subfield shall be encoded as specified in the following table. Any message parameter associated with horizontal target state for which an update has not been received from an on-board data source within the past 5 seconds shall be considered invalid and so indicated in the horizontal data available/source indicator subfield.

Coding		Meaning
(Binary)	*(Decimal)*	
00	0	No valid horizontal target state data is available
01	1	Autopilot control panel selected value, such as Mode Control Panel (MCP) or Flight Control Unit (FCU)
10	2	Maintaining current heading or track angle (e.g. autopilot mode select)
11	3	FMS/RNAV system (indicates track angle specified by leg type)

D.2.9 TARGET HEADING/TRACK ANGLE

This 9-bit (ME bits 28 — 36, message bits 60 — 68) subfield shall be used to provide aircraft's intended (i.e. target or selected) heading or track. The target heading/track angle subfield shall be encoded as specified in the following table.

Coding		Meaning
(Binary)	*(Decimal)*	
0 0000 0000	0	Target heading/track = Zero degrees
0 0000 0001	1	Target heading/track = 1 degree
0 0000 0010	2	Target heading/track = 2 degrees
***	***	***
1 0110 0111	359	Target heading/track = 359 degrees
1 0110 1000 through 1 1111 1111	360 through 511	Invalid

D.2.10 TARGET HEADING/TRACK INDICATOR

This 1-bit (ME bit 37, message bit 69) subfield shall be used to indicate whether a Heading Angle or a track angle is being reported in the target heading/track angle subfield. A value of ZERO (0) shall indicate the Target Heading Angle is being reported. A value of ONE (1) shall indicate that Track Angle is being reported.

D.2.11 HORIZONTAL MODE INDICATOR

This 2-bit (ME bits 38 — 39, Message bits 70 — 71) subfield shall be used to indicate whether the target heading/track is being acquired (i.e. lateral transition toward the target direction is in progress) or whether the target heading/track has been acquired and is currently being maintained. The horizontal mode Indicator subfield shall be encoded as specified in the following table.

Coding		*Meaning*
(Binary)	*(Decimal)*	
00	0	Unknown mode or information unavailable
01	1	“Acquiring” mode
10	2	“Capturing” or “Maintaining” mode
11	3	Reserved

D.2.12 NAVIGATION ACCURACY CATEGORY FOR POSITION (NAC_P)

This 4-bit (ME bits 40 — 43, message bits 72 — 75) subfield shall be used to indicate the navigational accuracy category of the navigation information used as the basis for the aircraft reported position. The NAC_P subfield shall be encoded as specified in the following table. If an update has not been received from an on-board data source for NAC_P within the past 5 seconds, then the NAC_P subfield shall be encoded as a value indicating unknown accuracy.

Coding		*Meaning = 95% horizontal and vertical accuracy bounds (EPU and VEPU)*
(Binary)	*(Decimal)*	
0000	0	EPU ≥ 18.52 km (10 NM) — Unknown accuracy
0001	1	EPU < 18.52 km (10 NM) — RNP-10 accuracy
0010	2	EPU < 7.408 km (4 NM) — RNP-4 accuracy
0011	3	EPU < 3.704 km (2 NM) — RNP-2 accuracy
0100	4	EPU < 1852 m (1NM) — RNP-1 accuracy
0101	5	EPU < 926 m (0.5 NM) — RNP-0.5 accuracy
0110	6	EPU < 555.6 m (0.3 NM) — RNP-0.3 accuracy
0111	7	EPU < 185.2 m (0.1 NM) — RNP-0.1 accuracy
1000	8	EPU < 92.6 m (0.05 NM) — e.g. GPS (with SA)
1001	9	EPU < 30 m *and* VEPU < 45 m — e.g. GPS (SA off)
1010	10	EPU < 10 m *and* VEPU < 15 m — e.g. WAAS
1011	11	EPU < 3 m *and* VEPU < 4 m — e.g. LAAS
1100 — 1111	12 — 15	Reserved

Note 1.— The Estimated Position Uncertainty (EPU) used in the table is a 95 per cent accuracy bound on horizontal position. EPU is defined as the radius of a circle, centered on the reported position, such that the probability of the actual position lying outside the circle is 0.05. When reported by a GPS or GNSS system, EPU is commonly called HFOM (Horizontal Figure of Merit).

Note 2.— Vertical Estimated Position Uncertainty (VEPU) is a 95 per cent accuracy limit on the vertical position (geometric altitude). VEPU is defined as a vertical position limit, such that the probability of the actual geometric altitude differing from the reported geometric altitude by more than that limit is 0.05. When reported by a GPS or GNSS system, VEPU is commonly called VFOM (Vertical Figure of Merit).

Note 3.— RNP accuracy includes error sources other than sensor error, whereas horizontal error for NAC_P only refers to horizontal position error uncertainty.

Note 4.— If geometric altitude is not being reported, then the VEPU tests are not assessed.

D.2.13 NAVIGATION INTEGRITY CATEGORY FOR BARO (NIC_{BARO})

This 1-bit (ME bit 44, message bit 76) subfield shall be used to indicate whether or not the barometric pressure-altitude being reported in the airborne position message (see §A.2.3.2) has been crosschecked against another source of pressure-altitude. The NIC_{BARO} subfield shall be encoded as specified in the following table. If an update has not been received from an on-board data source for NIC_{BARO} within the past 5 seconds, then the NIC_{BARO} subfield shall be encoded as a value of ZERO (0).

Coding	*Meaning*
0	The barometric altitude that is being reported in the Airborne Position Message is based on a Gilham coded input that has not been cross-checked against another source of pressure-altitude.
1	The barometric altitude that is being reported in the Airborne Position Message is either based on a Gilham code input that has been cross-checked against another source of pressure-altitude and verified as being consistent, or is based on a non-Gilham coded source.

Note 1.— The barometric altitude value itself is conveyed within the ADS-B Position Message.

Note 2.— The NIC_{BARO} subfield provides a method of indicating a level of data integrity for aircraft installed with Gilham encoding barometric altitude sources. Because of the potential of an undetected error when using a Gilham encoded altitude source, a comparison shall be performed with a second source and only if the two sources agree shall the NIC_{BARO} subfield be set to a value of "1". For other barometric altitude sources (Synchro or DADS) the integrity of the data is indicated with a validity flag or SSM. No additional checks or comparisons are necessary. For these sources the NIC_{BARO} subfield shall be set to a value of "1" whenever the barometric altitude is valid.

Note 3.— The use of Gilham type altimeters is strongly discouraged because of the potential for undetected altitude errors.

D.2.14 SURVEILLANCE INTEGRITY LEVEL (SIL)

This 2-bit (ME bits 45 — 46, message bits 77 — 78) subfield shall be used to define the probability of the integrity containment region described by the NIC subfield being exceeded for the selected position source, including any external signals used by the source. The SIL subfield shall be encoded as specified in the following table. If an update has not been received from an on-board data source for SIL within the past 5 seconds, then the SIL subfield shall be encoded as a value indicating "Unknown."

The probability specified by the SIL subfield shall be 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. the per sample probability of a position source error larger than the horizontal or vertical integrity containment region 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 an indication (see Note 1 below the table), within a time period determined by the positioning source, as indicated in the table.

Coding		*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*
(Binary)	*(Decimal)*		
00	0	Unknown	Unknown
01	1	$\leq 1 \times 10^{-3}$ per flight hour or per sample	$\leq 1 \times 10^{-3}$ per flight hour or per sample
10	2	$\leq 1 \times 10^{-5}$ per flight hour or per sample	$\leq 1 \times 10^{-5}$ per flight hour or per sample
11	3	$\leq 1 \times 10^{-7}$ per flight hour or per sample	$\leq 2 \times 10^{-7}$ per 150 seconds or per sample

Note 1.— "An Indication" may include, for example, a flag for invalid position report, or a change in NIC, or switching to another data source.

Note 2.— A problem for installations that include currently available GNSS receivers and FMS systems is that SIL is not output by these systems. Most implementers are expected to determine SIL by off-line analysis of the installed configuration. This off-line analysis can be performed on the various primary and alternate means of determining the reported position. SIL is a static value for each of these configurations.

Note 3.— The vertical integrity containment column only applies to NIC values greater than 8.

Note 4.— The SIL code value is the lower of the horizontal or vertical coding values.

Note 5.— It is recognized that there are three possible derivations of SIL: (a) the integrity value provided by navigation sensors with self-monitoring capability (e.g. GPS), (b) the reliability of aircraft systems given as indicated by a failure rate commensurate with the equipment design assurance, and (c) the integrity of other navigation systems, (e.g. RNP) that rely on ground-based self-monitoring equipment for integrity assurance, and for which no specific hourly integrity value can be ascribed. These three values are not readily interchangeable. Selection of the largest of the values as specified in the table above is felt to provide a reasonable bound on the order of magnitude of the probability of possible failures affecting ADS-B applications.

Note 6.— GNSS systems report integrity in terms of flight hours and FMS systems report in terms of per measurement sample (derived from a number of position measurements). While these are not equivalent measures of integrity, the difference is not considered to be critical for initial applications.

D.2.14.1 **Recommendations**.—

1. *SIL is intended to reflect the integrity of the navigation source of the position information broadcast, therefore the SIL value transmitted should be indicative of the true integrity of the ADS-B position data.*

2. *If SIL information is not provided by the navigation source, implementers should not arbitrarily set a SIL value of zero indicating unknown integrity.*

3. *Unless there is a tightly coupled navigation source where SIL can be unambiguously determined and set dynamically, the ADS-B Transmitting Subsystem should provision for the static setting of SIL as part of the installation procedure.*

D.2.15 CAPABILITY/MODE CODES

This 2-bit (ME bits 52 — 53, Message bits 84 — 85) subfield shall be used to indicate the current operational status of TCAS/ACAS systems/functions. This subfield shall be encoded as specified in the following table. If an update has not been received from an on-board data source for a Capability/Mode Code data element within the past 2 seconds, then that data element shall be encoded with a value of zero (0).

Coding	*Meaning*
ME bit 52 = 0	TCAS/ACAS operational or unknown
ME bit 52 = 1	TCAS/ACAS not operational
ME bit 53 = 0	No TCAS/ACAS Resolution Advisory active
ME bit 53 = 1	TCAS/ACAS Resolution Advisory active

D.2.16 EMERGENCY/PRIORITY STATUS

This 3-bit (ME bits 54 — 56, message bits 86 — 88) subfield shall be used to provide additional information regarding aircraft status. The Emergency/Priority Status subfield shall be encoded as specified in the following table. If an update has not been received from an on-board data source for the Emergency/Priority Status within the past 5 seconds, then the emergency/priority status subfield shall be encoded with a value indicating no emergency.

Coding		*Meaning*
(Binary)	*(Decimal)*	
000	0	No emergency
001	1	General emergency
010	2	Lifeguard/medical emergency
011	3	Minimum fuel
100	4	No communications
101	5	Unlawful interference
110	6	Downed aircraft
111	7	Reserved

Table D-2-98. BDS Code 6,2 — Target state and status information

MB FIELD

1		FORMAT TYPE CODE = 29
2		
3		
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	Target Altitude (see §D.2.7)
17		
18		
19		
20		
21		
22		
23		
24		
25	LSB	
26	MSB	Horizontal Data Available / Source Indicator
27	LSB	(see §D.2.8)
28	MSB	Target Heading / Track Angle (see §D.2.9)
29		
30		
31		
32		
33		
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	Navigation Accuracy Category — Position (NAC_P) (see §D.2.12)
41		
42		
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		Reserved
48		
49		
50		
51		
52	MSB	Capability / Mode Codes
53	LSB	(see §D.2.15)
54	MSB	Emergency / Priority Status
55		
56	LSB	(see §D.2.16)

PURPOSE: To provide aircraft state and status information.

D.3 REVISED FORMATS FOR METEOROLOGICAL REGISTERS 44_{16} AND 45_{16}

D.3.1 In order to keep registers 44_{16} and 45_{16} in conformance with the definitions used over other data links, the format of register 44_{16} and 45_{16} will be modified in the future as shown in the following tables.

Note.— When the revised formats are mature, they will be proposed for insertion as a revision to Appendix A.

Table D-2-68. BDS Code 4,4 — Meteorological routine air report

MB FIELD

1	
2	RESERVED
3	
4	
5	STATUS
6	MSB = 256 knots
7	
8	
9	WIND SPEED
10	
11	Range = [0, 511] knots
12	
13	
14	LSB = 1 knot
15	STATUS
16	MSB = 180 degrees
17	
18	WIND DIRECTION (True)
19	
20	Range = [0, 360] degrees
21	
22	
23	LSB = 180/128 degrees
24	STATUS
25	SIGN
26	MSB = 64°C
27	
28	
29	STATIC AIR TEMPERATURE
30	
31	Range = [-128, +128] ºC
32	
33	
34	
35	LSB = 0.125°C
36	STATUS
37	MSB = 1 024 hPa
38	
39	
40	AVERAGE STATIC PRESSURE
41	
42	Range = [0, 2 047] hPa
43	
44	
45	
46	
47	LSB = 1 hPa
48	TURBULENCE FLAG
49	STATUS
50	MSB = 64%
51	
52	
53	HUMIDITY
54	Range = [0, 127] %
55	
56	LSB = 1 %

PURPOSE: To allow meteorological data to be collected by ground systems.

1) The definition of bit 48: Turbulence flag:

0 = signifies turbulence data not available in Register 45_{16}.
1 = signifies turbulence data available in Register 45_{16}.

Note 1.— The average static pressure is not a requirement of Annex 3.

Note 2.— Humidity calculation may result in values greater than 100%.

Note 3.— Two's complement coding is used for all signed fields as specified in §A.2.2.2.

Note 4.— The requirement for the range of wind speeds in Annex 3 is from 0 to 250 knots.

Note 5.— The requirement for the range of static air temperature in Annex 3 is from –80°C to +60°C.

Table D-2-69. BDS code 4,5 — Meteorological hazard report

MB FIELD

1	STATUS	
2	MSB	WIND SHEAR HAZARD
3	LSB	
4	STATUS	
5	MSB	MICROBURST HAZARD
6	LSB	
7	STATUS	
8	MSB	ICING HAZARD
9	LSB	
10	STATUS	
11	MSB	WAKE VORTEX HAZARD
12	LSB	
13	STATUS	
14	SIGN	
15	MSB = 64°C	
16		
17		
18		STATIC AIR TEMPERATURE
19		
20		Range = [–128, +128]°C
21		
22		
23		
24	LSB = 0.125°C	
25	STATUS	
26	MSB = 4 096 feet	
27		
28		
29		
30		
31		
32		RADIO HEIGHT
33		
34		Range = [0, 8 190] feet
35		
36		
37	LSB = 2 feet	
38	STATUS	
39	MSB = 0.64	
40		
41		AVERAGE TURBULENCE EDR METRIC
42		
43		Range = [0, 1.26] (see 2)
44	LSB = 0.02	
45	MSB = 0.64	
46		
47		PEAK TURBULENCE EDR METRIC
48		
49		Range = [0, 1.26] (see 2)
50	LSB = 0.02	
51	MSB = 8 minutes	
52		TURBULENCE PEAK DELAY INTERVAL
53		Range = [0, 15] minutes
54	LSB = 1 minute	
55		RESERVED
56		

PURPOSE: To provide reports on the severity of meteorological hazards and related information.

1) Hazard coding:

The interpretation of the two bits assigned to each hazard shall be as defined in the table below:

Bit 1	Bit 2	
0	0	NIL
0	1	LIGHT
1	0	MODERATE
1	1	SEVERE

The definition of the terms LIGHT, MODERATE and SEVERE shall be those defined in the PANS-ATM (Doc 4444), where applicable.

2) Any EDR (Eddy Dissipation Rate) value larger than 1.26 shall be represented as 1.26.

Note 1.— The status bit defined in bit 38 indicates that Average Turbulence EDR Metric, Peak Turbulence EDR Metric and Turbulence Peak Delay Interval are valid.

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

Note 3.— The requirement for the range of static air temperature in Annex 3 is from –80°C to +60°C.

— END —

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