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Technical Provisions for Mode S Services and Extended Squitter

Approved by the Secretary General
and published under his authority

Second Edition — 2012

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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

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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 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 readout on demand by a ground interrogator, in addition to being delivered via an ADS-B message.

The second edition of this manual introduces a new version of extended squitter formats and protocols (Version 2). The first edition of this manual specified earlier versions of extended squitter messages (versions 0 and 1). Version 2 formats and protocols were developed to enhance integrity and accuracy reporting. To support identified operational needs for the use of ADS-B not covered by Version 1, a number of additional parameters were included in Version 2. Additionally, several parameters were modified, and a number of parameters no longer required to support ADS-B applications were removed.

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

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.

Cluster Obstacle. An obstacle, such as a group of buildings which extend vertically sufficiently to be considered to be in the flight path of an aircraft, and would be considered a potential threat to safe flight, if not otherwise identified.

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 1 to 4 Comm-A or Comm-B segments, from 2 to 16 Comm-C segments, or from 1 to 16 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.

Geometric Vertical Accuracy (GVA). The GVA parameter is a quantized 95 per cent bound of the error of the reported geometric altitude, specifically the Height Above the WGS-84 Ellipsoid (HAE). This parameter is derived from the Vertical Figure of Merit (VFOM) output by the position source.

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 centre 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 centre 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.

Line Obstacle. An obstacle, such as a power line or other cabling which might be considered to be in the flight path of an aircraft, and would be considered a threat to safe flight, if not otherwise identified.

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.

Obstacle. All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that:

a) are located on an area intended for the surface movement of aircraft; or

b) extend above a defined surface intended to protect aircraft in flight; or

c) stand outside those defined surfaces and that have been assessed *as being a hazard to air navigation.*

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).

Point Obstacle. An obstacle, generally affixed to the ground, that would extend vertically but not have sufficient volume to be considered more than a point in space. Tethered balloons, cellular and other towers, and antenna should be considered in the category of point obstacles.

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 predefined time period.

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.

Vertical Protection Limit (VPL). The vertical geometric position integrity containment region defined by the vertical distance centred on the reported vertical position within which the true vertical position lies.

ACRONYMS AND ABBREVIATIONS

ACAS	Airborne collision avoidance system
ADLP	Airborne data link processor
ADS-B	Automatic dependent surveillance — broadcast
ADS-R	Automatic dependent surveillance — rebroadcast
AF	Address field
ANP	Actual navigation performance
ATN	Aeronautical telecommunication network
ATS	Altitude type subfield
A/V	Aircraft/vehicle
Baro. alt.	Barometric altitude
BDS	Comm-B data selector
BITE	Built-in test equipment
CFDIU	Centralized fault display interface unit
CPR	Compact position reporting
DADS	Digital air data system
ELM	Extended length message
EPU	Estimated position uncertainty
ES	Extended squitter
FCC	Flight control computer
FCU	Flight control unit
FDE	Fault detection and exclusion
Ft	Foot/feet
FL	Flight level
FMS	Flight management system
GDLP	Ground data link processor
GFM	General formatter/manager
GICB	Ground-initiated Comm-B
GNSS	Global navigation satellite system
GPS	Global positioning system
GVA	Geometric vertical accuracy
HAE	Height above the ellipsoid
HAG	Height above the geoid
$HFOM_R$	Horizontal figure of merit for velocity
HIL	Horizontal integrity limit
HPL	Horizontal protection limit
HRD	Horizontal reference direction
II	Interrogator identifier
IMF	ICAO/Mode A flag
Knot	Kt
Lat/lon	Latitude/longitude
LSB	Least significant bit
MA	Message, Comm-A
MASPS	Minimum aviation system performance standard
MB	Message, Comm-B
MC	Message, Comm-C
MCP	Mode control panel

MD	Message, Comm-D
Min	Minute
MOPS	Minimum operational performance standards
MSB	Most significant bit
Msg	Message
MSL	Mean sea level
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
NM	Nautical miles
NUC_P	Navigational uncertainty category — position
NUC_R	Navigational uncertainty category — rate
OCC	Overlay command capability
OM	Operational mode
RAT	Resolution advisory termination
R_C	Radius of containment
RNP	Required navigation performance
s	Second(s)
SA	Selective availability
SAF	Single antenna flag
SARPs	Standards and Recommended Practices
SCS	Squitter capability subfield
SDA	System Design Assurance
SI	Surveillance identifier
SIC	Surveillance identifier capability
SIL	Surveillance integrity level (Version 1, first edition, Appendix B)
SIL	Source integrity level (Version 2, second edition, Appendix C)
SLM	Standard length message
SPI	Special position identification
SSE	Mode S specific services entity
SSM	Sign/status matrix
SSR	Secondary surveillance radar
SVID	Service volume ID
TIS	Traffic information service
TIS-B	Traffic information service — broadcast
TOMRs	Time of message receipt
TRS	Transmission rate subfield
UAT	Universal Access Transceiver
UTC	Universal time clock (Coordinated universal time)
VEPU	Vertical estimated position uncertainty
$VFOM_R$	Vertical figure of merit for velocity
VPL	Vertical protection limit
WAAS	Wide area augmentation system

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 (1 090 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 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 1 090 ES which was suitable for early implementation of 1 090 ES applications. Using these 1 090 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;

c) Chapter 3 contains specifications for Version 1 1 090 ES message formats and related requirements. Surveillance accuracy and integrity are reported separately as navigation accuracy category (NAC), navigation integrity category (NIC) and surveillance integrity level (SIL). Version 1 1 090 ES formats also include provisions for enhanced reporting of status information, the ground-to-air transmission of traffic information service — broadcast (TIS-B) messages and ADS-B rebroadcast (ADS-R) messages, and

d) Chapter 4 contains specifications for Version 2 1 090 ES message formats and related requirements that reflected needed revisions based on operational experience with ADS-B. The integrity level of the ADS-B source has been redefined and changes were made to the definitions of the NIC and NAC parameters. Version 2 1 090 ES formats now include the transmission of selected altitude, selected heading, and barometric pressure setting in the target state and status messages. Version 2 1 090 ES formats also include both the transmission of the Mode A (4096) codes, and the content of register 30_{16} (ACAS active resolution advisory).

1.1.3 The formats for versions 0, 1 and 2 are interoperable in the delivery of critical data. Version 2 formats are interoperable with Version 0 and 1 formats, except for minor differences of certain non-critical data, as presented in detail in Appendix C and summarized in Table 4-1. Additional guidance is provided in Appendix D of this document and in the *Aeronautical Surveillance Manual* (Doc 9924).

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 and Collision Avoidance Systems*, Chapters 2 through 4.

Ref. 3. RTCA/DO-260 (equivalent to EUROCAE/ED-102), *Minimum Operational Performance Standards for 1090 MHz Automatic Dependent Surveillance — Broadcast (ADS-B)*, RTCA, September 2000.

Ref. 4. RTCA/DO-260A, *Minimum Operational Performance Standards for 1090 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. 5. RTCA/DO-260B Corrigendum 1, (equivalent to EUROCAE/ED-102A), *Minimum Operational Performance Standards for 1090 MHz Automatic Dependent Surveillance — Broadcast (ADS-B) and Traffic Information Services (TIS-B)*, RTCA and EUROCAE, December 2009.

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 1 090 ES ADS-B messages are also included since registers are defined for each of these messages so that extended squitter messages can be readout 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

2.3.1 The initial standardization of 1 090 ES was consistent with RTCA/DO-260 [Ref. 3] and was termed 1 090 ES Version 0. Using these 1 090 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.

2.3.2 A number of revisions were implemented in the Compact Position Reporting (CPR) algorithm since the first edition of this manual and can be found in section C.2.6 of Appendix C. Therefore, the original specification of CPR was removed from section A.2.6 of Appendix A.

2.4 DETAILED TECHNICAL PROVISIONS

Detailed technical provisions for data formats and control parameters for Mode S services and Version 0 1 090 ES are specified in Appendix A.

2.5 IMPLEMENTATION GUIDELINES

Implementation guidelines for Mode S services and Version 0 1 090 ES formats and protocols are provided in Appendix D.

2.6 SERVICES UNDER DEVELOPMENT

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

Chapter 3

OVERVIEW OF EXTENDED SQUITTER VERSION 1

3.1 EXTENDED SQUITTER VERSION 1

3.1.1 The formats and protocols for 1 090 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. 4 in Chapter 1].

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 1 090 ES Version 1 and TIS-B/ADS-R are specified in Appendix B.

3.5 IMPLEMENTATION GUIDELINES

Implementation guidelines for Mode S services and 1 090 ES Version 1 formats and protocols are provided in Appendix D.

3.6 SERVICES UNDER DEVELOPMENT

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

Chapter 4

OVERVIEW OF EXTENDED SQUITTER VERSION 2

4.1 EXTENDED SQUITTER VERSION 2

4.1.1 The formats and protocols for 1 090 ES Version 2 were revised based on experience gained from operational usage with ADS-B that revealed a number of needed improvements, which included:

a) separated reporting of source and system integrity;

b) additional levels of NIC to better support airborne and surface applications;

c) incorporation of the broadcast of the Mode A code into the emergency/priority message, increased transmission rates after a Mode A code change, and the broadcast of the Mode A code on the surface;

d) revision to the target state and status message to include additional parameters;

e) eliminated the vertical component of NIC and NAC;

f) T = 0 position extrapolation accuracy changed from within 200 ms of the time of transmission to within 100 ms; and

g) capabilities were added to support airport surface applications.

4.1.2 TIS-B remained unchanged because it is version independent (see 3.2). ADS-R formats were updated to Version 2 to be compatible with changes to ADS-B formats.

4.1.3 The Version 2 formats and protocols in this manual are consistent with RTCA DO-260B and EUROCAE ED-102A [Ref. 5 in Chapter 1].

4.1.4 The formats for versions 0, 1 and 2 are interoperable in the delivery of critical data. Version 2 formats are interoperable with Version 0 and 1 formats, except for minor differences of certain non-critical data, as presented in detail in Appendix C and summarized in Table 4-1.

Table 4-1. ADS-B Version 2 Backward Compatibility Summary

	Description of ADS-B Version 2 Changes	*Backward Compatibility Impact to Version 1 Receiver*
1.	Add duplicate address processing for ADS-B and ADS-R.	None — Modifies Version 2 receiver requirements so no impact to Version 1 receivers.
2.	Add NIC value for R_C of 0.3 NM between currently defined NIC values for R_C of 0.2 and 0.5 NM.	ADS-B None — Uses an additional bit in transmitted message to encode. Version 1 receivers will decode as R_C of 0.6 NM. ADS-R. None — Version 2 additional bit allocated in Operational Status Message for ADS-R NIC Supplement B.
3.	Add ability to transmit UTC Coupled (T = 1) for the non-precision NIC values.	None.
4.	Add broadcast of Mode A code at higher rates than Version 1. Different update rates are required between the steady state condition (no Mode A code change) and when the code is changed.	Transparent to Version 1 receivers except they will receive more messages due to higher transmit rate.
5.	Delete requirement for “Receiving ATC Service” bit, but note it as reserved for that purpose in the future if Mode A code is ever supplanted.	None — not used air-to-air.
6.	NAC_V definition clarification.	None.
7.	Remove vertical components from NAC_P, NAC_V, NIC and SIL.	None.
8.	Add parameter for Geometric Vertical Accuracy.	None — Uses reserved bits that will not be decodable.
9.	Redefine SIL and add SIL Supplement and System Design Assurance.	None — New Source Integrity Level parameter replaces Surveillance Integrity Level. SIL Supplement and SDA uses reserved bits that will not be decodable.
10.	Delete CDTI bit and create 2-bit field to denote UAT IN and 1 090 ES IN (for Ground use).	The CDTI bit will be decoded incorrectly—but is not used by current avionics.
11.	Revise Target State and Status Message to add selected altitude, modify mode bits and include the pilot selected pressure altitude correction.	Since a different code is used for the updated message, Version 1 receivers will not decode the message at all. There are no current applications that use the target state data. However, since there are some integrity and accuracy parameters transmitted in the Target State and Status Message, Version 1 receivers will not be receiving these parameters at the proper update rate. However, not all aircraft transmit the Target State and Status Message.
12.	Add note to explain that NIC is to be immediately set to ZERO on receipt of an alarm discrete from the GPS sensor.	None.
13.	T = 0 position extrapolation accuracy changed from within 200 ms of the time of transmission to within 100 ms.	None.

	Description of ADS-B Version 2 Changes	*Backward Compatibility Impact to Version 1 Receiver*
14.	Support a Single Antenna Flag.	Version 1 contained a Single Antenna Flag, but since it has moved, receivers will not properly decode it. Current applications do not use the Single Antenna Flag.
15.	Ground Speed encoding change.	Slight change in values at lower Ground speeds, but since the Ground speed is highly inaccurate in the range of the change, this does not have a significant impact.
16.	Include Loss of GPS Position as a criteria for a fail/warn annunciation.	None.
17.	Redefine Length/Width Codes to add a code for "No Information Available."	Minor impact since smallest represented length/width would be interpreted as unknown.
18.	Change definition of TCAS Operational and TCAS RA active bits.	These bits will be decoded incorrectly—but are not used by current avionics.
19.	Add additional NIC values when reporting surface position data so that larger R_C values can be represented when on the surface.	None – Receivers will decode additional NICs as unknown integrity.
20.	Add TCAS RA broadcast.	None — Uses reserved code that will not be decodable.
21.	Add new equipment class to allow single antenna with A1 power level.	None.
22.	Modify Local CPR Reasonableness Test to account for air-to-ground and ground-to-air transitions.	None.

4.2 DETAILED TECHNICAL PROVISIONS

Detailed technical provisions for data formats and control parameters for 1 090 ES Version 2 and TIS-B/ADS-R are specified in Appendix C.

4.3 IMPLEMENTATION GUIDELINES

Implementation guidelines for Mode S services and 1 090 ES Version 2 formats and protocols are provided in Appendix D.

4.4 SERVICES UNDER DEVELOPMENT

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

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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 D.

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* Note 1
00_{16}	Not valid	N/A
01_{16}	Reserved	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 Note 4	0.2 s
06_{16}	Extended squitter surface position Note 4	0.2 s (see §A.2.3.3.1 and §A.2.3.3.2)
07_{16}	Extended squitter status Note 4	1.0 s
08_{16}	Extended squitter identification and category Note 4	15.0 s

Transponder register number	*Assignment*	*Maximum update interval* Note 1
09_{16}	Extended squitter airborne velocity Note 4	1.3 s
$0A_{16}$	Extended squitter event-driven information Note 4	variable
$0B_{16}$	Air/air information 1 (aircraft state)	1.3 s
$0C_{16}$	Air/air information 2 (aircraft intent)	1.3 s
$0D_{16}$–$0E_{16}$	Reserved for air/air state information	To be determined
$0F_{16}$	Reserved for ACAS	To be determined
10_{16}	Data link capability report	≤4.0 s (see §A.2.1.2)
11_{16}–16_{16}	Reserved for extension to datalink capability reports	5.0 s
17_{16}	Common usage GICB capability report	5.0 s
18_{16}–$1C_{16}$	Mode S specific services capability reports	see §A.2.5.4.2.1
$1D_{16}$–$1F_{16}$	Mode S specific services capability reports	5.0 s
20_{16}	Aircraft identification	5.0 s
21_{16}	Aircraft and airline registration markings	15.0 s
22_{16}	Antenna positions	15.0 s
23_{16}	Reserved for antenna position	15.0 s
24_{16}	Reserved for aircraft parameters	15.0 s
25_{16}	Aircraft type	15.0 s
26_{16}–$2F_{16}$	Reserved	N/A
30_{16}	ACAS active resolution advisory	[see Ref. 2 in Chapter 1 and Annex 10, Volume IV, §4.3.8.4.2.2]
31_{16}–$3F_{16}$	Reserved	N/A
40_{16}	Selected vertical intention	1.0 s
41_{16}	Next waypoint identifier	1.0 s
42_{16}	Next waypoint position	1.0 s
43_{16}	Next waypoint information	0.5 s
44_{16}	Meteorological routine air report	1.0 s
45_{16}	Meteorological hazard report	1.0 s
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	5.0 s
49_{16}–$4F_{16}$	Reserved	N/A
50_{16}	Track and turn report	1.3 s
51_{16}	Position report coarse	1.3 s
52_{16}	Position report fine	1.3 s
53_{16}	Air-referenced state vector	1.3 s
54_{16}	Waypoint 1	5.0 s
55_{16}	Waypoint 2	5.0 s
56_{16}	Waypoint 3	5.0 s
57_{16}–$5E_{16}$	Reserved	N/A
$5F_{16}$	Quasi-static parameter monitoring	0.5 s
60_{16}	Heading and speed report	1.3 s
61_{16}	Extended squitter emergency/priority status Note 4	1.0 s
62_{16}	Reserved for target state and status information Note 4	N/A

Transponder register number	*Assignment*	*Maximum update interval* Note 1
63_{16}	Reserved for extended squitter Note 4	N/A
64_{16}	Reserved for extended squitter Note 4	N/A
65_{16}	Extended squitter aircraft operational status Note 4	1.7 s
66_{16}–$6F_{16}$	Reserved for extended squitter Note 4	N/A
70_{16}–75_{16}	Reserved for future aircraft downlink parameters	N/A
76_{16}–$E0_{16}$	Reserved	N/A
$E1_{16}$–$E2_{16}$	Reserved for Mode S BITE	N/A
$E3_{16}$	Transponder type/part number	15 s
$E4_{16}$	Transponder software revision number	15 s
$E5_{16}$	ACAS unit part number	15 s
$E6_{16}$	ACAS unit software revision number	15 s
$E7_{16}$	Transponder Status and Diagnostics	15 s
$E8_{16}$	Reserved for Future Diagnostics	N/A
$E9_{16}$	Reserved for Future Diagnostics	N/A
EA_{16}	Vendor Specific Status and Diagnostics	15 s
EB_{16}	Reserved for Future Vendor Specific Diagnostics	N/A
EC_{16}	Reserved for Future Vendor Specific Diagnostics	N/A
ED_{16}–$F0_{16}$	Reserved	N/A
$F1_{16}$	Military applications	15 s
$F2_{16}$	Military applications	15 s
$F3_{16}$–FF_{16}	Reserved	N/A

Notes:

1. 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.

2. Register $0A_{16}$ is not to be used for GICB or ACAS crosslink readout.

3. If Extended Squitter is implemented, then register 08_{16} is not cleared or ZEROed once either Flight Identification or Aircraft Registration data has been loaded into the register during the current power-on cycle. register 08_{16} is not cleared since it provides information that is fundamental to track file management in the ADS-B environment. Refer to §D.2.4.3.3 for implementation guidelines regarding register 08_{16}.

4. These registers define Version 0 extended squitters.

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 maximum update interval 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. Unless otherwise specified, 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 D.

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 10_{16}) shall be updated within 1 second of the data changing and at least every 4 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 is present. This is indicated by bit 25 of the data link capability report contained in register 10_{16} being set to "ONE", and

2) the service corresponding to the application is shown as "supported" by the corresponding bit in the Common Usage Capability Report (register 17_{16}) being set to "ONE"; and

Note 1.— The intent of the capability bits in register 17_{16} is to indicate that useful data is contained in the corresponding 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 registers 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 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 provided). 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 is 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".

For interface formats other than ARINC 429, a similar approach is used.

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) Where the sign bit (ARINC 429 bit 29) is not required for a parameter, it has been actively excluded.

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

9) 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. As used in this manual, BDS A,B is equivalent to register AB_{16}.

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 are reserved for future allocation by ICAO and they shall be set to ZERO.

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
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

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*
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 per cent bound on the horizontal position error), VFOM (95 per cent 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.

Notes:

1. 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.

2. The Type Code allows users to determine whether the quality of the position is good enough for the intended application.

3. Airborne Position Messages with Type Code 18 or 22 (NUC_P = 0), and Surface Position Messages with Type Code 8 (NUC_P = 6, HPL≥185.2m, μ≥92.6m) are not appropriate to support most ADS-B applications since these Type

Codes indicate the accuracy and integrity of the broadcast position is unknown. Messages with these Type Codes are typically transmitted from installations where the ADS-B position is obtained from sources with no accompanying integrity information.

4. It is recommended that Version 0 extended squitter messages with Type Codes 8, 18 or 22 only be used if either the position accuracy or integrity can be verified by other means, or the application has no specific requirements for these parameters.

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 §C.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 §C.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 0.2 s UTC epochs. In that case, the F bit shall be 0 if the time of applicability is an even-numbered 0.2 s UTC epoch, or 1 if the time of applicability is an odd-numbered 0.2 s UTC epoch.

Note.— In such a case, an “even-numbered 0.2 s epoch” means an epoch which occurs an even number of 200-ms time intervals after an even-numbered UTC second. An “odd-numbered 0.2 s epoch” means an epoch which occurs an odd number of 200-ms time intervals after an even-numbered UTC second. Examples of even-numbered 0.2 s UTC epochs are 12.0 s, 12.4 s, 12.8 s, 13.2 s, 13.6 s, etc. Examples of odd-numbered UTC epochs are 12.2 s, 12.6 s, 13.0 s, 13.4 s, 13.8 s, 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 0.2 s 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 0.2 s 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 0.2 s 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 0.2 s UTC epoch, 100 ms before that next subsequent 0.2 s 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 0.2 s 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 0.2 s 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 2 seconds. At the end of this time-out of 2 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 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 1.3 s, whereas the minimum update rate of all other fields of register 06_{16} shall be once per 0.2 s. 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 1.3 s, whereas the minimum update rate of all other fields of register 06_{16} shall be once per 0.2 s.

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 §C.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 0.2 s time tick for UTC time of position validity. The F bit shall alternate between 0 and 1 for successive 0.2 s 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 §C.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 metres in most cases, the longitude position accuracy may only be approximately 3.0 metres 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 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 4-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 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 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 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 $0A_{16}$ 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 time period 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 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 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*

CC-4 ENCODING: EN-ROUTE OPERATIONAL CAPABILITIES

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

CC-1 ENCODING: SURFACE OPERATIONAL CAPABILITIES		
CC-1 CODING		
Bit 21, 22	*Bit 23, 24*	*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.2.3.11.7 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*

OM-2 ENCODING: APPROACH AND LANDING OPERATIONAL CAPABILITY STATUS

OM-2 CODING		
Bit 33, 34	*Bit 35, 36*	*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.2.3.11.10 *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*

OM-1 ENCODING: SURFACE OPERATIONAL CAPABILITY STATUS

OM1 CODING		
Bit 37, 38	*Bit 39, 40*	*MEANING*
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 registers 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.

Notes:

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

2. The identification register, 08_{16}, is not cleared since it contains data that rarely changes in flight and is not frequently updated (see §A.2.1, Note 3). 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). Refer to §D.2.4.3.3 for implementation guidelines regarding register 08_{16}.

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 registers 10_{16}, and 18_{16} to $1C_{16}$. It shall also clear individual bits in register 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 17_{16})

A bit in register 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 (registers 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 (registers $1D_{16}$ 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 17_{16} since a bit in this register means "application installed and operational".

The transponder shall not clear the other capability registers (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 $0A_{16}$ 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 $0A_{16}$ 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 readout of this information by air-ground or air-air register readout. 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 $0A_{16}$. 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 $0A_{16}$ 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 40_{16}.

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

The Mode S extended squitters use compact position reporting (CPR) to encode latitude and longitude efficiently into messages, as specified in §C.2.6.

A.2.7 TABLES FOR SECTION A.2

Tables are numbered A-2-X where “X” is the decimal equivalent of the BDS code Y/Z. 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 and 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 and 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 and A-2-226 (Reserved for Mode S BITE)

A-2-232 and A-2-233

A-2-235 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 §C.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 §C.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°
15	
16	GROUND TRACK (TRUE)
17	(specified in §A.2.3.3.2)
18	
19	
20	LSB = 360/128°
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 §C.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 §C.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
2	LSB SUBFIELD (TRS)
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 lb or 7 031 kg)
2 = Medium 1 (>15 500 to 75 000 lb, or 7 031 to 34 019 kg)
3 = Medium 2 (>75 000 to 300 000 lb, or 34 019 to 136 078 kg)
4 = High vortex aircraft
5 = Heavy (>300 000 lb or 136 078 kg)
6 = High performance (>5 g 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

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 kt		SUPERSONIC: LSB = 4 kt	
17	All zeros = no velocity info		All zeros = no velocity info	
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 kt		SUPERSONIC: LSB = 4 kt	
28	All zeros = no velocity info		All zeros = no velocity info	
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 info; 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 info; LSB = 25 ft			
52	Value		Difference	
53	1		0 ft	
54	2		25 ft	
55	126		3 125 ft	
56	127		3 137.5 ft	

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

Subtype shall be coded as follows:

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

IFR capability shall be coded as follows:

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

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

NUC_R shall be coded as follows:

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

Table A-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°			
16				
17				
18	MAGNETIC HEADING			
19	(specified in §A.2.3.5.6)			
20				
21				
22				
23				
24	LSB = 360/1 024°			
25	AIRSPEED TYPE: 0 = IAS, 1 = TAS			
26	AIRSPEED			
27	NORMAL: LSB = 1 kt		SUPERSONIC: LSB = 4 kt	
28	All zeros = no velocity info		All zeros = no velocity info	
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 info; 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 info; LSB = 25 ft			
52	Value	Difference		
53	1	0 ft		
54	2	25 ft		
55	126	3 125 ft		
56	127	>3 137.5 ft		

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

Subtype shall be coded as follows:

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

IFR capability shall be coded as follows:

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

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

NUC_R shall be coded as follows:

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

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

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

MB FIELD

1	
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	
27	
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33	
34	
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36	
37	
38	
39	
40	
41	
42	
43	
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46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	

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 $6F_{16}$, except for registers 62_{16} and 65_{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).

Note.— The data in this register is not intended for extraction using GICB or ACAS cross-link protocols. The readout of this register is discouraged since the contents are indeterminate.

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

MB FIELD

1	STATUS
2	MSB = 1 024 kt
3	
4	
5	TRUE AIR SPEED
6	
7	
8	Range = [0, 2 047] kt
9	
10	
11	
12	LSB = 1.0 kt
13	SWITCH (0 = Magnetic heading, 1 = True heading)
14	STATUS
15	SIGN
16	MSB = 90°
17	
18	HEADING
19	
20	
21	Range = [–180, +180]°
22	
23	
24	LSB = 360/1 024°
25	STATUS
26	SIGN
27	MSB = 90°
28	
29	
30	
31	TRUE TRACK ANGLE
32	
33	
34	
35	
36	Range = [–180, +180]°
37	
38	
39	
40	LSB = 360/32 768°
41	STATUS
42	MSB = 1 024 kt
43	
44	
45	
46	GROUND SPEED
47	
48	
49	
50	
51	Range = [0, 2 048] kt
52	
53	
54	
55	LSB = 1/8 kt
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 ft
3	
4	
5	
6	LEVEL-OFF ALTITUDE
7	
8	Range = [0, 65 520] ft
9	
10	
11	
12	
13	LSB = 16 ft
14	STATUS
15	SIGN
16	MSB = 90°
17	
18	
19	NEXT COURSE (TRUE GROUND TRACK)
20	
21	Range = [–180, +180]°
22	
23	
24	LSB = 360/1 024°
25	STATUS
26	MSB = 128 s
27	
28	TIME TO NEXT WAYPOINT
29	All ONEs = time exceeds 255 s
30	
31	
32	Range = [0, 256] s
33	
34	LSB = 0.5 s
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°
48	
49	ROLL ANGLE
50	
51	Range = [–90, +89]°
52	
53	LSB = 45/64°
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 manoeuvre.

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	Overlay Command Capability (OCC) (see 19)
16	Reserved for ACAS (see 1 and 15)
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, 16, 17 and 18)
39	
40	
41	MSB
42	
43	
44	
45	
46	
47	Bit array indicating the support status of DTE
48	Sub-addresses 0 to 15 (see 3 and 8)
49	
50	
51	
52	
53	
54	
55	
56	LSB

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

The coding of this register shall conform to:

1) Annex 10, Volume IV, §3.1.2.6.10.2 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 sub-address in the range of 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 10, plus or minus 1 second. 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.

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).

(Requirements are continued on the next page)

Table A-2-16. BDS code 1,0 — Data link capability report (concluded)

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	ICAO	RTCA	EUROCAE
0	Mode S subnetwork not available		
1	Doc 9688 (1996)		
2	Doc 9688 (1998)		
3	Annex 10, Volume III, Amendment 77		
4	Doc 9871, 1st edition	DO-181D	ED-73C
5	Doc 9871, 2nd edition	DO-181E	ED-73E
6–127	Reserved		

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 = Reserved

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 = Reserved

15) Bit 16 shall be set to ONE (1) to indicate that ACAS is operational and set to ZERO (0) to indicate that ACAS has failed or is on standby.

16) Bit 37 shall be set to ONE (1) to indicate the capability of hybrid surveillance, and set to ZERO (0) to indicate that there is no hybrid surveillance capability.

17) Bit 38 shall be set to ONE (1) to indicate that ACAS is generating both TAs and RAs, and set to ZERO (0) to indicate the generation of TAs only.

18)

Bit 40	Bit 39	Applicable MOPS Documents
0	0	RTCA DO-185 (see Note 1)
0	1	RTCA DO-185A (see Note 1)
1	0	RTCA DO-185B
1	1	Reserved for future versions (see Note 2)

Notes:

1. *RTCA DO-185 equipment is also referenced as TCAS logic version 6.04A. Equipment compliant to DO-185A, or later versions, are SARPs compliant.*

2. *Future versions of ACAS will be identified using Part Numbers and Software Version Numbers specified in registers $E5_{16}$ and $E6_{16}$.*

19) The Overlay Command Capability (OCC) in Bit 15 shall be interpreted as follows:

0 = No Overlay Command Capability
1 = Overlay Command Capability

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

Table A-2-23. BDS code 1,7 — Common usage GICB capability report

MB FIELD

1	0,5 Extended squitter airborne position
2	0,6 Extended squitter surface position
3	0,7 Extended squitter status
4	0,8 Extended squitter identification and category
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	
31	
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	
42	RESERVED
43	
44	
45	
46	
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54	
55	
56	

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}.

5) Bit 6 is set to ONE (1) upon the first loading of register $0A_{16}$ and shall remain set until either the transponder is powered OFF or ADS-B transmission is terminated.

6) Bits 17 and 18 shall only be set to ONE (1) if the STATUS bits in register 51_{16} and 52_{16} are set to 1.

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 §D.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 §D.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 §D.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 §D.2.4.2.

Table A-2-28. BDS code 1,C — Mode S specific services GICB capability report (5 of 5)

MB FIELD

1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	RESERVED
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 §D.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 §D.2.4.3.

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

MB FIELD

Bit			
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	AIRCRAFT REGISTRATION NUMBER	
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		
45	MSB		
46			
47	CHARACTER 1		
48			
49			
50	LSB	ICAO AIRLINE REGISTRATION MARKING	
51	MSB		
52			
53	CHARACTER 2		
54			
55			
56	LSB		

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.

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 metres along the aircraft centre 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 metres 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

Bit		Subfield	
1	MSB		
2			
3		AIRCRAFT TYPE	
4			
5			
6	LSB		
7	MSB		
8		NUMBER OF ENGINES	
9	LSB		
10	MSB		
11			
12		ENGINE TYPE	
13			
14			
15	LSB		
16	MSB		
17			
18		CHARACTER 1	
19			
20			
21	LSB		
22	MSB		
23			
24		CHARACTER 2	
25			
26			
27	LSB		
28	MSB		
29			
30		CHARACTER 3	MODEL DESIGNATION
31			
32			
33	LSB		
34	MSB		
35			
36		CHARACTER 4	
37			
38			
39	LSB		
40	MSB		
41			
42		CHARACTER 5	
43			
44			
45	LSB		
46	MSB		
47			
48		WAKE TURBULENCE CATEGORY	
49			
50			
51	LSB		
52			
53			
54		RESERVED	
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 ft
3	
4	
5	MCP/FCU SELECTED ALTITUDE
6	
7	Range = [0, 65 520] ft
8	
9	
10	
11	
12	
13	LSB = 16 ft
14	STATUS
15	MSB = 32 768 ft
16	
17	
18	FMS SELECTED ALTITUDE
19	
20	Range = [0, 65 520] ft
21	
22	
23	
24	
25	
26	LSB = 16 ft
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 levelled off) at the end of the current manoeuvre. 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) Reserved bits 40 to 47 shall be set to ZERO (0).

6) Bits 48 to 56 shall indicate the status (see §D.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

   Reserved bits 52 and 53 shall be set to ZERO (0).

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

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°
4	
5	
6	BEARING TO WAYPOINT
7	
8	Range = [–180, +180]°
9	
10	
11	
12	LSB = 360/2 048°
13	STATUS
14	MSB = 204.8 min
15	
16	
17	
18	TIME TO GO
19	
20	Range = [0, 410] min
21	
22	
23	
24	
25	LSB = 0.1 min
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 kt
7	
8	
9	WIND SPEED
10	
11	Range = [0, 511] kt
12	
13	
14	LSB = 1 kt
15	MSB = 180°
16	
17	
18	WIND DIRECTION (True)
19	
20	Range = [0, 360]°
21	
22	
23	LSB =180/256°
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 kt.

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 ft
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

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

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

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

1) The single status bit (bit 1) shall only be set to ONE (1) if at least latitude and longitude in register 51_{16} and FOM in register 52_{16} are valid. 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.

4) If the barometric pressure is invalid, then the field shall be set to ALL ZEROs, but the status (bit 1) shall not be affected.

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°
7	
8	
9	
10	
11	
12	
13	LATITUDE FINE
14	
15	Range = [0, 180/128]°
16	
17	
18	
19	
20	
21	
22	
23	LSB = 90/16 777 216°
24	MSB = 90/128°
25	
26	
27	
28	
29	
30	
31	LONGITUDE FINE
32	
33	Range = [0, 180/128]°
34	
35	
36	
37	
38	
39	
40	
41	LSB = 90/16 777 216°
42	SIGN
43	MSB = 65 536 ft
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] ft
54	
55	
56	LSB = 8 ft

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 only be set to ONE (1) if at least latitude and longitude in register 51_{16} and FOM in register 52_{16} are valid. This bit shall be identical to the status bit in register $51_{16.}$

2) The LATITUDE (fine) and LONGITUDE (fine) parameters are in 2s 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 $51_{16.}$

4) If the Pressure Altitude and the GNSS Height are invalid, then the field shall be set to ALL ZEROs, but the status (bit 1) shall not be affected.

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.

Note 4.— When LATITUDE (fine) and LONGITUDE (fine) are not available, the setting of the single status bit is not impacted, and LATITUDE (fine) and LONGITUDE (fine) are zeroed.

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

MB FIELD

1	STATUS
2	SIGN
3	MSB = 90°
4	
5	
6	MAGNETIC HEADING
7	
8	Range = [–180, +180]°
9	
10	
11	
12	LSB = 90/512°
13	STATUS
14	MSB = 512 kt
15	
16	
17	INDICATED AIRSPEED (IAS)
18	
19	Range = [0, 1 023] kt
20	
21	
22	
23	LSB = 1 kt
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 kt
36	
37	
38	
39	
40	TRUE AIRSPEED
41	
42	Range = [0, 2 048] kt
43	
44	
45	
46	LSB = 0.5 kt
47	STATUS
48	SIGN
49	MSB = 8 192 ft/min
50	
51	ALTITUDE RATE
52	
53	Range = [–16 384, +16 320] ft/min
54	
55	
56	LSB = 64 ft/min

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.

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

MB 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 min
33	
34	ESTIMATED TIME OF ARRIVAL
35	(NORMAL FLIGHT)
36	
37	Range = [0, 60] min
38	
39	
40	LSB = 60/512 min
41	MSB = 320 FL
42	
43	ESTIMATED FLIGHT LEVEL
44	(NORMAL FLIGHT)
45	Range = [0, 630] FL
46	LSB = 10 FL
47	MSB = 30 min
48	
49	TIME TO GO
50	(DIRECT ROUTE)
51	
52	Range = [0, 60] min
53	
54	
55	LSB = 60/512 min
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

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

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

Parameter Monitor Coding:

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

2) The meteorological hazards subfield shall report changes to turbulence, wind shear, wake vortex, icing and microburst, as in register 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°)
3	MSB = 90°
4	
5	
6	MAGNETIC HEADING
7	
8	Range = [–180, +180]°
9	
10	
11	
12	LSB = 90/512°
13	STATUS
14	MSB = 512 kt
15	
16	
17	INDICATED AIRSPEED
18	
19	Range = [0, 1023] kt
20	
21	
22	
23	LSB = 1 kt
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 ft/min
38	
39	
40	BAROMETRIC ALTITUDE RATE
41	
42	Range = [–16 384, +16 352] ft/min
43	
44	
45	LSB = 8 192/256 = 32 ft/min
46	STATUS
47	SIGN 1 = Below
48	MSB = 8 192 ft/min
49	
50	
51	INERTIAL VERTICAL VELOCITY
52	
53	Range = [–16 384, +16 352] ft/min
54	
55	
56	LSB = 8 192/256 = 32 ft/min

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 §D.2.4.6.

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

MB FIELD

Bit		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.

Note.—The data in this register is not intended for extraction using GICB or ACAS cross-link protocols. The readout of this register is discouraged since the contents are indeterminate.

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

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

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

Table A-2-227. BDS code E,3 — Transponder type/part 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 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 characters 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

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

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 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-2-231. BDS code E,7 — Transponder status and diagnostics

MB FIELD

1	MSB
2	
3	
4	BDS Register Number = E,7
5	
6	
7	
8	LSB
9	MSB SDI Code
10	LSB
11	Non-Diversity Transponder
12	Diversity Failure
13	Upper Receiver Failure
14	Lower Receiver Failure
15	Upper Squitter Failure
16	Lower Squitter Failure
17	Air/Ground #1 Input Status
18	Air/Ground #2 Input Status
19	GPS Time Mark #1 Status
20	GPS Time Mark #2 Status
21	Mode S Limiting During Power-ON Cycle
22	Mode S Limiting
23	Extended Squitter Disable Status
24	ACAS Input Inactive
25	ADS-B Out Status
26	Selected Control Inactive or Failure
27	MSB Control Input Selection
28	LSB
29	MSB Multiple Air Data Source Reporting
30	LSB Selection (e.g. Source in Use)
31	Altitude Alternate Port Selection
32	MSB Altitude Port A Status
33	LSB
34	MSB Altitude Port B Status
35	LSB
36	FMC/GNSS Source Select
37	MSB FMC/GNSS #1 Bus Status
38	LSB
39	MSB FMC/GNSS #2 Bus Status
40	LSB
41	MSB Multiple IRS/AHRS Data Source
42	LSB Reporting Selection (e.g. source in Use)
43	IRS/FMS Source Select
44	MSB IRS/FMS/Data Concentrator In #1
45	LSB
46	MSB IRS/FMS/Data Concentrator In #2
47	LSB
48	FMC Select
49	MSB FMC #1/General In Bus Status
50	LSB
51	MSB FMC #2/General In Bus Status
52	LSB
53	MSB MSP/ATSU/CMU In #1 Status
54	LSB
55	MSB MSP/ATSU/CMU In #2 Status
56	LSB

PURPOSE: To report the configuration and status of the transponder at any given GICB request.

The coding of this register shall conform to:

SDI Code shall be coded as follows:

"00" = Not Used
"01" = Side 1
"10" = Side 2
"11" = Not Used

Non-Diversity Transponder shall be coded as follows:

"0" = Diversity
"1" = Non-Diversity

Bits 12 through 16, and 24 through 26 shall be coded as follows:

"0" = Ok
"1" = Failure

Bits 17 through 20, and Bit 23 shall be coded as follows:

"0" = Inactive or Unknown
"1" = Active

Mode S Limiting During Power-ON Cycle shall be coded as follows:

"0" = No Limiting Event
"1" = Active (e.g. In Limiting)

Bits 24 through 26 shall be coded as follows:

"0" = Active
"1" = Inactive or Failed

Control Input Selection shall be coded as follows:

"00" = Burst Time
"01" = Port A or 1
"10" = Port B or 2
"11" = Port C or 3

Bits 29 through 30 and 41 through 42 shall be coded as follows:

"00" = No Data or Not Used
"01" = Source #1 is being Used
"10" = Source #2 is being used
"11" = Source # 3 is being Used

Altitude Alternate Port Selection shall be coded as follows:

"0" = Port A Selected
"1" = Alternate Port Selection is Active, e.g. Port B selected

Bits 32 through 35, 37 through 40, 44 through 47, and 49 through 56 shall be coded as follows:

"00" = No Data or Not Used
"01" = Active
"10" = Inactive
"11" = Fail

Bits 36, 43, and 48 shall be coded as follows:

"0" = Port #1 Selected
"1" = Port #2 Selected

Table A-2-234. BDS code E,A — Vendor specific status and diagnostics

MB FIELD

1	MSB
2	
3	
4	BDS Register Number "E,A"
5	
6	
7	
8	LSB
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	
31	
32	Manufacturer defined diagnostic field
33	
34	
35	
36	
37	
38	
39	
40	
41	
42	
43	
44	
45	
46	
47	
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53	
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56	

PURPOSE: To report diagnostic status and configuration information in a format defined by the transponder manufacturer.

1) This register allows manufacturers to define configuration and status data that may be specific to their implementation or installation. This register is designed to be a compliment to register $E7_{16}$.

2) This register should only be serviced if the transponder hardware and software can be identified via service of register $E3_{16}$ and/or register $E4_{16}$.

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 = Reserved
1 = Mode code information
2-31 = Reserved

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 (ft)*
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 §A.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

Bit 5 in register $1D_{16}$ shall be set to zero at all times.

Notes:

1. This service allows ground stations to control the Sensitivity Level of ACAS by sending a message to the transponder for delivery to ACAS. This service is required when a transponder supports an ACAS installation. Refer to Annex 10, Volume IV, §4.3.8.4.2, for complete requirements.

2. ACAS installed and operational is communicated in the Data Link Capability Report (register 10_{16}). Therefore, this service is not required to be marked in register $1D_{16}$.

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	Reserved
1	Dataflash
2	Local system management
3 to 255	Reserved

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

EC field value	*Meaning*
	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	Reserved
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
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	Reserved
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 (Reserved)

RT = 1 (Reserved)

RT = 2 Local system management

RT = 3 to 255 (Reserved)

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 s	
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 (LB) (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	RESERVED		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 (LB)		41	MSB
	LSB (2 BITS)		42	
	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

This packet shall always be sent as a linked Comm-B. The second segment being a direct copy of the relevant register.

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 D.

B.2. DATA FORMATS FOR TRANSPONDER REGISTERS

B.2.1 REGISTER ALLOCATION

The register allocation shall be as specified in §A.2.1, with the exception that extended squitter registers for Version 1 are defined in the following table.

Register number	*Assignment*	*Maximum update interval* *Note 1*
05_{16}	Extended Squitter Airborne Position Note 4	0.2 s
06_{16}	Extended Squitter Surface Position Note 4	0.2 s
07_{16}	Extended Squitter Status	1.0 s
08_{16}	Extended Squitter Identification and Category Note 4	15.0 s
09_{16}	Extended Squitter Airborne Velocity Note 4	1.3 s
$0A_{16}$	Extended Squitter Event-Driven Information	variable

Register number	*Assignment*	*Maximum update interval* Note 1
61_{16}	Extended Squitter Aircraft Status Note 4	1.0 s
62_{16}	Target State and Status Information Note 4	0.5 s
63_{16}-64_{16}	Reserved for Extended Squitter	
65_{16}	Extended Squitter Aircraft Operational Status Note 4	2.5 s
66_{16}-$6F_{16}$	Reserved for Extended Squitter	

Notes:

1. 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.

2. Register $0A_{16}$ is not to be used for GICB or ACAS crosslink readout.

3. If Extended Squitter is implemented, then register 08_{16} is not cleared or ZEROed once either Flight Identification or Aircraft Registration data has been loaded into the register during the current power-on cycle. Register 08_{16} is not cleared since it provides information that is fundamental to track file management in the ADS-B environment. Refer to §C.2.4.3.3 for implementation guidelines regarding register 08_{16}.

4. These registers define Version 1 extended squitters.

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		
		0		$R_C < 0.1$ NM (185.2 m)	NIC = 8		
8		0		$R_C \geq 0.1$ 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
		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		
		0		$R_C < 8$ NM (14.816 km)	NIC = 2		
17		0		$R_C < 20$ NM (37.04 km)	NIC = 1		
18		0		$R_C \geq 20$ 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		$R_C \geq 25$ 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	0		Reserved				
	1		Surface System Status (Allocated for National Use)				
	2–7		Reserved				
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				

Notes:

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.

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

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.

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).

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.

6. 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.

7. The position quality in Version 1 extended squitter messages is provided by the Navigational Accuracy Category (NAC_P), Navigational Integrity Category (NIC), NIC Supplement, and Surveillance Integrity Level (SIL) parameters.

8. NAC_P provides an indication of position accuracy, while SIL, NIC and the NIC Supplement in combination provide an indication of the integrity associated with the broadcast position. NAC_P, SIL and the NIC Supplement are transmitted in the Extended Squitter Aircraft Operational Status Message. NAC_P and SIL are also transmitted in the Target State and Status Message. NIC is determined from the message Type Code. The NIC Supplement is used with some values of NIC to distinguish between two possible values of the containment radius. In the absence of the NIC Supplement, the higher NIC containment radius should be used.

9. Version 1 position messages with Type Codes 8, 18 or 22 and position messages associated with SIL of 0 or NAC_P of 0 are not appropriate to support most ADS-B applications since the accuracy or integrity of the position broadcast in these messages is unknown by the transmitting device.

10. It is recommended that Version 1 extended squitter messages with unknown accuracy or integrity only be used if either the position accuracy or integrity can be verified by other means, or the application has no specific requirements for these parameters.

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 of 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 of 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 of 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 of 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 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 heading/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 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 TARGET STATE AND STATUS INFORMATION

The target state and status information squitter shall be formatted as specified in the definition of register 62_{16} and in the following paragraphs:

B.2.3.9.1 TRANSMISSION RATE

The Target State and Status 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.

B.2.3.9.2 MESSAGE DELIVERY

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

B.2.3.9.3 VERTICAL DATA AVAILABLE/SOURCE INDICATOR

This 2-bit (ME bits 8–9, Message bits 40–41) subfield shall be used to identify whether 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 the vertical 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 Vertical Data Available/Source Indicator subfield.

Coding		
(Binary)	*(Decimal)*	*Meaning*
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

B.2.3.9.4 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 (FL). A value of ONE (1) shall indicate a target altitude referenced to barometric corrected altitude (MSL).

B.2.3.9.5 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		
(Binary)	*(Decimal)*	*Meaning*
00	0	Capability for reporting holding altitude only
01	1	Capability for reporting either holding altitude or autopilot control panel selected altitude

Coding		
(Binary)	*(Decimal)*	*Meaning*
10	2	Capability for reporting either holding altitude, autopilot control panel selected altitude, or any FMS/RNAV level-off altitude
11	3	Reserved

B.2.3.9.6 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		
(Binary)	*(Decimal)*	*Meaning*
00	0	Unknown mode or information unavailable
01	1	“Acquiring” Mode
10	2	“Capturing” or “Maintaining” Mode
11	3	Reserved

B.2.3.9.7 TARGET ALTITUDE

This 10-bit (ME bits 16–25, Message bits 48–57) subfield shall be used to provide the 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		
(Binary)	*(Decimal)*	*Meaning*
00 0000 0000	0	Target altitude = –1 000 ft
00 0000 0001	1	Target altitude = –900 ft
00 0000 0010	2	Target altitude = –800 ft
***	***	***
00 0000 1011	11	Target altitude = zero (0) ft
00 0000 1100	12	Target altitude = 100 ft
***	***	***
11 1111 0010	1010	Target altitude = 100 000 ft
11 1111 0011 — 11 1111 1111	1011–1023	Invalid (out of range)

B.2.3.9.8 HORIZONTAL DATA AVAILABLE/SOURCE INDICATOR

This 2-bit (ME bits 26–27, message bits 58–59) subfield shall be used to identify whether the 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 the 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		
(Binary)	*(Decimal)*	*Meaning*
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)

B.2.3.9.9 TARGET HEADING/TRACK ANGLE

This 9-bit (ME bits 28–36, message bits 60–68) subfield shall be used to provide the 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		
(Binary)	*(Decimal)*	*Meaning*
0 0000 0000	0	Target heading/track = zero°
0 0000 0001	1	Target heading/track = 1°
0 0000 0010	2	Target heading/track = 2°
***	***	***
1 0110 0111	359	Target heading/track = 359°
1 0110 1000 through 1 1111 1111	360 through 511	Invalid

B.2.3.9.10 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.

B.2.3.9.11 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		
(Binary)	*(Decimal)*	*Meaning*
00	0	Unknown mode or information unavailable
01	1	"Acquiring" mode
10	2	"Capturing" or "Maintaining" mode
11	3	Reserved

B.2.3.9.12 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		
(Binary)	*(Decimal)*	*Meaning = 95% horizontal and vertical accuracy bounds (EPU and VEPU)*
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 (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

Notes:

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, centred 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).

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).

3. RNP accuracy includes error sources other than sensor error, whereas horizontal error for NAC_P only refers to horizontal position error uncertainty.

4. If geometric altitude is not being reported, then the VEPU tests are not assessed.

B.2.3.9.13 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.

Notes:

1. The barometric altitude value itself is conveyed within the ADS-B Position Message.

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.

3. The use of Gilham-type altimeters is strongly discouraged because of the potential for undetected altitude errors.

B.2.3.9.14 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), 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

Notes:

1. "An Indication" may include, for example, a flag for invalid position report, or a change in NIC, or switching to another data source.

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.

3. The vertical integrity containment column only applies to NIC values greater than 8.

4. The SIL code value is the lower of the horizontal or vertical coding values.

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 provides a reasonable bound on the order of magnitude of the probability of possible failures affecting ADS-B applications.*

6. GNSS systems report integrity in terms of flight hours, and FMS systems report integrity 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.2.3.9.14.1 **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.*

B.2.3.9.15 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

B.2.3.9.16 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		
(Binary)	*(Decimal)*	*Meaning*
000	0	No emergency
001	1	General emergency
010	2	Lifeguard/medical emergency

Coding		
(Binary)	*(Decimal)*	*Meaning*
011	3	Minimum fuel
100	4	No communications
101	5	Unlawful interference
110	6	Downed aircraft
111	7	Reserved

B.2.3.10 AIRCRAFT OPERATIONAL STATUS

The aircraft operational status message squitter shall be formatted as specified in the definition of register 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; and

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.

<table>
<tr><td>Msg Bit #</td><td>57</td><td>58</td><td>59</td><td>60</td><td>61</td><td>62-72</td></tr>
<tr><td>“ME” Bit #</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30-40</td></tr>
<tr><td rowspan="4">OM format</td><td colspan="2">0 0</td><td>ACAS
RA active</td><td>IDENT switch
active</td><td>Receiving ATC
services</td><td>Reserved</td></tr>
<tr><td colspan="2">0 1</td><td colspan="4">Reserved</td></tr>
<tr><td colspan="2">1 0</td><td colspan="4">Reserved</td></tr>
<tr><td colspan="2">1 1</td><td colspan="4">Reserved</td></tr>
</table>

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		
(Binary)	*(Decimal)*	*Meaning*
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) AND NIC SUPPLEMENT

B.2.3.10.6.1 The NIC supplement is a 1-bit (ME bit 44, message bit 76) subfield that shall be used in conjunction 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.

Note.— The first 5-bit field ("ME" bits 1–5, Message bits 33–37) in every Mode S extended squitter message contains the format TYPE code. The format TYPE code differentiates the messages into several classes: Airborne Position, Airborne Velocity, Surface Position, Identification, Aircraft Intent, Aircraft State, etc. In addition, the format TYPE code also encodes the NIC value of the source used for the position report. The NIC value is used to allow surveillance applications to determine whether the reported geometric position has an acceptable level of integrity containment region for the intended use. The NIC integrity containment region is described horizontally and vertically using two parameters: the containment radius, $R_{C,}$ and the Vertical Protection Limit, VPL. The format TYPE code also differentiates 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 code and NIC values conform to the definition contained in the table in §B.2.3.1.

B.2.3.10.6.2 If an update has not been received from an on-board data source for the NIC value within the past 5 seconds, then the TYPE Code and NIC Supplement 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

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
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		
(Binary)	*(Decimal)*	*Meaning = 95% horizontal and vertical accuracy bounds (EPU and VEPU)*
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

Notes:

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, centred 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).

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).

3. RNP accuracy includes error sources other than sensor error, whereas horizontal error for NAC_P only refers to horizontal position error uncertainty.

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), 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

Notes:

1. "An Indication" may include, for example, a flag for invalid position report, or a change in NIC, or switching to another data source.

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.

3. The vertical integrity containment column applies to NIC values greater than 8.

4. The SIL code value is the lower of the horizontal or vertical coding values.

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.

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.— 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.

<table>
<tr><th rowspan="2">A/V — L/W code (Decimal)</th><th colspan="3">Length code</th><th>Width code</th><th colspan="2">Upper-bound length and width for each length/width code</th></tr>
<tr><th>ME bit 49</th><th>ME bit 50</th><th>ME bit 51</th><th>ME bit 52</th><th>Length (metres)</th><th>Width (metres)</th></tr>
<tr><td>0</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td>0</td><td rowspan="2">15</td><td>11.5</td></tr>
<tr><td>1</td><td>1</td><td>23</td></tr>
<tr><td>2</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">1</td><td>0</td><td rowspan="2">25</td><td>28.5</td></tr>
<tr><td>3</td><td>1</td><td>34</td></tr>
<tr><td>4</td><td>0</td><td>1</td><td>0</td><td>0</td><td>35</td><td>33</td></tr>
</table>

	Length code			*Width code*	*Upper-bound length and width for each length/width code*	
A/V — L/W code (Decimal)	*ME bit 49*	*ME bit 50*	*ME bit 51*	*ME bit 52*	*Length (metres)*	*Width (metres)*
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 two 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 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 s (±0.2 s)
	>0	Reserved
24		Reserved
25		Reserved
26		Reserved
27		Reserved
28	= 1	5.0 s (±0.2 s)
	= 2	10 s after RAT transitions from 0 to 1

Message type	*Message subtype*	*Message lifetime*
	0, >2	Reserved
29	= 0	2.5 s (±0.2 s)
	>0	Reserved
30		Reserved
31	= 0, 1	5.0 s (±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 §C.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 Heading/ground track: 0 = Invalid, 1 = Valid
14	MSB = 180°
15	
16	HEADING/GROUND TRACK
17	(specified in §B.2.3.3.2)
18	
19	
20	LSB = 360/128°
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 §C.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 §C.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	FORMAT TYPE CODE (specified in §B.2.3.1)
2		
3		
4		
5	LSB	
6	MSB	EMITTER 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 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 lb or 7 031 kg)
2 = Small (15 500 to <75 000 lb or 7 031 to <34 019 kg)
3 = Large (75 000 to 300 000 lb or 34 019 to 136 078 kg)
4 = High vortex aircraft
5 = Heavy (>300 000 lb or 136 078 kg)
6 = High performance (>5 g acceleration) and high speed (>400 kt)
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

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 kt		SUPERSONIC: LSB = 4 kt	
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 kt		SUPERSONIC: LSB = 4 kt	
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°			
16				
17				
18	MAGNETIC HEADING			
19	(specified in §B.2.3.5.6)			
20				
21				
22				
23				
24	LSB = 360/1 024°			
25	AIRSPEED TYPE: 0 = IAS, 1 = TAS			
26	AIRSPEED			
27	NORMAL: LSB = 1 kt		SUPERSONIC: LSB = 4 kt	
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.

Note.—The data in this register is not intended for extraction using GICB or ACAS cross-link protocols. The readout of this register is discouraged since the contents are indeterminate.

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-2-98. BDS Code 6,2 — Target state and status information

MB FIELD

PURPOSE: To provide aircraft state and status information.

Bit		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 §B.2.3.9.3)
10		Target Altitude Type (see §B.2.3.9.4)
11		Backward Compatibility Flag = 0
12	MSB	Target Altitude Capability
13	LSB	(see §B.2.3.9.5)
14	MSB	Vertical Mode Indicator
15	LSB	(see §B.2.3.9.6)
16	MSB	Target Altitude
17		(see §B.2.3.9.7)
18		
19		
20		
21		
22		
23		
24		
25	LSB	
26	MSB	Horizontal Data Available/Source Indicator
27	LSB	(see §B.2.3.9.8)
28	MSB	Target Heading/Track Angle
29		(see §B.2.3.9.9)
30		
31		
32		
33		
34		
35		
36	LSB	
37		Target Heading/Track Indicator (see §B.2.3.9.10)
38	MSB	Horizontal Mode Indicator (see §B.2.3.9.11)
39	LSB	
40	MSB	Navigation Accuracy Category — Position (NAC_P)
41		(see §B.2.3.9.12)
42		
43	LSB	
44		Navigation Integrity Category — Baro (NIC_{BARO}) (see §B.2.3.9.13)
45	MSB	Surveillance Integrity Level (SIL)
46	LSB	(see §B.2.3.9.14)
47		Reserved
48		
49		
50		
51		
52	MSB	Capability/Mode Codes
53	LSB	(see §B.2.3.9.15)
54	MSB	Emergency/Priority Status
55		(see §B.2.3.9.16)
56	LSB	

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

Notes:

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.

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.

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.

TIS-B Format Definition					
Bit #	1 ---- 5	6 --- 8	9 ----- 32	33 ------------------------- 88	89 ---- 112
DF = 18 Field Names	DF[5]	CF[3]	AA[24]	ME[56]	PI[24]
	10010				
	MSB	MSB	MSB	MSB	MSB
	LSB	LSB	LSB	LSB	LSB

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

CF value	ICAO/Mode A Flag (IMF)	Meaning
	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.
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 A.2.3.2.1.

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 kt. 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 kt.

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 kt*
0	No ground speed information
1	GS ≤ 16
2	16 ≤ GS < 48
3	48 < GS < 80
*****	*****
62	1936 ≤ GS < 1968
63	GS ≥ 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

Bit	
1	MSB
2	
3	FORMAT TYPE CODE
4	(see §B.2.3.1)
5	LSB
6	MSB SURVEILLANCE STATUS
7	LSB
8	IMF (see §B.3.4.1.1)
9	MSB
10	
11	
12	
13	PRESSURE-ALTITUDE
14	
15	This is the altitude code (AC) as specified in §3.1.2.6.5.4
16	of Annex 10, Volume IV, but with the M-bit removed
17	
18	
19	
20	LSB
21	RESERVED
22	CPR FORMAT (F) (see §A.2.3.2.1)
23	MSB
24	
25	
26	
27	
28	
29	
30	CPR ENCODED LATITUDE
31	
32	(CPR airborne format specified in §C.2.6)
33	
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	
47	CPR ENCODED LONGITUDE
48	
49	(CPR airborne format specified in §C.2.6)
50	
51	
52	
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 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°
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 §C.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 §C.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

1	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:

<u>Set A:</u>

0 = No ADS-B emitter category information
1 = Light (<15 500 lb or 7 031 kg)
2 = Small (15 500 to <75 000 lb or 7 031 to <34 019 kg)
3 = Large (75 000 to 300 000 lb or 34 019 to 136 078 kg)
4 = High vortex aircraft
5 = Heavy (>300 000 lb or 136 078 kg)
6 = High performance (>5 g acceleration) and high speed (>400 kt)
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:

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 kt		SUPERSONIC: LSB = 4 kt	
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 kt		SUPERSONIC: LSB = 4 kt	
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	RESERVED			
54				
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

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°			
16				
17				
18	HEADING			
19	(specified in §B.2.3.5.6)			
20				
21				
22				
23				
24	LSB = 360/1 024°			
25	AIRSPEED TYPE: 0 = IAS, 1 = TAS			
26	AIRSPEED			
27	NORMAL: LSB = 1 kt		SUPERSONIC: LSB = 4 kt	
28	All zeros = no velocity information		All zeros = no velocity information	
29	<u>Value</u>	<u>Velocity</u>	<u>Value</u>	<u>Velocity</u>
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	<u>Value</u>		<u>Vertical Rate</u>	
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	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.

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	<u>Value</u>	<u>Vertical Rate</u>
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	<u>Value</u>	<u>Difference</u>
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

PROVISIONS FOR EXTENDED SQUITTER VERSION 2

C.1 INTRODUCTION

C.1.1 INTRODUCTION

Appendix C defines data formats and protocols that shall be used for implementation of 1 090 MHz extended squitter, Version Two (2).

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

Section C.1 Introduction

Section C.2 Data formats for transponder registers

Section C.3 Traffic information services – broadcast (TIS-B) formats and coding

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

Section C.5 Provisions for Backward Compatibility with Version 0 and Version 1 ADS-B Systems.

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

C.2 DATA FORMATS FOR TRANSPONDER REGISTERS

C.2.1 REGISTER ALLOCATION

The register allocation shall be as specified in §A.2.1, with the exception that extended squitter registers for Version 2 are defined in Table C-1.

Table C-1. Register Allocation

Register number	*Assignment*	*Maximum update interval* Note 3
05_{16}	Extended Squitter Airborne Position	0.2 s
06_{16}	Extended Squitter Surface Position	0.2 s
07_{16}	Extended Squitter Status	1.0 s
08_{16}	Extended Squitter Identification and Category	15.0 s
09_{16}	Extended Squitter Airborne Velocity	1.3 s
$0A_{16}$	Extended Squitter Event-Driven Information	variable
61_{16}	Extended Squitter Aircraft Status	1.0 s
62_{16}	Target State and Status Information	0.5 s
63_{16}–64_{16}	Reserved for Extended Squitter	
65_{16}	Extended Squitter Aircraft Operational Status	2.5 s
66_{16}–$6F_{16}$	Reserved for Extended Squitter	

Notes:

1. The register number is equivalent to the B-Definition Subfield (BDS) value (see §2.2.14.4.20.b of RTCA DO-181E [EUROCAE ED-73E, §3.18.4.18.b]).

2. Register $0A_{16}$ is not to be used for GICB or ACAS crosslink readout.

3. The term "minimum update rate" is used in this manual. The "minimum update rate" is obtained when data is loaded in one register field once every "maximum update interval."

4. If Extended Squitter is implemented, then register 08_{16} is not cleared or ZEROed once either Flight Identification or Aircraft Registration data has been loaded into the register during the current power-on cycle. Register 08_{16} is not cleared since it provides information that is fundamental to track file management in the ADS-B environment. Refer to §C.2.4.3.3 for implementation guidelines regarding register 08_{16}.

5. These registers define Version 2 extended squitters.

C.2.1.1 The details of the data to be entered into the registers assigned for Extended Squitter shall be as defined in this Appendix. Table C-1 specifies the maximum update interval at which the appropriate transponder register(s) shall be reloaded with valid data. Any valid data shall be reloaded into the relevant field as soon as it becomes available at the Mode S Specific Services Entity (SSE) interface regardless of the update rate. Unless otherwise specified, if data are not available for a time no greater than twice the specified "maximum update interval," or 2 seconds (whichever is the greater), then the status bit (if provided) shall indicate that the data in that field are invalid, and the field shall be ZEROed.

C.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).

C.2.2 GENERAL CONVENTIONS ON DATA FORMATS

C.2.2.1 VALIDITY OF DATA

For requirements on the validity of data, see §A.2.2.1.

C.2.2.2 REPRESENTATION OF NUMERICAL DATA

Numerical data shall be represented as specified in §A.2.2.2.

C.2.2.3 RESERVED FIELDS

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

C.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, §3.1.2.8.7 of Annex 10, Volume IV). The data content and the transmit times shall be the same as specified for the transponder case.

C.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 Code. The format TYPE Code differentiates the messages into several classes: Airborne Position, Airborne Velocity, Surface Position, Identification, Aircraft Intent, Aircraft State, etc. In addition, the format TYPE Code encodes the Navigation Integrity Category (NIC) of the source used for the position report. The format TYPE Code also differentiates 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 Table C-2.

Table C-2. "TYPE" Code Subfield Definitions (DF = 17 or 18)

TYPE code	*Subtype code*	*NIC supplement*			*Format (message type)*	*Horizontal containment radius limit (R_C)*	*Navigation integrity category (NIC)*	*Altitude type*	*Notes*
		A	*B*	*C*					
0	Not Present	Not Applicable			No Position Information (Airborne or Surface Position Messages)	R_C unknown	NIC = 0	Baro Altitude or No Altitude Information	1, 2, 3
1	Not Present	Not Applicable			Aircraft Identification and Category Message (§C.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	--	0	Surface Position Message (§C.2.3.3)	R_C < 7.5 m	NIC = 11	No Altitude Information	
6		0	--	0		R_C < 25 m	NIC = 10		
7		1	--	0		R_C < 75 m	NIC = 9		5
		0	--	0		R_C < 0.1 NM (185.2 m)	NIC = 8		
8		1	--	1		R_C < 0.2 NM (370.4 m)	NIC = 7		8
		1	--	0		R_C < 0.3 NM (555.6 m)	NIC = 6		
		0	--	1		R_C < 0.6 NM (1 111.2 m)			
		0	--	0		R_C > 0.6 NM (1 111.2 m) or unknown	NIC = 0		
9	Not Present	0	0	--	Airborne Position Message (§C.2.3.2)	R_C < 7.5 m	NIC = 11	Baro Altitude	
10		0	0	--		R_C < 25 m	NIC = 10		
11		1	1	--		R_C < 75 m	NIC = 9		5
		0	0	--		R_C < 0.1 NM (185.2 m)	NIC = 8		
12		0	0	--		R_C < 0.2 NM (370.4 m)	NIC = 7		
13		0	1	--		R_C < 0.3 NM (555.6 m)	NIC = 6		7
		0	0	--		R_C < 0.5 NM (926 m)			
		1	1	--		R_C < 0.6 NM (1 111.2 m)			
14		0	0	--		R_C < 1.0 NM (1 852 m)	NIC = 5		
15		0	0	--		R_C < 2 NM (3.704 km)	NIC = 4		
16		1	1	--		R_C < 4 NM (7.408 km)	NIC = 3		6
		0	0	--		R_C < 8 NM (14.816 km)	NIC = 2		
17		0	0	--		R_C < 20 NM (37.04 km)	NIC = 1		
18		0	0	--		R_C > 20 NM (37.04 km) or unknown	NIC = 0		
19	0	Not Applicable			Reserved	Not Applicable	Not Applicable	Difference between "Baro Altitude" and "GNSS Height (HAE)"	
	1–4				Airborne Velocity Message (§C.2.3.5)				
	5–7				Reserved				
20	Not	0	0	--	Airborne Position Message	R_C < 7.5 m	NIC = 11	GNSS Height	2

TYPE code	*Subtype code*	*NIC supplement A*	*NIC supplement B*	*NIC supplement C*	*Format (message type)*	*Horizontal containment radius limit (R_C)*	*Navigation integrity category (NIC)*	*Altitude type*	*Notes*
21	Present	0	0	--	(§C.2.3.2)	R_C < 25 m	NIC = 10	(HAE)	
22		0	0	--		R_C > 25 m or unknown	NIC = 0		
23	0	*Not Applicable*			Test Message				
	1–7				Reserved				
24	0				Reserved				
	1				Surface System Status (Allocated for National Use)				
	2–7				Reserved				
25–26					Reserved				
27					Reserved for Trajectory Change Message				
28	0				Reserved				
	1				Extended Squitter Aircraft Status Message (Emergency/Priority Status and Mode A Code) (§C.2.3.7.3)				
	2				Extended Squitter Aircraft Status Message (1 090 ES TCAS/ACAS RA Broadcast Message) (§C.2.3.7.2)				
	3–7				Reserved				
29	0				Target State and Status Message (ADS-B Version Number = 1, defined in RTCA DO-260A, §N.3.5)				
	1				Target State and Status Message (§C.2.3.9) (ADS-B Version Number = 2, defined in this manual)				
	2–3				Reserved				
30	0–7				Reserved				
31	0–1				Aircraft Operational Status Message (§C.2.3.10)				
	2–7				Reserved				

Notes:

*1. "Baro Altitude" means barometric pressure altitude, relative to a standard pressure of 1 013.25 millibars (29.92 in.Hg.). It does **not** mean baro-corrected altitude.*

2. TYPE codes 20 to 22 or TYPE Code 0 are to be used when valid "Baro Altitude" is not available.

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 9–20, and bits 22–56 set to ZERO (0). If neither horizontal position nor barometric altitude information is available, then all 56 bits of register 05_{16} are set to zero. The ZERO (0) TYPE Code field indicates that latitude and longitude information is not available, while the Zero altitude field indicates that altitude information is not available.

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 horizontal protection limit (HPL) or autonomous horizontal integrity limit (HIL) in different documents.

5. The "NIC Supplement-A" in the Aircraft Operational Status Message (see §C.2.3.10.6) enables the Report Assembly Function in ADS-B Receiving Subsystem to determine whether the ADS-B Transmitting Subsystem is announcing NIC = 8 (R_C < 0.1 NM) or NIC = 9 (R_C < 75 m).

6. The "NIC Supplement-B" field in the Airborne Position Message (see §C.2.3.2.5), and NIC Supplement-A in the Aircraft Operational Status Message (see §C.2.3.10.6) enables the Report Assembly Function in ADS-B Receiving Subsystem to determine whether the ADS-B Transmitting Subsystem is announcing NIC = 2 (R_C < 8 NM) or NIC = 3 (R_C < 4 NM).

7. The "NIC Supplement-B" field in the Airborne Position Message (see §C.2.3.2.5) and the "NIC Supplement-A" in the Aircraft Operational Status Message (see §C.2.3.10.6) enables the Report Assembly Function in ADS-B Receiving Subsystem to determine whether the ADS-B Transmitting Subsystem is announcing R_C < 0.3 NM, or R_C < 0.5 NM or R_C < 0.6 NM.

8. The NIC Supplement-A field in the Aircraft Operational Status Message (see §C.2.3.10.6) together with the NIC Supplement-C field in the Surface Capability Class (CC) Code Subfield of the Aircraft Operational Status Message (see §C.2.3.10.20) enable the Report Assembly Function in ADS-B Receiving Subsystem to determine whether the ADS-B Transmitting Subsystem is announcing NIC = 7 with either (R_C < 0.2 NM) or NIC = 6 (R_C < 0.3 NM) or NIC = 6 with (R_C < 0.6 NM) or NIC = 0 with (R_C >= 0.6 NM or unknown).

9. Future versions of this manual may limit transmission of Surface Position Messages at lower NIC and/or NAC_P values for transponder-based systems.

C.2.3.1.1 AIRBORNE POSITION MESSAGE TYPE CODE

C.2.3.1.1.1 Airborne Position Message TYPE Code if Containment Radius is Available

Notes:

1. 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.

2. Although these requirements do not require HPL limiting, it is expected that some regulators will only accept installations that limit HPL. This may be standardized accordingly in future versions of this manual.

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 Code 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 Code subfield of Airborne Position Messages to a value in the range of 9 to 18 in accordance with Table C-2.

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 Code subfield of Airborne Position Messages to a value in the range of 20 to 22 depending on the radius of containment (R_C) in accordance with Table C-2.

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 Code subfield in Airborne Position Messages to a value in the range of 9 to 18 depending on the radius of containment R_C in accordance with Table C-2. (In that case, the ALTITUDE subfield of the Airborne Position Messages shall be set to all ZEROs in order to indicate that valid altitude information is not available.)

C.2.3.1.1.2 Airborne Position Message TYPE Code if Containment Radius is Not Available

If R_C (radius of containment) 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 Code subfield to ZERO (0) if valid horizontal position information is not available.

b) The ADS-B Transmitting Subsystem shall set the TYPE Code 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 Code subfield to 22.

C.2.3.1.1.3 Airborne Position Message TYPE Code During Fault Detection and Exclusion Condition

Under normal operating conditions, the R_C can be directly determined from Horizontal Protection Limit (HPL) or Horizontal Integrity Limit (HIL) inputs to the ADS-B Transmitting Subsystem from the GPS/GNSS receiver. However, there are times when the Fault Detection and Exclusion (FDE) function of the GPS/GNSS receiver has detected a satellite failure but has not excluded the satellite from the navigation data solution. For the purposes of this manual, the condition just described will be referred to as an “FDE Fault” which is typically annunciated by the GPS/GNSS receiver by an appropriate method. For example, ARINC 743A compliant GPS/GNSS receivers will set Label “130” bit “11” to ONE (1) to indicate the “FDE Fault.” If an “FDE Fault” does not exist, then bit “11” is set to ZERO (0). Of importance is the situation that even though an “FDE Fault” indication has been set, the GPS/GNSS typically continues to provide HPL or HIL data as well as Latitude, Longitude and Velocity data while continuing to declare them to be valid on the interface. As the “FDE Fault” condition represents a condition where the position and accuracy data cannot be guaranteed by the GPS/GNSS receiver, the ADS-B Transmitting Subsystem shall apply the following process upon detection of the “FDE Fault” annunciation:

Notes:

1. If position sources can be demonstrated to overcome this degraded state of integrity when the “FDE Fault” condition occurs, then the following requirements do not apply.

2. Factors such as surface multi-path have been observed to cause intermittent annunciation of “FDE Faults” by the GPS/GNSS receiver. Such occurrences will result in the intermittent settings of the subfields addressed in subparagraphs “a,” “c” and “d” below. These intermittent conditions should be taken into account by ADS-B and Air Traffic Services that are using the data provided by the ADS-B Transmitting Subsystems.

a) The “TYPE” Code of Airborne Position Messages shall be set to either “18” or “22,” whichever is applicable in order to indicate that R_C is UNKNOWN.

Note.— The “TYPE” Code is not required to be set to ZERO (0), as to do so would indicate that there is NO Position Data which will result in the ADS-B Transmitting Subsystem declaring an ADS-B Function Failure (see RTCA DO-260B, §2.2.11.6).

b) Valid Latitude and Longitude Position data shall continue to be processed and reported in the Airborne Position Message as required.

c) The NIC Supplement-B subfield in the Airborne Position Message will be set to ZERO (0) in accordance with §C.2.3.10.6 and Table C-28 for a NIC Value of ZERO (0) when “TYPE” Code is set to either “18” or “22”.

d) The NIC Supplement-A subfield in the Airborne Aircraft Operational Status Message (TYPE = 31, Subtype = 0) shall be set to ZERO (0) in accordance with §C.2.3.10.6 and Table C-28 for a NIC Value of ZERO (0) when “TYPE” code is set to either “18” or “22.”

e) The NAC_P subfield in the Aircraft Operational Status Message (TYPE = 31, Subtype = 0) shall be set to ZERO (0) in accordance with §C.2.3.9.9 and Table C-13 in order to specify that the accuracy is UNKNOWN.

f) The NAC_V subfield in the Airborne Velocity Message (TYPE = 19) shall be set to ZERO (0) in accordance with §C.2.3.5.4 and Table C-5.

C.2.3.1.1.4 Broadcast of TYPE Code Equal to ZERO (0)

The TYPE Code Equal to ZERO message may be required as a consequence of the following events:

a) An ADS-B Airborne Position or Surface Position Message register has not been loaded with data in the last 2 seconds. In this case, the ADS-B Message register shall be cleared (i.e. all 56 bits set to ZERO) once it has timed out. Transmission of the ADS-B Message that broadcasts the contents of the register shall be terminated if the ADS-B Message register has not been loaded in 60 seconds, except that transmission termination of Surface Position Messages does not apply to Non-Transponder-Based Devices on aircraft that are on the surface, on surface vehicles, or if barometric altitude information is available. Broadcast of the ADS-B Airborne Position or Surface Position Message shall resume once data has been loaded into the ADS-B Message register.

b) The data management function responsible for loading the ADS-B Message registers determines that all navigation sources that can be used for the Airborne or Surface Position Message are either missing or invalid. In this case the data management function shall clear (set all data fields to ALL ZEROs) the TYPE Code and all other fields of the Airborne or Surface Position Message and insert the ZEROed message into the appropriate ADS-B Message register. This should only be done once in support of the detection of the loss of data insertion and shall result in the suppression of the broadcast of the related ADS-B Message.

c) Note that in all of the cases discussed above, a TYPE Code of ZERO infers a message of ALL ZEROs. The only exception is that the Airborne Position Message format shall contain barometric altitude code as set by the transponder when so implemented. There is no analogous case for the other Extended Squitter Message Types, since a ZERO value in any of the fields indicates that no valid information is available.

C.2.3.1.2 SURFACE POSITION MESSAGE TYPE CODE

C.2.3.1.2.1 Surface Position Message TYPE Code if Containment Radius is Available

If R_C (horizontal radius of containment) 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 Table C-2.

Notes:

1. 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.

2. Although these requirements do not require HPL limiting, it is expected that some regulators will only accept installations that limit HPL. This may be standardized accordingly in future versions of this manual.

C.2.3.1.2.2 Surface Position Message TYPE Code if Radius of Containment is Not Available

If R_C (horizontal radius of containment) 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 Code subfield to ZERO (0) if valid horizontal position information is not available.

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

C.2.3.1.2.3 Surface Position Message TYPE Code based on Horizontal Protection Level or Estimated Horizontal Position Accuracy

a) If valid horizontal position information is available, then the “TYPE” Code in the Surface Position Message shall be set in the range of 5 to 8.

b) If R_C (Horizontal Radius of Containment) information is available from the navigation data source, the “TYPE” Code shall be selected according to the R_C value, in accordance with Table C-2.

c) If R_C is not available from the navigation data source, then the “TYPE” Code shall be set to 8, and NIC Supplement-A and NIC Supplement-C shall be set to ZERO (0).

C.2.3.1.2.4 Surface Position Message TYPE Code During Fault Detection and Exclusion Condition

Under normal operating conditions, the R_C can be directly determined from Horizontal Protection Limit (HPL) or Horizontal Integrity Limit (HIL) inputs to the ADS-B Transmitting Subsystem from the GPS/GNSS receiver. However, there are times when the Fault Detection and Exclusion (FDE) function of the GPS/GNSS receiver has detected a satellite failure but has not excluded the satellite from the navigation data solution. For the purposes of this manual, the condition just described will be referred to as an “FDE Fault” which is typically annunciated by the GPS/GNSS receiver by an appropriate method. For example, ARINC 743A compliant GPS/GNSS receivers will set Label “130” bit “11” to ONE (1) to indicate the “FDE Fault.” If an “FDE Fault” does not exist, then bit “11” is set to ZERO (0). Of importance is the situation that even though an “FDE Fault” indication has been set, the GPS/GNSS typically continues to provide HPL or HIL data as well as Latitude, Longitude, and Velocity data while continuing to declare them to be valid on the interface. As the “FDE Fault” condition represents a condition where the position and accuracy data cannot be guaranteed by the GPS/GNSS receiver, the ADS-B Transmitting Subsystem shall apply the following process upon detection of the “FDE Fault” annunciation:

Note.— If position sources can be demonstrated to overcome this degraded state of integrity when the “FDE Fault” condition occurs, then the following requirements do not apply.

a) The "TYPE" Code of Surface Position Messages shall be set to "8" in order to indicate that R_C is UNKNOWN.

Note.— The "TYPE" Code is not required to be set to ZERO (0), as to do so would indicate that there is NO Position Data which will result in the ADS-B Transmitting Subsystem declaring an ADS-B Function Failure (see RTCA DO-260B, §2.2.11.6).

b) Valid Latitude and Longitude Position data shall continue to be processed and reported in the Surface Position Message as required.

c) The NIC Supplement-A and NIC Supplement-C subfields in the Surface Aircraft Operational Status Message (TYPE = 31, Subtype = 1) shall be set to ZERO (0) in accordance with §C.2.3.10.6 and Table C-28 for a NIC Value of ZERO (0) when "TYPE" Code is set to "8."

d) The NAC_P subfield in the Surface Aircraft Operational Status Message (TYPE = 31, Subtype = 1) shall be set to ZERO (0) in accordance with §C.2.3.9.9 and Table C-13 in order to specify that the accuracy is UNKNOWN.

e) The NAC_V CC subfield in the Surface Aircraft Operational Status Message (TYPE = 31, Subtype = 1) shall be set to ZERO (0) in accordance with §C.2.3.5.4 and Table C-5.

Note.— Factors such as surface multi-path have been observed to cause intermittent annunciation of "FDE Faults" by the GPS/GNSS receiver. Such occurrences will result in the intermittent settings of the subfields addressed in subparagraphs "a," "c" and "d" above. These intermittent conditions should be taken into account by ADS-B and Air Traffic Services that are using the data provided by the ADS-B Transmitting Subsystems.

C.2.3.2 AIRBORNE POSITION FORMAT

The Airborne Position squitter shall be formatted as specified in the definition of register 05_{16} in Figure C-1 and described in the following paragraphs.

C.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 one-bit field ("ME" bit 22, Message bit 54) shall be used to define the CPR Format (F) type. A CPR Format equal to ZERO (0) shall denote an even format coding, while a CPR Format equal to ONE (1) shall denote an odd format coding (§C.2.6.7).

C.2.3.2.2 TIME SYNCHRONIZATION (T)

This one-bit field ("ME" bit 21, Message bit 53) shall indicate whether or not the Time of Applicability of the message is synchronized with UTC time. "T" equal to ZERO (0) shall denote that the time is not synchronized to UTC. "T" equal to ONE (1) shall denote that Time of Applicability is synchronized to UTC time.

When T = 1, the time of validity in the Airborne Message format shall be encoded in the 1-bit "F" field which (in addition to CPR format type) shall indicate 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 shall be an exact even-numbered UTC second.

C.2.3.2.3 CPR ENCODED LATITUDE/LONGITUDE

The CPR Encoded Latitude/Longitude field in the Airborne Position Message shall be a 34-bit field ("ME" bits 23–56, Message bits 55–88) containing the Latitude and Longitude of the Aircraft's Airborne Position. The Latitude and Longitude shall each occupy 17 bits. The Airborne Latitude and Longitude encoding shall contain Airborne CPR-encoded values in accordance with §C.2.6. The unambiguous range for the local decoding of Airborne Messages shall be 666 km (360 NM). The positional accuracy maintained by the Airborne CPR encoding shall be approximately 5.1 metres.

Notes:

1. The Latitude/Longitude encoding is also a function of the CPR format value (the "F" bit) described above.

2. Although the positional accuracy of the airborne CPR encoding is approximately 5.1 metres in most cases, implementers should be aware that 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.

C.2.3.2.3.1 Extrapolating Position (When T = 1)

If "T" is set to one, Airborne Position Messages shall have Times of Applicability that are exact 0.2 UTC second epochs. In that case, the "F" bit shall be ZERO (0) if the Time of Applicability is an even-numbered 0.2 second UTC epoch, or ONE (1) if the Time of Applicability is an odd-numbered 0.2 second epoch.

Note 1.— Here, an "even-numbered 0.2 second epoch" means an epoch that occurs in an even number of 200-millisecond time intervals after an even-numbered UTC second. An "odd-numbered 0.2 second epoch" means an epoch that occurs in an odd number of 200-millisecond time intervals after an even-numbered UTC second. Examples of even-numbered 0.2 second UTC epochs are 12.0 s, 12.4 s, 12.8 s, 13.2 s, 13.6 s. Examples of odd-numbered UTC epochs are 12.2 s, 12.6 s, 13.0 s, 13.4 s, 13.8 s.

The CPR-encoded Latitude and Longitude that are loaded into the Airborne Position register will comprise an estimate of the A/V position at the Time of Applicability of that Latitude and Longitude, which is an exact 0.2 second 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 ensures that the ADS-B Receiving Subsystem may easily recover the Time of Applicability of the data in the Airborne Position Message as follows:

- If F = 0, the Time of Applicability shall be the nearest even-numbered 0.2 second UTC epoch to the time that the Airborne Position Message is received.

- If F = 1, the Time of Applicability shall be the nearest odd-numbered 0.2 second UTC epoch to the time that the Airborne Position Message is received.

Note 2.— If the Airborne Position register is loaded every 200 ms, the ideal time to load that register would be 100 ms before the Time of Applicability of the data being loaded. The register would then be re-loaded, with data applicable at the next subsequent 0.2 second UTC epoch, 100 ms before that next subsequent 0.2 second epoch. That 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.

The position data that is loaded into the Airborne Position register shall be an estimate of the A/V position at the Time of Applicability.

Note 3.— 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 0.2 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 0.2 second UTC epoch. This process shall continue with new position fixes as they become available from the source of navigation data.

C.2.3.2.3.2 Extrapolating Position (When T = 0)

"T" shall be set to ZERO (0) if the Time of Applicability of the data being loaded into the position register is not synchronized to any particular UTC epoch. The position being transmitted must have a Time of Applicability that is no greater than 100 ms from the time of transmission. Additionally, the position register shall be reloaded with position data at intervals that are no more than 200 ms apart. This ensures that the position contained in the position registers will have a Time of Applicability that is never more than 200 ms different from any time during which the register holds that data. If the transmitted position data is loaded from the position register, the position register shall be updated such that the 100 ms performance is achieved.

Note.— This may be accomplished by loading the Airborne Position register at intervals that are 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. For example, loading the register at 200 ms intervals would require that the time of applicability at register load time is exactly 100 ms ahead of the register load time. Greater flexibility in the time of applicability at register load time is provided by increasing the update rate.

If "T" is ZERO (0), then ADS-B Receiving Subsystems shall accept Airborne Position Messages as being current as of the Time of Receipt. Updating the position data as above ensures that the ADS-B Transmitting Subsystem does not induce more than 100 ms of timing error into the transmitted position data.

C.2.3.2.3.3 Time-Out When New Position Data is Unavailable

In the event that the navigation input ceases, the extrapolation described in §C.2.3.2.3.1 and §C.2.3.2.3.2 shall be limited to no more than 2 seconds. At the end of this timeout of 2 seconds, all fields of the Airborne Position register, except the altitude field, shall be cleared (set to ZERO).

Note.— The altitude field, bits 9 to 20 of the register, would only be cleared if current altitude data were no longer available.

With the appropriate register fields cleared, the broadcast of the ZERO TYPE Code field shall serve to notify ADS-B Receiving Subsystems that the data in the Latitude and Longitude fields are invalid.

C.2.3.2.4 ALTITUDE

This 12-bit field ("ME" bits 9–20, Message bits 41–52) shall provide the aircraft altitude. Depending on the TYPE Code, this field shall contain either:

a) Barometric altitude encoded in 25- or 100-foot increments (as indicated by the Q Bit); or

b) GNSS height above ellipsoid (HAE).

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

C.2.3.2.5 NIC SUPPLEMENT-B

The first 5-bit field ("ME" bits 1–5, Message bits 33–37) in every Mode S Extended Squitter Message contains the format TYPE Code. The format TYPE Code differentiates the 1 090 ES Messages into several classes: Airborne Position, Airborne Velocity, Surface Position, Identification and Category, Aircraft Intent, Aircraft Status, etc. In addition, the format TYPE Code also encodes the Navigation Integrity Category (NIC) value of the source used for the position report.

The NIC Supplement-B is a 1-bit ("ME" bit 8, Message bit 40) subfield in the Airborne Position Message that is used in conjunction with the TYPE Code and NIC value to allow surveillance applications to determine whether the reported geometric position has an acceptable level of integrity containment region for the intended use. The NIC integrity containment region is described horizontally using the radius of containment, R_C. The format TYPE Code also differentiates 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 Code and related NIC values conforms to the definition contained in Table C-28. If an update has not been received from an on-board data source for the determination of the TYPE Code value based on the radius of containment within the past 2 seconds, then the TYPE Code value shall be encoded to indicate that R_C is "Unknown."

C.2.3.3 SURFACE POSITION FORMAT

The Surface Position squitter shall be formatted as specified in the definition of register 06_{16} in Figure C-2, and described in the following paragraphs.

C.2.3.3.1 MOVEMENT

This 7-bit field ("ME" bits 6–12, Message bits 38–44) shall provide information on the Ground Speed of the aircraft. A non-linear scale shall be used as defined in the Table C-3, where speeds are given in km/h (kt).

C.2.3.3.2 HEADING

C.2.3.3.2.1 Heading/Ground Track Status

This one bit field ("ME" bit 13, Message bit 45) shall define the validity of the Heading/Ground Track value. Coding for this field shall be as follows: 0 = not valid 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. Some regulators have already established such limits. These limits may be standardized accordingly in future versions of these MOPS.)*

Table C-3. Coding of the Movement Field

Coding (Decimal)	Meaning	Quantization
0	No Movement Information Available	
1	Aircraft Stopped (Ground Speed = 0 kt)	
2	0 kt < Ground Speed ≤ 0.2315 km/h (0.125 kt)	
3–8	0.2315 km/h (0.125 kt) < Ground Speed ≤ 1.852 km/h (1 kt)	0.2700833 km/h steps
9–12	1.852 km/h (1 kt) < Ground Speed ≤ 3.704 km/h (2 kt)	0.463 km/h (0.25 kt) steps
13–38	3.704 km/h (2 kt) < Ground Speed ≤ 27.78 km/h (15 kt)	0.926 km/h (0.50 kt) steps
39–93	27.78 km/h (15 kt) < Ground Speed ≤ 129.64 km/h (70 kt)	1.852 km/h (1.00 kt) steps
94–108	129.64 km/h (70 kt) < Ground Speed ≤ 185.2 km/h (100 kt)	3.704 km/h (2.00 kt) steps
109–123	185.2 km/h (100 kt) < Ground Speed ≤ 324.1 km/h (175 kt)	9.26 km/h (5.00 kt) steps
124	324.1 km/h (175 kt) < Ground Speed	
125	Reserved for Aircraft Decelerating	
126	Reserved for Aircraft Accelerating	
127	Reserved for Aircraft Backing-Up	

C.2.3.3.2.2 Heading/Ground Track Value

This 7-bit field (“ME” bits 14–20, Message bits 46–52) shall define the direction (in degrees clockwise from true or magnetic north) of aircraft motion on the surface. The Heading/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 (binary 000 0000) indicating a value of ZERO degrees. 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 (§C.2.3.10.13).

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

The one-bit (“ME” bit 22, Message bit 54) CPR Format (F) field for the Surface Position Message shall be encoded as specified for the Airborne Position Message. That is, F = 0 shall denote an even format coding, while F = 1 shall denote an odd format coding (§C.2.6.7).

C.2.3.3.4 TIME SYNCHRONIZATION (T)

This one-bit field (“ME” bit 21, Message bit 53) shall indicate whether or not the Time of Applicability of the message is synchronized with UTC time. “T” equal to ZERO (0) shall denote that the time is not synchronized to UTC. “T” equal to ONE (1) shall denote that Time of Applicability is synchronized to UTC time.

When T = 1, the time of validity in the Airborne Message format shall be encoded in the 1-bit “F” field that (in addition to CPR format type) shall indicate the 0.2 second time tick for UTC time of position validity. The “F” bit shall alternate between ZERO (0) and ONE (1) for successive 0.2 second time ticks, beginning with F = 0 when the Time of Applicability is an exact even-numbered UTC second.

C.2.3.3.5 CPR ENCODED LATITUDE/LONGITUDE

The CPR Encoded Latitude/Longitude field in the Surface Position Message shall be a 34-bit field (“ME” bits 23–56, Message bits 55–88) 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 encoding shall contain Surface CPR-encoded values in accordance with §C.2.6. The unambiguous range for local decoding of Surface Messages shall be 166.5 km (90 NM). The positional accuracy maintained by the Surface CPR encoding shall be approximately 1.25 metres.

Notes:

1. The Latitude/Longitude encoding is also a function of the CPR format value (the “F” bit).

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

C.2.3.3.5.1 Extrapolating Position (when T = 1)

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

C.2.3.3.5.2 Extrapolating Position (when T = 0)

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

C.2.3.3.5.3 Time-Out When New Position Data is Unavailable

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

C.2.3.4 IDENTIFICATION AND CATEGORY FORMAT

The Identification and Category squitter shall be formatted as specified in the definition of register 08_{16} in Figure C-4, and described in the following paragraphs.

C.2.3.4.1 AIRCRAFT IDENTIFICATION CODING

Note.— The coding of Aircraft Identification is defined in Annex 10, Volume IV, §3.1.2.9.1.2 and Table 3-8, and in §2.2.19.1.13 of RTCA DO-181E (EUROCAE ED-73E, §3.23.1.13).The definition in Annex 10 reads:

"Each character shall be coded as a 6-bit subset of the International Alphabet Number 5 (IA-5) as illustrated in Table 3-8. The character code shall be transmitted with the high order unit (b_6) first and the reported aircraft identification shall be transmitted with its left-most character first. Characters shall be coded consecutively without intervening SPACE code. Any unused character spaces at the end of the subfield shall contain a SPACE character code."

Table C-4. Aircraft Identification Character Coding
(extracted from Annex 10, Volume IV)

				b_6	0	0	1	1
				b_5	0	1	0	1
b_4	b_3	b_2	b_1					
0	0	0	0			P	SP[1]	0
0	0	0	1		A	Q		1
0	0	1	0		B	R		2
0	0	1	1		C	S		3
0	1	0	0		D	T		4
0	1	0	1		E	U		5
0	1	1	0		F	V		6
0	1	1	1		G	W		7
1	0	0	0		H	X		8
1	0	0	1		I	Y		9
1	0	1	0		J	Z		
1	0	1	1		K			
1	1	0	0		L			
1	1	0	1		M			
1	1	1	0		N			
1	1	1	1		O			

[1]SP = SPACE code

C.2.3.5 AIRBORNE VELOCITY FORMAT

The Airborne Velocity squitter shall be formatted as specified in the definition of register 09_{16} in Figure C-5, and described in the following paragraphs.

C.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 for velocities under 1 000 knots, and Subtype 2 shall be used for aircraft capable of supersonic flight when the velocity might exceed 1 022 knots.

This message shall not be broadcast if the only valid data is the Intent Change flag (§C.2.3.5.3). After initialization, broadcast shall be suppressed by loading register 09_{16} with ALL ZEROs and then discontinuing updating 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 knots. A switch to the normal velocity coding shall be made if both the East-West AND North-South velocities drop below 1 000 knots.

C.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 unknown. These Subtypes shall substitute Airspeed and Heading for the velocity over ground. Subtype 3 shall be used at subsonic velocities, while Subtype 4 shall be reserved for Airspeeds in excess of 1 000 knots.

The Air Referenced Velocity is contained in the Airborne Velocity Subtypes 3 and 4, and the velocity information is required from only certain classes of ADS-B equipped aircraft.

Note.— Air Referenced Velocity Messages may be received from airborne aircraft that are also broadcasting messages containing ground referenced velocity information. ADS-B Receiving Subsystems conformant to this manual are required to receive and process ground referenced and Air Referenced Velocity Messages from the same aircraft and output the corresponding reports. Although not required in this manual, future versions of this manual will specify under what conditions both ground referenced and air referenced velocity would be transmitted. This is intended to provide compatibility with anticipated future requirements for the transmission of both types of velocity information.

This Airborne Velocity Message shall not be broadcast if the only valid data is the Intent Change flag (§C.2.3.5.3). After initialization, broadcast shall be suppressed by loading register 09_{16} with ALL ZEROs and then discontinuing updating the register until data input is available again.

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

C.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

Notes:

1. *Register 43_{16} is not included since it contains dynamic data that will be continuously changing.*
2. *A 4-second delay is required to provide for settling time for intent data derived from manually set devices.*

C.2.3.5.4 *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) as specified in Table C-5.

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.

If the external data source provides 95 per cent accuracy figures of merit for horizontal 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 according to Table C-5.

Table C-5. Determining NAC_V Based on Position Source Declared Horizontal Velocity Error

Navigation Accuracy Category for Velocity		
Coding		
(Binary)	*(Decimal)*	*Horizontal Velocity Error*
000	0	>10 m/s
001	1	<10 m/s
010	2	<3 m/s
011	3	<1 m/s
100	4	<0.3 m/s

Note.— A non-excluded satellite failure requires that the NAC_V parameter be set to ZERO (binary 000) along with R_C being set to Unknown to indicate that the velocity error is ≥10 m/s (see §C.2.3.1.1.3 and §C.2.3.1.2.4).

C.2.3.5.5 *HEADING IN AIRBORNE VELOCITY MESSAGES*

C.2.3.5.5.1 *Heading Status*

This one bit ("ME" bit 14, Message bit 46) subfield in Airborne Velocity Messages, Subtype 3 or 4 shall define the availability of the Heading value. Coding for this field will be: 0 = not available and 1 = available.

C.2.3.5.5.2 *Heading Value*

This 10-bit ("ME" bits 15–24, Message bits 47–56) subfield in Airborne Velocity Messages, Subtype 3 or 4 shall give the Aircraft Heading (in degrees clockwise from true or magnetic north) when velocity over ground is not available. The 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 ALL ZEROs (binary 00 0000 0000) indicating a value of ZERO degrees. The data in the field shall be rounded to the nearest multiple of 360/1 024 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 (§C.2.3.10.13).

C.2.3.5.6 DIFFERENCE FROM BARO ALTITUDE IN AIRBORNE VELOCITY MESSAGES

This 8-bit ("ME" bits 49–56, Message bits 81–88) subfield shall give the signed difference between barometric and GNSS altitude. Coding for this field shall be as indicated in Figure C-5 and Figure C-6.

If Airborne Position is being reported using Format TYPE Codes 9 or 10, only GNSS HAE shall be used. For Format TYPE Codes 9 or 10, if GNSS HAE is not available, the field shall be coded with ALL ZEROs. For Format TYPE Codes 11 through 18, either GNSS HAE or altitude MSL shall be used. The basis for the Baro Altitude difference (either GNSS HAE or altitude MSL) shall be used consistently for the reported difference.

Note.— Although the above requirements allow this subfield to be based on MSL in certain cases, it is expected that some regulators will only accept installations that report based on WGS-84 HAE. HAE will be required for some State mandates, and the manufacturer must ensure that when converting from HAG (e.g. MSL) to HAE, the same model used by the position source is used. This could be standardized accordingly in future versions of this manual.

C.2.3.6 AIRCRAFT STATUS REGISTER FORMAT

The Aircraft Status register shall be formatted as specified in the definition of register 07_{16} in Figure C-3 and described in the following paragraphs.

C.2.3.6.1 PURPOSE

Note.— Unlike the other Extended Squitter registers, the contents of this register are not broadcast. The purpose of this register is to serve as an interface between the transponder function and the General Formatter/Manager function (GFM, §C.2.5). The two fields defined for this format are the Transmission Rate Subfield and the Altitude Type Subfield.

C.2.3.6.2 TRANSMISSION RATE SUBFIELD (TRS)

This field shall only be 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 register 07_{16} shall be used by the GFM (§C.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.

C.2.3.6.3 ALTITUDE TYPE SUBFIELD (ATS)

This field shall only be used for a transponder implementation of Extended Squitter.

Note.— The transponder normally loads the altitude field of the airborne position squitter from the same digital source as used for addressed replies. 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 (§C.2.5) inserts GNSS height (HAE) into the airborne position squitter, it shall instruct the transponder not to insert the baro altitude into the altitude field. The ATS shall be used for this purpose.

C.2.3.7 EVENT-DRIVEN PROTOCOL

A message inserted in register $0A_{16}$ (or an equivalent transmit register) shall be broadcast once by the transponder at the earliest opportunity. Formats for messages using this protocol shall be identical to those defined for register 61_{16} (see Figure C-7).

Note.— The GFM (§C.2.5) is responsible for ensuring pseudo-random timing, priority and for observing the maximum transmission rate for this register of 2 per second. Additional details are specified in §C.2.5.4 and in the following paragraphs. A summary of the transmission rates for all extended squitters is shown in Table C-35.

C.2.3.7.1 PURPOSE

Note.— The Event-Driven protocol is intended as a flexible means to support the broadcast of messages beyond those defined for position, velocity and identification. These typically will be messages that are broadcast regularly for a time period based on the occurrence of an event and/or having a variable broadcast rate as determined by processes external to the transponder. Two examples are: (1) the broadcast of Emergency/Priority Status at a periodic rate during a declared aircraft emergency, and (2) the broadcast of TCAS/ACAS Resolution Advisory data during a declared event.

C.2.3.7.2 TCAS/ACAS RESOLUTION ADVISORY (RA) BROADCAST

The 1 090 ES TCAS/ACAS RA Broadcast Message contains the same information as the RA message readout using the GICB protocol, including the aircraft ICAO 24-bit Address. A ground-based 1 090 ES receiver with an omni-directional receiving capability can provide TCAS/ACAS RA Messages to the ground systems much sooner than with a scanning beam antenna. The TCAS/ACAS RA information is defined as a Subtype = 2 of the existing 1 090 ES Aircraft Status Message.

The airborne aircraft broadcast rates and priorities for the TCAS/ACAS RA Broadcast Message are defined below. The format for broadcasting a 1 090 ES Aircraft Status Message with TCAS/ACAS RA Message content (1 090 ES Message TYPE = 28, Subtype = 2) is defined in Figure C-8b.

C.2.3.7.2.1 Transmission Rate

The ADS-B Aircraft Status (TYPE = 28) TCAS/ACAS RA Broadcast Message (Subtype = 2) shall be broadcast starting within 0.5 second after the transponder notification of the initiation of a TCAS/ACAS Resolution Advisory.

The ADS-B Aircraft Status (TYPE = 28) TCAS/ACAS RA Broadcast Message (Subtype = 2) shall be broadcast using the Event-Driven Protocol at random intervals that are uniformly distributed over the range of 0.7 to 0.9 second for the duration of the TCAS/ACAS Resolution Advisory. A summary of the transmission rates for all extended squitters is shown in Table C-35.

C.2.3.7.2.2 Message Delivery

ADS-B Aircraft Status TCAS/ACAS RA Broadcast Message delivery is accomplished using the Event-Driven protocol. The broadcast of the TCAS/ACAS RA Broadcast Message shall be terminated 24 ±1 second after the Resolution Advisory Termination (RAT) flag (see §4.3.8.4.2.2.1.3 of Annex 10, Volume IV) transitions from ZERO (0) to ONE (1). The broadcast of the ADS-B Aircraft Status TCAS/ACAS RA Broadcast Message takes priority over the Emergency/Priority Status broadcast, and all other Event-Driven Message types, as specified in §C.2.5.4.3.

C.2.3.7.3 EMERGENCY/PRIORITY STATUS AND MODE A CODE

Register 61_{16} contains an exact bit-for-bit duplication of the Emergency/Priority Status information that is broadcast using an Event-Driven Aircraft Status Extended Squitter Message (TYPE = 28 and Subtype = 1). Subtype = 1 is used specifically to provide Emergency/Priority Status information and the broadcast of the Mode A (4096) Code. The contents of register 61_{16} shall be formatted as specified in Figure C-8a, and described in the following paragraphs.

C.2.3.7.3.1 Transmission Rate

The Aircraft Status (TYPE = 28) Emergency/Priority Status ADS-B Message (Subtype = 1) shall be broadcast using the Event–Driven protocol. The rate of transmission varies depending on other conditions. If the transmission of the Mode A Code is disabled, the transmission of the "Emergency/Priority Status Message" occurs only when an emergency condition is active. When the transmission of the Mode A Code is enabled, the transmission rate of the "Emergency/Priority Status Message" depends on whether the Mode A Code is changed, or if an emergency condition is active.

When the Mode A Code is set to "1000," the 1 090 ES Transmitting Subsystem shall disable the transmission of the Mode A Code and broadcast the "Emergency/Priority Message" in accordance with §C.2.3.7.3.1.1 only when an emergency is declared. Otherwise, the Mode A Code transmission is enabled, and the broadcast rates of §C.2.3.7.3.1.2 apply. A summary of the transmission rates for all extended squitters is shown in Table C-35.

Note.— The use of Mode A Code "1000" for this purpose is in accordance with the provision to disable the transmission of the Mode A Code on 1 090 ES. This will occur at such time that the ATC systems no longer depend on the Mode A Code to identify aircraft.

C.2.3.7.3.1.1 "Emergency/Priority Status Message" Broadcast Rates When Transmission of Mode A Code is Disabled

When the Mode A Code transmission is disabled as per §C.2.3.7.3.1, the following transmit rates apply:

a) The "Emergency/Priority Status Message" (TYPE = 28, Subtype = 1) shall be broadcast at random intervals that are uniformly distributed over the range of 0.7 to 0.9 second relative to the previous "Emergency/Priority Status" for the duration of the emergency condition which is established by any value other than ZERO in the "Emergency/Priority Status" subfield.

   Note.— Emergency conditions resulting from the Mode A Code being set to 7500, 7600 or 7700 are covered by the requirements in §C.2.3.7.3.1.2.

b) In the case where there is no emergency condition established by a ZERO value in the "Emergency/Priority Status" subfield, then the "Emergency/Priority Status Message" shall not be broadcast.

C.2.3.7.3.1.2 Emergency/Priority Status Message Broadcast Rates When Transmission of Mode A Code is Enabled

When the Mode A Code transmission is enabled as per §C.2.3.7.3.1, the following transmit rates apply:

a) The “Emergency/Priority Status” (TYPE = 28, Subtype = 1) shall be broadcast at random intervals that are uniformly distributed over the range of 0.7 to 0.9 second relative to the previous “Emergency/Priority Status” under the following conditions:

 1) For a duration of 24 ±1 second following a Mode A Code change by the pilot except if the Mode A Code is changed to 7500, 7600 or 7700.

 Note.— In the case where the Mode A Code is set to 7500, 7600 or 7700, the transmission of the emergency condition is covered by 2) below. Setting the Mode A Code to 7500, 7600 or 7700 is indicated by a Permanent Alert in the “Surveillance Status” field (value of 1) (see Figure C-1). A change in the Mode A Code, except to 7500, 7600 or 7700, is indicated by a Temporary Alert in the “Surveillance Status” subfield (value of 2) (see Figure C-1).

 2) For the duration of an emergency condition by any non-ZERO value in the “Emergency/Priority Status” subfield, if the emergency code is cleared by the pilot changing the Mode A Code to other than 7500, 7600 or 7700, the broadcast of the “Emergency/Priority Status” Message shall be continued for 24 ±1 second as stated in 1) above.

b) In the absence of conditions specified in a) above, the “Emergency/Priority Status” Message shall be broadcast at random intervals that are uniformly distributed over the range of 4.8 to 5.2 seconds relative to the previous “Emergency/Priority Status” Message.

C.2.3.7.3.2 Message Delivery

The Aircraft Status (TYPE = 28) Emergency/Priority Status (Subtype = 1) Message delivery shall be accomplished using the Event-Driven protocol (§C.2.3.7). The broadcast of this message takes priority over the Event-Driven protocol broadcasts of all other message types, except for the ADS-B Aircraft Status TCAS/ACAS RA Broadcast Message (TYPE = 28, Subtype = 2), which takes priority over the Emergency/Priority Status broadcast, and all other Event-Driven Message types, as specified in §C.2.5.4.3.

C.2.3.8 PERIODIC STATUS MESSAGES

Operational Status Messages and Target State and Status Messages are Periodic Status Messages that are broadcast independently in the same manner as the Airborne Position, Surface Position, Airborne Velocity and Aircraft Identification Messages. In previous editions of this manual, Operational Status and Target State and Status Messages were included under the event-driven protocol and subject to the hard limit of two transmissions per second in any second as per §C.2.5.4. The combination of Periodic Status Messages and Event-Driven Messages does not exceed two messages per second averaged over 60 seconds.

C.2.3.9 TARGET STATE AND STATUS INFORMATION

Register 62_{16} contains an exact bit-for-bit duplicate of the Target State and Status Extended Squitter Message (TYPE = 29 and Subtype = 1), and shall be formatted as specified in Figure C-9, and described in the following paragraphs.

C.2.3.9.1 TRANSMISSION RATE

The Target State and Status 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. A summary of the transmission rates for all extended squitters is shown in Table C-35.

Note.— In previous editions of this manual, the Target State and Status Message was delivered using the Event-Driven protocol.

C.2.3.9.2 SOURCE INTEGRITY LEVEL (SIL) SUPPLEMENT

The “SIL Supplement” (Source Integrity Level Supplement) subfield is a 1-bit (“ME” bit 8, Message bit 40) field that defines whether the reported SIL probability is based on a “per hour” probability or a “per sample” probability as defined in Table C-6.

Table C-6. “SIL Supplement” Subfield Encoding

Coding	*Meaning*
0	Probability of exceeding NIC radius of containment is based on “per hour”
1	Probability of exceeding NIC radius of containment is based on “per sample”

- **Per hour:** The probability of the reported geometric position laying outside the NIC containment radius in any given hour without an alert or an alert longer than the allowable time-to-alert.

  Note.— The probability of exceeding the integrity radius of containment for GNSS position sources is based on a per hour basis, as the NIC will be derived from the GNSS Horizontal Protection Level (HPL) which is based on a probability of 1×10^{-7} per hour.

- **Per sample:** The probability of a reported geometric position laying outside the NIC containment radius for any given sample.

  Note.— The probability of exceeding the integrity radius of containment for IRU, DME/DME and DME/DME/LOC position sources may be based on a per sample basis.

C.2.3.9.3 SELECTED ALTITUDE TYPE

The “Selected Altitude Type” subfield is a 1-bit (“ME” bit 9, Message bit 41) field that shall be used to indicate the source of Selected Altitude data that is being used to encode “ME” bits 10–20 (Message bits 42–52). Encoding of the “Selected Altitude Type” is defined in Table C-7. Whenever there is no valid MCP/FCU or FMS Selected Altitude data available, then the “Selected Altitude Type” subfield is set to ZERO (0).

Table C-7. "Selected Altitude Type" Subfield Encoding

Coding	*Meaning*
0	Data being used to encode "ME" bits 10–20 is derived from the Mode Control Panel/Flight Control Unit (MCP/FCU) or equivalent equipment.
1	Data being used to encode "ME" bits 10–20 is derived from the Flight Management System (FMS).

C.2.3.9.4 MCP/FCU SELECTED ALTITUDE OR FMS SELECTED ALTITUDE

a) The "MCP/FCU Selected Altitude or FMS Selected Altitude" subfield is an 11-bit ("ME" bits 10–20, Message bits 42–52) field that contains either "MCP/FCU Selected Altitude" or "FMS Selected Altitude" data in accordance with the following subparagraphs.

b) Whenever valid Selected Altitude data is available from the Mode Control Panel/Flight Control Unit (MCP/FCU) or equivalent equipment, such data shall be used to encode "ME" bits 10–20 (Message bits 42–52) in accordance with Table C-8. Use of MCP/FCU Selected Altitude is then declared in the "Selected Altitude Type" subfield as specified in Table C-7.

c) Whenever valid Selected Altitude data is NOT available from the Mode Control Panel/Flight Control Unit (MCP/FCU) or equivalent equipment, but valid Selected Altitude data is available from the Flight Management System (FMS), then the FMS Selected Altitude data is used to encode "ME" bits 10–20 (Message bits 42–52) in accordance with Table C-8. Use of FMS Selected Altitude is then declared in the "Selected Altitude Type" subfield as specified in Table C-7.

d) Encoding of Selected Altitude data in "ME" bits 10–20 (Message bits 42–52) is in accordance with Table C-8. Encoding of the data is rounded so as to preserve accuracy of the source data within ±1/2 LSB.

e) Whenever there is NO valid MCP/FCU or FMS Selected Altitude data available, then the "MCP/FCU Selected Altitude or FMS Selected Altitude" subfield ("ME" bits 10–20, Message bits 42–52) shall be set to ZERO (0) as indicated in Table C-8.

Table C-8. "MCP/FCU Selected Altitude or FMS Selected Altitude" Subfield Encoding

Coding ("ME" bits 10–20)		*Meaning*
(Binary)	*(Decimal)*	
000 0000 0000	0	**NO Data *or* INVALID Data**
000 0000 0001	1	0 ft
000 0000 0010	2	32 ft
000 0000 0011	3	64 ft
*** **** ****	***	*** **** ****
*** **** ****	***	*** **** ****
*** **** ****	***	*** **** ****
111 1111 1110	2046	65440 ft
111 1111 1111	2047	65472 ft

C.2.3.9.5 BAROMETRIC PRESSURE SETTING (MINUS 800 MILLIBARS)

a) The "Barometric Pressure Setting (Minus 800 millibars)" subfield is a 9-bit ("ME" bits 21–29, Message bits 53-61) field that contains Barometric Pressure Setting data that has been adjusted by subtracting 800 millibars from the data received from the Barometric Pressure Setting source.

b) After adjustment by subtracting 800 millibars, the Barometric Pressure Setting is encoded in "ME" bits 21–29 (Message bits 53–61) in accordance with Table C-9.

c) Encoding of Barometric Pressure Setting data in "ME" bits 21–29 (Message bits 53–61) shall be rounded so as to preserve a reporting accuracy within ±1/2 LSB.

d) Whenever there is NO valid Barometric Pressure Setting data available, then the "Barometric Pressure Setting (Minus 800 millibars) subfield ("ME" bits 21–29, Message bits 53–61) shall be set to ZERO (0) as indicated in Table C-9.

e) Whenever the Barometric Pressure Setting data is greater than 1 208.4 or less than 800 millibars, then the "Barometric Pressure Setting (minus 800 millibars) subfield ("ME" bits 21–29, Message bits 53–61) shall be set to ZERO (0).

Note.— This Barometric Pressure Setting data can be used to represent QFE or QNH/QNE, depending on local procedures. It represents the current value being used to fly the aircraft.

Table C-9. "Barometric Pressure Setting (minus 800 millibars)" Subfield Encoding

Coding ("ME" bits 21–29)		*Meaning*
(Binary)	*(Decimal)*	
0 0000 0000	0	**NO Data *or* INVALID Data**
0 0000 0001	1	0 millibars
0 0000 0010	2	0.8 millibars
0 0000 0011	3	1.6 millibars
* **** ****	***	*** **** ****
* **** ****	***	*** **** ****
* **** ****	***	*** **** ****
1 1111 1110	510	407.2 millibars
1 1111 1111	511	408.0 millibars

C.2.3.9.6 SELECTED HEADING STATUS

The "Selected Heading Status" subfield is a 1-bit ("ME" bit 30, Message bit 62) field that shall be used to indicate the status of Selected Heading data that is being used to encode "ME" bits 32–39 (Message bits 64–71) in accordance with Table C-10.

Table C-10. "Selected Heading Status" Subfield Encoding

Coding ("ME" bit 30)	*Meaning*
0	Data being used to encode "ME" bits 32–39 (Message bits 64–71) is either **NOT** Available or is **INVALID**. See Table C-12.
1	Data being used to encode "ME" bits 32–39 (Message bits 64–71) is Available and is **VALID**. See Table C-12.

C.2.3.9.7 SELECTED HEADING SIGN

The "Selected Heading Sign" subfield is a 1-bit ("ME" bit 31, Message bit 63) field that shall be used to indicate the arithmetic sign of Selected Heading data that is being used to encode "ME" bits 32–39 (Message bits 64–71) in accordance with Table C-11.

Table C-11. "Selected Heading Sign" Subfield Encoding

Coding ("ME" bit 31)	*Meaning*
0	Data being used to encode "ME" bits 32–39 (Message bits 64–71) is positive in an angular system having a range between +180 and –180°. (For an Angular Weighted Binary system which ranges from 0.0 to 360°, the sign bit is positive or zero for all values that are less than 180°). See Table C-12.
1	Data being used to encode "ME" bits 32–39 (Message bits 64–71) is negative in an angular system having a range between +180 and –180°. (For an Angular Weighted Binary system which ranges from 0.0 to 360°, the sign bit is ONE for all values that are greater than 180°). See Table C-12.

C.2.3.9.8 SELECTED HEADING

a) The "Selected Heading" subfield is an 8-bit ("ME" bits 32–39, Message bits 64–71) field that contains Selected Heading data encoded in accordance with Table C-12.

b) Encoding of Selected Heading data in "ME" bits 31–39 (Message bits 63–71) shall be rounded so as to preserve accuracy of the source data within ±1/2 LSB.

c) Whenever there is NO valid Selected Heading data available, then the Selected Heading Status, Sign and Data subfields ("ME" bits 30–39, Message bits 62–71) shall be set to ZERO (0) as indicated in Table C-12.

Note.— The Selected Heading parameter does not have a source bit in this edition to indicate its reference orientation (true north or magnetic north). Implementers of the Target State and Status Message that utilize magnetic north orientation are encouraged whenever possible to use input parameters to populate this field, as that is the de facto standard utilized by most users of this data. However, since many aircraft have flight decks that can operate in either true north or magnetic north orientation, this field should be encoded with the current active value in the flight deck, regardless of orientation. Users of the Selected Heading data should be aware that there is no method defined in this edition to indicate its reference orientation.

Table C-12. "Selected Heading Status, Sign and Data" Subfields Encoding

"ME" Bit Coding			*Meaning*	
30	*31*	*32 -------- 39*		
Status	*Sign*	*Data*		
0	0	0000 0000	**NO Data *or* INVALID Data**	
1	0	0000 0000	0.0	degrees
1	0	0000 0001	0.703125	degrees
1	0	0000 0010	1.406250	degrees
*	*	**** ****	**** **** ****	

"ME" Bit Coding			Meaning
30	31	32 -------- 39	
Status	Sign	Data	
*	*	**** ****	**** **** ****
*	*	**** ****	**** **** ****
1	0	1111 1111	179.296875 degrees
1	1	0000 0000	180.0 or –180.0 degrees
1	1	0000 0001	180.703125 or –179.296875 degrees
1	1	0000 0010	181.406250 or –178.593750 degrees
*	*	**** ****	**** **** ****
*	*	**** ****	**** **** ****
*	*	**** ****	**** **** ****
1	1	1000 0000	270.000 or –90.0000 degrees
1	1	1000 0001	270.703125 or –89.296875 degrees
1	1	1000 0010	271.406250 or –88.593750 degrees
1	1	1111 1110	358.593750 or –1.4062500 degrees
1	1	1111 1111	359.296875 or –0.7031250 degrees

C.2.3.9.9 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 shown in Table C-13. If an update has not been received from an on-board data source for NAC_P within the past 2 seconds, then the NAC_P subfield shall be encoded as a value indicating "Unknown Accuracy."

Table C-13. Encoding of Navigation Accuracy Category for Position (NAC_P)

Coding		Meaning = 95% Horizontal Accuracy Bounds (EPU)
(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 (1NM) — RNP –1 accuracy
0101	5	EPU < 926 m (0.5 NM) — RNP –0.5 accuracy

Coding		*Meaning = 95% Horizontal Accuracy Bounds (EPU)*
(Binary)	*(Decimal)*	
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 — e.g. GPS (SA off)
1010	10	EPU < 10 m — e.g. WAAS
1011	11	EPU < 3 m — e.g. LAAS
1100–1111	12–15	Reserved

Notes:

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, centred 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).

2. RNP accuracy includes error sources other than sensor error, whereas horizontal error for NAC_P only refers to horizontal position error uncertainty.

3. A non-excluded satellite failure requires that the NAC_P parameter be set to ZERO (binary 0000) along with R_C being set to Unknown to indicate that the position has been determined to be invalid (see §C.2.3.1.1.3 and §C.2.3.1.2.4).

C.2.3.9.10 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 (§C.2.3.2) has been cross-checked against another source of pressure altitude. The NIC_{BARO} subfield shall be encoded as shown in Table C-14. If an update has not been received from an on-board data source for NIC_{BARO} within the past 2 seconds, then the NIC_{BARO} subfield shall be encoded as a value of ZERO (0).

Table C-14. NIC_{BARO} Encoding

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

Notes:

1. The barometric altitude value itself is conveyed within the ADS-B Position Message.

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 will be performed with a second source, and only if the two sources agree will 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 will be set to a value of "1" whenever the barometric altitude is valid.

3. The use of Gilham type altimeters is strongly discouraged because of the potential for undetected altitude errors.

C.2.3.9.11 SOURCE INTEGRITY LEVEL (SIL)

This 2-bit ("ME" bits 45–46, Message bits 77–78) subfield shall be used to define the probability of the reported horizontal position exceeding the radius of containment defined by the NIC, without alerting, assuming no avionics faults. Although the SIL assumes there are no unannunciated faults in the avionics system, the SIL must consider the effects of a faulted Signal-in-Space, if a Signal-in-Space is used by the position source. The probability of an avionics fault causing the reported horizontal position to exceed the radius of containment defined by the NIC, without alerting, is covered by the System Design Assurance (SDA) parameter (§C.2.3.10.14).

The SIL probability can be defined as either "per sample" or "per hour" as defined in the SIL Supplement (SIL_{SUPP}) in §C.2.3.9.2.

Notes:

1. For GNSS position sources the HIL or HPL is provided with a probability of 1×10^{-7} per hour, which should be used to set the SIL to 3.

2. The GPS defined HPL probability rate of 10^{-7} per hour is based on the GPS constellation fault rate of 10^{-4} per hour and a 10^{-3} probability of missed detection, given that the fault occurs. Different containment radii indicated by the HPL are all defined at the missed detection probability of 10^{-3}.

3. Fault detection is an essential consideration in determining the SIL parameter. Fault detection assures, at a specified probability of missed detection, that the error is no greater than a specified limit without an alert.

4. For alternate ADS-B position sources to report integrity, they will need to be certified for their fault detection characteristics.

The "SIL" subfield is encoded in accordance with Table C-15. 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 2 seconds, then the SIL subfield shall be encoded as a value of ZERO (0), indicating "Unknown."

Table C-15. Source Integrity Level (SIL) Encoding

SIL Coding		*Probability of Exceeding the NIC Containment Radius (R_C)*
(Binary)	*(Decimal)*	
00	0	Unknown or >1 × 10^{-3} per flight hour or per sample
01	1	≤1 × 10^{-3} per flight hour or per sample
10	2	≤1 × 10^{-5} per flight hour or per sample
11	3	≤1 × 10^{-7} per flight hour or per sample

C.2.3.9.12 STATUS OF MCP/FCU MODE BITS

The “Status of MCP/FCU Mode Bits” subfield is a 1-bit (“ME” bit 47, Message bit 79) field that shall be used to indicate whether the mode bits (“ME” bits 48, 49, 50, 52 and 54, Message bits 80, 81, 82, 84, and 86) are actively being populated (e.g. set) in the Target State and Status Message in accordance with Table C-16.

If information is provided to the ADS-B Transmitting Subsystem to set either “ME” bit 48, 49, 50, 52 or 54 (Message bit 80, 81, 82, 84 or 86) to either “0” or “1,” then bit 47 shall be set to ONE (1). Otherwise, bit 47 shall be set to ZERO (0).

Table C-16. “Status of MCP/FCU Mode Bits” Subfield Encoding

Coding (“ME” Bit 47)	*Meaning*
0	No Mode Information is being provided in “ME” bits 48, 49, 50, 52 or 54 (Message bits 80, 81, 82, 84 or 86)
1	Mode Information is deliberately being provided in “ME” bits 48, 49, 50, 52, or 54 (Message bits 80, 81, 82, 84 or 86)

C.2.3.9.13 AUTOPILOT ENGAGED

The “Autopilot Engaged” subfield is a 1-bit (“ME” bit 48, Message bit 80) field that shall be used to indicate whether the autopilot system is engaged or not.

a) The ADS-B Transmitting Subsystem shall accept information from an appropriate interface that indicates whether or not the Autopilot is engaged.

b) The ADS-B Transmitting Subsystem shall set “ME” bit 48 (Message bit 80) in accordance with Table C-17.

Table C-17. “Autopilot Engaged” Subfield Encoding

Coding (“ME” Bit 48)	*Meaning*
0	Autopilot is NOT Engaged (e.g. not actively coupled and flying the aircraft)
1	Autopilot is Engaged (e.g. actively coupled and flying the aircraft)

C.2.3.9.14 VNAV MODE ENGAGED

The “VNAV Mode Engaged” subfield is a 1-bit (“ME” bit 49, Message bit 81) field that shall be used to indicate whether the Vertical Navigation Mode is active or not.

a) The ADS-B Transmitting Subsystem shall accept information from an appropriate interface that indicates whether or not the Vertical Navigation Mode is active.

b) The ADS-B Transmitting Subsystem shall set “ME” bit 49 (Message bit 81) in accordance with Table C-18.

Table C-18. “VNAV Engaged” Subfield Encoding

Coding (“ME” Bit 49)	*Meaning*
0	VNAV Mode is NOT Active
1	VNAV Mode is Active

C.2.3.9.15 ALTITUDE HOLD MODE

The “Altitude Hold Mode” subfield is a 1-bit (“ME” bit 50, Message bit 82) field that shall be used to indicate whether the Altitude Hold Mode is active or not.

a) The ADS-B Transmitting Subsystem shall accept information from an appropriate interface that indicates whether or not the Altitude Hold Mode is active.

b) The ADS-B Transmitting Subsystem shall set “ME” bit 50 (Message bit 82) in accordance with Table C-19.

Table C-19. “Altitude Hold Mode” Subfield Encoding

Coding (“ME” Bit 50)	*Meaning*
0	Altitude Hold Mode is NOT Active
1	Altitude Hold Mode is Active

C.2.3.9.16 RESERVED FOR ADS-R FLAG

The “Reserved for ADS-R Flag” subfield in the Target State and Status Message is a 1-bit (“ME” bit 51, Message bit 83) field that shall be used to specify the rebroadcast of a 1 090 MHz ADS-B Message received by a ground station on an alternate ADS-B data link as indicated in §C.4.4.6.

C.2.3.9.17 APPROACH MODE

The “Approach Mode” subfield is a 1-bit (“ME” bit 52, Message bit 84) field that shall be used to indicate whether the Approach Mode is active or not.

a) The ADS-B Transmitting Subsystem shall accept information from an appropriate interface that indicates whether or not the Approach Mode is active.

b) The ADS-B Transmitting Subsystem shall set “ME” bit 52 (Message bit 84) in accordance with Table C-20.

Table C-20. “Approach Mode” Subfield Encoding

Coding (“ME” Bit 52)	*Meaning*
0	Approach Mode is NOT Active
1	Approach Mode is Active

C.2.3.9.18 TCAS/ACAS OPERATIONAL

The “TCAS/ACAS Operational” subfield is a 1-bit (“ME” bit 53, Message bit 85) field that shall be used to indicate whether the TCAS/ACAS System is Operational or not.

a) The ADS-B Transmitting Subsystem shall accept information from an appropriate interface that indicates whether or not the TCAS/ACAS System is Operational.

b) The ADS-B Transmitting Subsystem shall set “ME” bit 53 (Message bit 85) in accordance with Table C-21.

Table C-21. “TCAS/ACAS Operational” Subfield Encoding

Coding (“ME” Bit 53)	*Meaning*
0	TCAS/ACAS System is NOT Operational (Any time RI ≠ 3 or 4)
1	TCAS/ACAS System IS Operational (RI = 3 or 4)

Notes:

1. ADS-B does not consider TCAS/ACAS Operational equal to ONE (1) unless the TCAS/ACAS is in a state which can issue an RA (e.g. RI = 3 or 4).

2. As a reference point, RTCA DO-181E (EUROCAE ED-73E) Mode-S Transponders consider that the TCAS/ACAS System is operational when "MB" bit 16 of register 10_{16} is set to "ONE" (1). This occurs when the transponder to TCAS/ACAS interface is operational and the transponder is receiving TCAS/ACAS RI = 2, 3 or 4. (Refer to RTCA DO-181E (EUROCAE ED-73E), Appendix B, Table B-3-16.) RI = 0 is STANDBY, RI = 2 is TA ONLY and RI = 3 is TA/RA.

C.2.3.9.19 LNAV MODE ENGAGED

The "LNAV Mode Engaged" subfield is a 1-bit ("ME" bit 54, Message bit 86) field that is used to indicate whether the Lateral Navigation Mode is active or not.

a) The ADS-B Transmitting Subsystem accepts information from an appropriate interface that indicates whether or not the Lateral Navigation Mode is active.

b) The ADS-B Transmitting Subsystem sets the "ME" bit 54 (Message bit 86) in accordance with Table C-22.

Table C-22. "LNAV" Mode Engaged" Subfield Encoding

Coding ("ME" Bit 54)	*Meaning*
0	LNAV Mode is NOT Active or Unknown
1	LNAV Mode is Active

C.2.3.10 AIRCRAFT OPERATIONAL STATUS MESSAGE

Register 65_{16} contains an exact bit-for-bit duplicate of the Aircraft Operational Status Message Extended Squitter (TYPE = 31 and Subtype = 0/1). The contents of the Aircraft Operational Status Message shall be formatted as specified Figure C-10, and described in the following paragraphs.

C.2.3.10.1 TRANSMISSION RATE

The rate at which the ADS-B Aircraft Operational Status Messages (TYPE = 31 and Subtype = 0/1) are broadcast is given for various conditions in the following subparagraphs. A summary of the transmission rates for all extended squitters is shown in Table C-35.

a) Airborne Aircraft Operational Status Messages (TYPE = 31, Subtype = 0) shall be broadcast at the rates given in the following subparagraphs when aircraft operational status information is valid and when in the airborne state;

1) No Change in TCAS/ACAS RA Active/NAC_P/SIL/NIC_{SUPP} Data:

If there has been no change in the TCAS/ACAS RA Active, NAC_P, SIL or NIC_{SUPP} information provided in the Airborne Aircraft Operational Status Message (TYPE = 31, Subtype = 0), then the messages shall be broadcast at random intervals that are uniformly distributed over the range of 2.4 to 2.6 seconds relative to the previous Airborne Aircraft Operational Status Message for as long as data is available to satisfy the requirements of subparagraph a) above.

2) Change in TCAS/ACAS RA Active/NAC_P/SIL/NIC_{SUPP} Data with Target State and Status:

If there has been a change in the TCAS/ACAS RA Active, NAC_P, SIL or NIC_{SUPP} information provided in the Airborne Aircraft Operational Status Message (TYPE = 31, Subtype = 0), and Target State and Status Messages are being broadcast, then the Airborne Aircraft Operational Status Messages (TYPE = 31, Subtype = 0) shall be broadcast at random intervals that are uniformly distributed over the range of 2.4 to 2.6 seconds relative to the previous Airborne Aircraft Operational Status Message for as long as data is available to satisfy the requirements of subparagraph a) above.

3) Change in TCAS/ACAS RA Active/NAC_P/SIL/NIC_{SUPP} Data with No Target State and Status:

If there has been a change in the TCAS/ACAS RA Active, NAC_P, SIL or NIC_{SUPP} information provided in the Airborne Aircraft Operational Status Message (TYPE = 31, Subtype = 0), and Target State and Status Messages are NOT being broadcast, then the Airborne Aircraft Operational Status Messages (TYPE = 31, Subtype = 0) shall be broadcast at random intervals that are uniformly distributed over the range of 0.7 to 0.9 second relative to the previous Airborne Aircraft Operational Status Message for a period of 24 ±1 second.

b) Surface Aircraft Operational Status Messages (TYPE = 31, Subtype = 1) shall be broadcast at the rates given in the following subparagraphs when aircraft operational status information is valid and when in the ON-Ground state;

1) Aircraft/Vehicle Not Moving:

If the aircraft/vehicle is on-ground and NOT moving, then Surface Aircraft Operational Status Messages (TYPE = 31, Subtype = 1) shall be broadcast at random intervals that are uniformly distributed over the range of 4.8 to 5.2 seconds relative to the previous Surface Aircraft Operational Status Message for as long as data is available to satisfy the requirements of subparagraph b) above.

2) Aircraft/Vehicle Is Moving but No Change in NIC_{SUPP}/NAC/SIL Data:

If the Aircraft/Vehicle IS Moving and there has been no change in the NIC_{SUPP}, NAC, or SIL data provided in the Surface Aircraft Operational Status Message (TYPE = 31, Subtype = 1), then the messages shall be broadcast at random intervals that are uniformly distributed over the range of 2.4 to 2.6 seconds relative to the previous Surface Aircraft Operational Status Message for as long as data is available to satisfy the requirements of subparagraph b) above.

3) Aircraft/Vehicle Is Moving with Change in NIC_{SUPP}/NAC/SIL Data:

If the Aircraft/Vehicle IS Moving and there has been a change in the NIC_{SUPP}, NAC, or SIL data provided in the Surface Aircraft Operational Status Message (TYPE = 31, Subtype = 1), then the messages shall be broadcast at random intervals that are uniformly distributed over the range of 0.7 to 0.9 seconds relative to the previous Surface Aircraft Operational Status Message for a period of 24 ±1 second.

C.2.3.10.2 MESSAGE DELIVERY

Message delivery is independent of the Event-Driven protocol and is classified as a Periodic Status Message.

Note.— In the previous edition of this manual, the Operational Status Message was delivered using the Event-Driven protocol.

C.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 Table C-23 and Table C-24.

For an ADS-B Transmitting Subsystem compliant with this manual, if an update has not been received from an on-board data source within the past 2 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 as "No Capability" or "Unknown" capability.

Table C-23. Airborne Capability Class (CC) Code for Version 2 Systems

Msg Bit #	41	42	43	44	45	46	47	48	49	50	51	52	53–56
"ME" Bit #	9	10	11	12	13	14	15	16	17	18	19	20	21–24
Content	= 0,0		TCAS/ACAS Operational	1 090 ES IN	Reserved = 0,0		ARV	TS	TC		UAT IN	Reserved for ADS-R	Reserved [4]
	0,1		Reserved										
	1,0		Reserved										
	1,1		Reserved										

Subfield Coding:

1. TCAS/ACAS Operational
   = 0: TCAS/ACAS is NOT Operational
   = 1: TCAS/ACAS IS Operational

2. 1 090 ES IN (1 090 MHz Extended Squitter)
   = 0: Aircraft has NO 1 090 ES Receive capability
   = 1: Aircraft has 1 090 ES Receive capability

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

6. UAT IN (Universal Access Transceiver)
   = 0: Aircraft has No UAT Receive capability
   = 1: Aircraft has UAT Receive capability

Table C-24. Surface Capability Class (CC) Code for Version 2 Systems

Msg Bit #	41	42	43	44	45	46	47	48	49 --- 51	52
"ME" Bit #	9	10	11	12	13	14	15	16	17 --- 19	20
Content	= 0,0		Reserved = 0	1 090 ES IN	Reserved = 0,0		B2 Low	UAT IN	NAC_V [3]	NIC Supplement-C [1]
	0,1		Reserved							
	1,0		Reserved							
	1,1		Reserved							

Subfield Coding:

1. 1 090 ES IN (1 090 MHz Extended Squitter)
   = 0: Aircraft has NO 1 090 ES Receive capability
   = 1: Aircraft has 1 090 ES Receive capability

2. 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

3. UAT IN (Universal Access Transceiver)
   = 0: Aircraft has NO UAT Receive capability
   = 1: Aircraft has UAT Receive capability

4. NACV (Navigation Accuracy Category for Velocity)

5. NIC Supplement-C (NIC Supplement for use on the Surface)

C.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 OM subfield for Airborne Operational Status Messages (Subtype = 0) shall be as shown in Table C-25. Encoding of the OM subfield for Surface Operational Status Messages (Subtype = 1) shall be as shown in Table C-26.

Table C-25. Airborne Operational Mode (OM) Subfield Format

<table>
<tr><td>Msg Bit #</td><td>57</td><td>58</td><td>59</td><td>60</td><td>61</td><td>62</td><td>63 -- 64</td><td>65 --- 72</td></tr>
<tr><td>"ME" Bit #</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31 -- 32</td><td>33 --- 40</td></tr>
<tr><td rowspan="4">OM Format</td><td colspan="2">= 0 0</td><td>TCAS/ ACAS RA Active [1]</td><td>IDENT Switch Active [1]</td><td>Reserved for Receiving ATC Services [1]</td><td>Single Antenna Flag [1]</td><td>System Design Assurance [2]</td><td>Reserved [8]</td></tr>
<tr><td colspan="2">0, 1</td><td colspan="6">Reserved</td></tr>
<tr><td colspan="2">1, 0</td><td colspan="6">Reserved</td></tr>
<tr><td colspan="2">1, 1</td><td colspan="6">Reserved</td></tr>
</table>

Subfield Coding:

1. TCAS/ACAS Resolution Advisory (RA) Active
   = 0: TCAS II or ACAS RA not active
   = 1: TCAS/ACAS RA is active

2. IDENT Switch Active
   = 0: Ident switch not active
   = 1: Ident switch active – retained for 18 ±1 seconds

3. Reserved for Receiving ATC Services
   = 0: Set to ZERO for this edition of this manual

4. Single Antenna Flag (SAF)
   = 0: Systems with two functioning antennas
   = 1: Systems that use only one antenna

5. System Design Assurance (SDA)
   (see Table C-32)

Table C-26. Surface Operational Mode (OM) Subfield Format

<table>
<tr><td>Msg Bit #</td><td>57</td><td>58</td><td>59</td><td>60</td><td>61</td><td>62</td><td>63 -- 64</td><td>65 --- 72</td></tr>
<tr><td>"ME" Bit #</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31 -- 32</td><td>33 --- 40</td></tr>
<tr><td rowspan="4">OM Format</td><td colspan="2">= 0, 0</td><td>TCAS/ ACAS RA Active [1]</td><td>IDENT Switch Active [1]</td><td>Reserved for Receiving ATC Services [1]</td><td>Single Antenna Flag [1]</td><td>System Design Assurance [2]</td><td>GPS Antenna Offset [8]</td></tr>
<tr><td colspan="2">0, 1</td><td colspan="6">Reserved</td></tr>
<tr><td colspan="2">1, 0</td><td colspan="6">Reserved</td></tr>
<tr><td colspan="2">1, 1</td><td colspan="6">Reserved</td></tr>
</table>

Subfield Coding:

1. TCAS/ACAS Resolution Advisory (RA) Active
   = 0: TCAS II or ACAS RA **not** active
   = 1: TCAS/ACAS RA is active

2. IDENT Switch Active
   = 0: Ident switch not active
   = 1: Ident switch active – retained for 18 ±1 seconds

3. Reserved for Receiving ATC Services
   = 0: Set to ZERO for this edition of this manual

4. Single Antenna Flag (SAF)
   = 0: Systems with two functioning antennas
   = 1: Systems that use only one antenna

5. System Design Assurance (SDA)
   (see Table C-32)

6. GPS Antenna Offset
   (see Table C-33 and Table C-34)

C.2.3.10.5 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 shown in Table C-27.

Table C-27. Version Number Encoding

VERSION NUMBER SUBFIELD		
Coding		*Meaning*
(Binary)	*(Decimal)*	
000	0	Conformant to Doc 9871, Appendix A
001	1	Conformant to Doc 9871, Appendix B
010	2	Conformant to Doc 9871, Appendix C
011–111	3–7	Reserved

C.2.3.10.6 NAVIGATION INTEGRITY CATEGORY (NIC) AND NIC SUPPLEMENT-A

The first 5-bit field (“ME” bits 1–5, Message bits 33–37) in every Mode S Extended Squitter Message contains the format TYPE Code. The format TYPE Code differentiates the 1 090 ES Messages into several classes: Airborne Position, Airborne Velocity, Surface Position, Identification and Category, Aircraft Intent, Aircraft Status, etc. In addition, the format TYPE Code also encodes the NIC value of the source used for the position report.

The NIC Supplement-A is a 1-bit (“ME” bit 44, Message bit 76) subfield in the Aircraft Operational Status Message that is used in conjunction with the TYPE Code and NIC value to allow surveillance applications to determine whether the reported geometric position has an acceptable level of integrity containment region for the intended use. The NIC integrity containment region is described horizontally using the radius of containment, R_C. The format TYPE Code also differentiates 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 Code and NIC values conforms to the definition contained in Table C-28. If an update has not been received from an on-board data source for the determination of the TYPE Code value based on the radius of containment within the past 2 seconds, then the TYPE Code value shall be encoded to indicate that R_C is “Unknown.”

Table C-28. Navigation Integrity Category (NIC) Encoding

NIC Value	*Radius of Containment (R_C)*	*Airborne*			*Surface*		
		Airborne Position TYPE Code	*NIC Supplement Codes*		*Surface Position TYPE Code*	*NIC Supplement Codes*	
			A	*B*		*A*	*C*
0	R_C unknown	0, 18 or 22	0	0	0, 8	0	0
1	R_C < 20 NM (37.04 km)	17	0	0	N/A	N/A	N/A
2	R_C < 8 NM (14.816 km)	16	0	0	N/A	N/A	N/A
3	R_C < 4 NM (7.408 km)	16	1	1	N/A	N/A	N/A
4	R_C < 2 NM (3.704 km)	15	0	0	N/A	N/A	N/A
5	R_C < 1 NM (1 852 m)	14	0	0	N/A	N/A	N/A
6	R_C < 0.6 NM (1 111.2 m)	13	1	1	8	0	1
	R_C < 0.5 NM (926 m)	13	0	0	N/A	N/A	N/A
	R_C < 0.3 NM (555.6 m)	13	0	1	8	1	0
7	R_C < 0.2 NM (370.4 m)	12	0	0	8	1	1
8	R_C < 0.1 NM (185.2 m)	11	0	0	7	0	0
9	R_C < 75 m	11	1	1	7	1	0
10	R_C < 25 m	10 or 21	0	0	6	0	0
11	R_C < 7.5 m	9 or 20	0	0	5	0	0
12	Reserved						
13	Reserved						
14	Reserved						
15	Reserved						

Notes:

1. "N/A" means "This NIC value is not available in the ADS-B Surface Position Message formats."

2. NIC Supplement-A is broadcast in the Aircraft Operational Status Message, "ME" bit 44 (Message bit 76, see Figure C-10). NIC Supplement-B is broadcast in the Airborne Position Message, "ME" bit 8 (Message bit 40, see Figure C-1). NIC Supplement-C is broadcast in the Surface Capability Class (CC) Code Subfield of the Aircraft Operational Status Message, "ME" bit 20 (Message bit 52, see Table C-24).

3. A non-excluded satellite failure requires that the R_C be set to Unknown along with the NAC_P parameter being set to ZERO to indicate that the position has been determined to be invalid (see §C.2.3.1.1.3 and §C.2.3.1.2.4).

C.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 shown in Table C-13. If an update has not been received from an on-board data source for NAC_P within the past 2 seconds, then the NAC_P subfield shall be encoded as a value indicating "Unknown Accuracy."

C.2.3.10.8 GEOMETRIC VERTICAL ACCURACY (GVA)

This 2-bit ("ME" bits 49–50, Message bits 81–82) subfield in the Airborne Operational Status Message (Subtype = 0) shall be encoded as shown in Table C-29, and set by using the Vertical Figure of Merit (VFOM) (95 per cent) from the GNSS position source used to report the geometric altitude.

Note.— The geometric altitude may be reported directly in the altitude field in the Airborne Position Message (§C.2.3.2) or indirectly using the Difference From Barometric Altitude subfield (§C.2.3.5.6) in the Airborne Velocity Message (§C.2.3.5) when barometric altitude is reported in the altitude field in the Airborne Position Message (§C.2.3.2).

Table C-29. Encoding of the Geometric Vertical Accuracy (GVA) Subfield in Aircraft Operational Status Messages

GVA Encoding (decimal)	*Meaning (metres)*
0	Unknown or >150 metres
1	≤150 metres
2	≤45 metres
3	Reserved

Note.— For the purposes of this manual, values for 0, 1 and 2 are encoded. It is expected that ADS-B transmitting subsystems with ADS-B Version numbers greater than 2 will define the GVA encoding of "3" as a value less than 45 metres at some point in the future. Therefore, ADS-B Version 2 receiving subsystems should treat the GVA encoding of "3" as less than 45 metres for data received from ADS-B Version numbers 2 or greater.

C.2.3.10.9 SOURCE INTEGRITY LEVEL (SIL)

This 2-bit ("ME" bits 51–52, Message bits 83–84) subfield is defined for the Target State and Status Message in §C.2.3.9.11 and Table C-15, and remains the same in the Operational Status Message.

C.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 (§C.2.3.2) has been cross-checked against another source of pressure altitude. The NIC_{BARO} subfield shall be encoded as shown in Table C-14. If an update has not been received from an on-board data source for NIC_{BARO} within the past 2 seconds, then the NIC_{BARO} subfield shall be encoded as a value of ZERO (0).

C.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 Table C-30. Once the actual Length and Width of the A/V has been determined, each A/V shall be assigned the smallest A/V Length and Width Code from Table C-30 for which the actual length is less than or equal to the upper bound length for that Length/Width Code, and for which the actual width is less than or equal to the upper bound width for that Length/Width Code.

Table C-30. A/V Length and Width Code

<table>
<tr><th rowspan="2">A/V – L/W Code (decimal)</th><th colspan="3">Length Code</th><th>Width Code</th><th colspan="2">Upper-Bound Length and Width for Each Length/Width Code</th></tr>
<tr><th>"ME" Bit 49</th><th>"ME" Bit 50</th><th>"ME" Bit 51</th><th>"ME" Bit 52</th><th>Length (metres)</th><th>Width (metres)</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td colspan="2">No Data or Unknown</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td>15</td><td>23</td></tr>
<tr><td>2</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">1</td><td>0</td><td rowspan="2">25</td><td>28.5</td></tr>
<tr><td>3</td><td>1</td><td>34</td></tr>
<tr><td>4</td><td rowspan="2">0</td><td rowspan="2">1</td><td rowspan="2">0</td><td>0</td><td rowspan="2">35</td><td>33</td></tr>
<tr><td>5</td><td>1</td><td>38</td></tr>
<tr><td>6</td><td rowspan="2">0</td><td rowspan="2">1</td><td rowspan="2">1</td><td>0</td><td rowspan="2">45</td><td>39.5</td></tr>
<tr><td>7</td><td>1</td><td>45</td></tr>
<tr><td>8</td><td rowspan="2">1</td><td rowspan="2">0</td><td rowspan="2">0</td><td>0</td><td rowspan="2">55</td><td>45</td></tr>
<tr><td>9</td><td>1</td><td>52</td></tr>
<tr><td>10</td><td rowspan="2">1</td><td rowspan="2">0</td><td rowspan="2">1</td><td>0</td><td rowspan="2">65</td><td>59.5</td></tr>
<tr><td>11</td><td>1</td><td>67</td></tr>
</table>

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)*
12	1	1	0	0	75	72.5
13				1		80
14	1	1	1	0	85	80
15				1		90

If the aircraft or vehicle is longer than 85 metres, or wider than 90 metres, then decimal aircraft/vehicle length/width Code 15 shall be used.

Note.— For example, consider a powered glider with an overall length of 24 metres and wingspan of 50 metres. Normally, an aircraft of that length would be in length category 1 (that is, have a length code of 1). But since the wingspan exceeds 34 metres, it does not qualify for even the "wide" subcategory (width code = 1) of length category 1. Such an aircraft would be assigned length code = 4 and width code = 1, meaning "length less than 55 metres and width less than 52 metres."

C.2.3.10.12 TRACK ANGLE/HEADING

The Track Angle/Heading is 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 when the Air/Ground status is determined to be in the "On-Ground" state as indicated in §3.1.2.6.10.1.2 of Annex 10, Volume IV.

C.2.3.10.13 HORIZONTAL REFERENCE DIRECTION (HRD)

This 1-bit ("ME" bit 54, Message bit 86) subfield will be used to indicate the reference direction (true north or magnetic north) for horizontal directions such as Heading and Track Angle. The Horizontal Reference Direction subfield will be encoded as specified in Table C-31.

Note.— The HRD flag only applies to the Heading/Ground Track subfield in the Surface Position Message or the Heading subfield in the Airborne Velocity Message (Subtypes 3 and 4).

Table C-31. Horizontal Reference Direction (HRD) Encoding

HRD Value	*Meaning*
0	true north
1	magnetic north

C.2.3.10.14 SYSTEM DESIGN ASSURANCE (SDA)

The position transmission chain includes the ADS-B transmission equipment, ADS-B processing equipment, position source, and any other equipment that processes the position data and position quality metrics that shall be transmitted.

The "System Design Assurance" (SDA) subfield is a 2-bit ("ME" bits 31–32, Message bits 63–64) field that shall define the failure condition that the position transmission chain is designed to support as defined in Table C-32.

The supported failure condition shall indicate the probability of a position transmission chain fault causing false or misleading information to be transmitted. The definitions and probabilities associated with the supported failure effect are defined in AC 25.1309-1A, AC 23.1309-1D, and AC 29-2C. All relevant systems attributes should be considered including software and complex hardware in accordance with RTCA DO-178B (EUROCAE ED-12B) or RTCA DO-254 (EUROCAE ED-80).

Table C-32. "System Design Assurance" OM Subfield in Aircraft Operational Status Messages

SDA Value		*Supported Failure Condition* Note 2	*Probability of Undetected Fault causing transmission of False or Misleading Information* Notes 3,4	*Software & Hardware Design Assurance Level* Notes 1,3
(decimal)	*(binary)*			
0	00	Unknown/no safety effect	$> 1 \times 10^{-3}$ per flight hour or unknown	N/A
1	01	Minor	$\leq 1 \times 10^{-3}$ per flight hour	D
2	10	Major	$\leq 1 \times 10^{-5}$ per flight hour	C
3	11	Hazardous	$\leq 1 \times 10^{-7}$ per flight hour	B

Notes:

1. Software Design Assurance per RTCA DO-178B (EUROCAE ED-12B). Airborne Electronic Hardware Design Assurance per RTCA DO-254 (EUROCAE ED-80).

2. Supported Failure Classification defined in AC-23.1309-1D, AC-25.1309-1A, AC-27-1B and AC 29-2C.

3. Because the broadcast position can be used by any other ADS-B equipped aircraft or by ATC, the provisions in AC 23.1309-1D that allow reduction in failure probabilities and design assurance level for aircraft under 6 000 pounds do not apply.

4. Includes probability of transmitting false or misleading latitude, longitude, or associated accuracy and integrity metrics.

C.2.3.10.15 SIL SUPPLEMENT

The "SIL Supplement" (Source Integrity Level Supplement) subfield is a 1-bit ("ME" bit 8, Message bit 40) field that shall define whether the reported SIL probability is based on a "per hour" probability or a "per sample" probability as defined in §C.2.3.9.2 and Table C-6.

C.2.3.10.16 TCAS/ACAS OPERATIONAL

The "TCAS/ACAS Operational" subfield ("ME" bit 11, Message bit 43) of the CC Codes subfield in ADS-B Aircraft Operational Status Messages (TYPE = 31, SUBTYPE = 0, for airborne participants) is used to indicate whether the TCAS/ACAS System is Operational or not, and remains as defined for use in the Target State and Status Message (§C.2.3.9.18), with the encoding as specified in Table C-21.

C.2.3.10.17 1 090 ES IN

The CC Code subfield for "1 090 ES IN" in Aircraft Operational Status Messages (TYPE = 31, Subtype = 0 or 1) is a 1-bit field ("ME" bit 12, Message bit 44) that is set to ONE (1) if the transmitting aircraft has the capability to receive ADS-B 1 090 ES Messages. Otherwise, this CC code subfield is set to ZERO (0).

C.2.3.10.18 UAT IN

The "UAT IN" CC Code subfield ("ME" bit 19, Message bit 51, TYPE = 31, Subtype = 0, for airborne participants AND "ME" Bit 16, Message bit 48, TYPE = 31, Subtype = 1 for surface participants) in ADS-B Aircraft Operational Status Messages is so called because it denotes whether the aircraft is equipped with the capability to receive ADS-B Universal Access Transceiver (UAT) Messages.

The "UAT IN" CC Code in Aircraft Operational Status Messages is set to ZERO (0) if the aircraft is NOT fitted with the capability to receive ADS-B UAT Messages. The "UAT IN" CC Code Subfield is set to ONE (1) if the aircraft has the capability to receive ADS-B UAT Messages.

C.2.3.10.19 NAVIGATION ACCURACY CATEGORY FOR VELOCITY (NAC_V)

This 3-bit subfield ("ME" bits 17–19, Message bits 49–51) indicates the Navigation Accuracy Category for Velocity (NAC_V) as defined in §C.2.3.5.4, with the encoding as specified in Table C-5.

C.2.3.10.20 NIC SUPPLEMENT-C

The NIC Supplement-C subfield in the Aircraft Operational Status Message is a one-bit subfield ("ME" bit 20, Message bit 52) that, together with the TYPE subfield in Surface Position Messages and the NIC Supplement-A in the Operational Status Message ("ME" Bit 44, Message Bit 76), is used to encode the Navigation Integrity Category (NIC) of the transmitting ADS-B participant.

If an update has not been received from an on-board data source for the determination of the NIC value within the past 2 seconds, then the NIC Supplement subfield is encoded to indicate the larger Radius of Containment (R_C).

Table C-28 lists the possible NIC codes and the values of the TYPE subfield of the Airborne and Surface Position Messages, and of the NIC Supplement-A, NIC Supplement-B and NIC Supplement-C subfields that are used to encode those NIC codes in messages on the 1 090 MHz ADS-B data link.

C.2.3.10.21 GPS ANTENNA OFFSET

The "GPS Antenna Offset" subfield is an 8-bit ("ME" bits 33–40, Message bits 65–72) field in the OM Code Subfield of surface format Aircraft Operational Status Messages that defines the position of the GPS antenna in accordance with the following.

a) Lateral Axis GPS Antenna Offset:

"ME" bits 33–35 (Message bits 65–67) are used to encode the lateral distance of the GPS Antenna from the longitudinal axis (Roll) axis of the aircraft. Encoding is established in accordance with Table C-33.

Table C-33. Lateral Axis GPS Antenna Offset Encoding

"ME" Bit (Message Bit)			*Upper Bound of the GPS Antenna Offset Along Lateral (Pitch) Axis Left or Right of Longitudinal (Roll) Axis*	
33 (65)	*34 (66)*	*35 (67)*		
0 = left 1 = right	*Encoding*			
	Bit 1	*Bit 0*	*Direction*	*(metres)*
0	0	0	LEFT	NO DATA
	0	1		2
	1	0		4
	1	1		6
1	0	0	RIGHT	0
	0	1		2
	1	0		4
	1	1		6

Notes:

1. Left means toward the left wing tip moving from the longitudinal centre line of the aircraft.

2. Right means toward the right wing tip moving from the longitudinal centre line of the aircraft.

3. Maximum distance left or right of aircraft longitudinal (roll) axis is 6 metres or 19.685 feet. If the distance is greater than 6 metres, then the encoding should be set to 6 metres.

4. The "No Data" case is indicated by encoding of "000" as above, while the "ZERO" offset case is represented by encoding of "100" as above.

5. The accuracy requirement is assumed to be better than 2 metres, consistent with the data resolution.

b) Longitudinal Axis GPS Antenna Offset:

"ME" bits 36–40 (Message bits 68–72) are used to encode the longitudinal distance of the GPS Antenna from the NOSE of the aircraft. Encoding is established in accordance with Table C-34. If the Antenna Offset is compensated by the Sensor to be the position of the ADS-B participant's ADS-B Position Reference Point (RTCA DO-242A, §3.4.4.9.7), then the encoding is set to binary "00001" in Table C-34.

Table C-34. Longitudinal Axis GPS Antenna Offset Encoding

"ME" Bit (Message Bit)					*Upper Bound of the GPS Antenna Offset Along Longitudinal (Roll) Axis Aft From Aircraft Nose*
36 (68)	*37 (69)*	*38 (70)*	*39 (71)*	*40 (72)*	
Encoding					
Bit 4	*Bit 3*	*Bit 2*	*Bit 1*	*Bit 0*	*(metres)*
0	0	0	0	0	NO DATA
0	0	0	0	1	Position Offset Applied by Sensor
0	0	0	1	0	2
0	0	0	1	1	4
0	0	1	0	0	6
*	*	*	*	*	***
*	*	*	*	*	***
*	*	*	*	*	***
1	1	1	1	1	60

Notes:

1. *Maximum distance aft from aircraft nose is 60 metres or 196.85 feet.*

2. *The accuracy requirement is assumed to be better than 2 metres, consistent with the data resolution.*

C.2.3.10.22 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.

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

C.2.4 INITIALIZATION AND TIMEOUT

Note.— Initialization and timeout functions for Extended Squitter broadcast are performed by the transponder and are specified in RTCA DO-260B (EUROCAE ED-102A). A description of these functions is presented in the following paragraphs to serve as reference material for the section on the GFM (§C.2.5).

C.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, Aircraft Identification and Category, Airborne Velocity, Target State and Status and Operational Status when data are inserted into registers 05_{16}, 06_{16}, $08_{16,}$ 09_{16}, 62_{16} and 65_{16}, respectively. This determination shall be made individually for each squitter type, as specified in §2.2.3.3 of RTCA DO-260B (EUROCAE ED-102A). The insertion of just altitude or surveillance status data into 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.

C.2.4.2 EXTENDED SQUITTER BROADCAST RATES

The maximum 1 090 MHz ADS-B message transmission rate shall not exceed the maximum rates as specified in §3.1.2.8.9.1, Annex 10, Volume IV.

The summary of all extended squitter broadcast rates is presented in Table C-35.

Table C-35. 1 090 MHz Extended Squitter ADS-B Message Broadcast Rates

<table>
<tr><th colspan="3"></th><th colspan="3">Broadcast Rate</th></tr>
<tr><th>Transponder Register</th><th>Event Driven Message Priority</th><th>1 090 ES ADS-B Message</th><th>On-the-Ground, not moving</th><th>On-the-Ground and moving</th><th>Airborne</th></tr>
<tr><td>BDS 0,5</td><td>N/A</td><td>Airborne Position</td><td>N/A</td><td>N/A</td><td>2/1 s (0.4–0.6 s)</td></tr>
<tr><td>BDS 0,6</td><td>N/A</td><td>Surface Position</td><td>LOW RATE
1/5 s
(4.8–5.2 s)</td><td>HIGH RATE
2/1 s
(0.4–0.6 s)</td><td>N/A</td></tr>
<tr><td>BDS 0,8</td><td>N/A</td><td>Aircraft Identification and Category</td><td>LOW RATE
1/10 s
(9.8–10.2 s)</td><td>HIGH RATE
1/5 s
(4.8–5.2 s)</td><td>HIGH RATE
1/5 s
(4.8–5.2 s)</td></tr>
<tr><td>BDS 0,9</td><td>N/A</td><td>Airborne Velocity</td><td>N/A</td><td>N/A</td><td>2/1 s
(0.4–6 s)</td></tr>
<tr><td rowspan="3">BDS 6,1</td><td rowspan="3">TCAS/ACAS
RA = 1

Emergency = 2</td><td rowspan="3">Aircraft Status
(Emergency/Priority Status, Subtype = 1)

(TCAS/ACAS RA Broadcast, Subtype = 2)</td><td colspan="3">TCAS/ACAS RA or Mode A Code Change
0.7–0.9 s</td></tr>
<tr><td colspan="3">No TCAS/ACAS RA, No Mode A Change
4.8–5.2 s</td></tr>
<tr><td colspan="3">No TCAS/ACAS RA, No Mode A Change, No Emergency, Mode A Code set to $1\ 000_8$
No Transmission</td></tr>
<tr><td>BDS 6,2</td><td>N/A</td><td>Target State and Status (TSS)</td><td>N/A</td><td>N/A</td><td>1.2–1.3 s</td></tr>
<tr><td rowspan="3">BDS 6,5</td><td rowspan="3">N/A</td><td rowspan="3">Aircraft Operational Status</td><td rowspan="3">4.8–5.2 s</td><td>No change
NIC_{SUPP}/NAC/SIL
2.4–2.6 s</td><td>TSS being broadcast or not
No change
TCAS/NAC/SIL/NIC_{SUPP}
2.4–2.6 s</td></tr>
<tr><td rowspan="2">Change in
NIC_{SUPP}/NAC/SIL
0.7–0.9 s</td><td>TSS being broadcast
Change in
TCAS/NAC/SIL/NIC_{SUPP}
2.4–2.6 s</td></tr>
<tr><td>TSS not broadcast [2]
Change in
TCAS/NAC/SIL/NIC_{SUPP}
0.7–0.9 s</td></tr>
</table>

N/A = Not Applicable

C.2.4.3 REGISTER TIMEOUT

Notes:

1. These data subfields are cleared to prevent the reporting of outdated position and velocity information.

2. During a register timeout event, the "ME" field of the ADS-B Broadcast Message may contain ALL ZEROs, except for those fields that may be updated due to the receipt of new data.

3. All references in this subsection relate to the treatment of data subfields in specific ADS-B Messages after the data in that subfield has not been refreshed for some specified time period, known as a "timeout." The requirements for terminating the actual transmission of ADS-B Messages are specified separately in the subparagraphs of §C.2.4.4.

a) The ADS-B Transmitting Subsystem shall clear all but the altitude and surveillance status subfields of the Airborne Position Message, if no new position data is received within 2 seconds of the previous input data update.

Note.— During a timeout event the Format TYPE Code is set to ZERO (see §C.2.3.1.1.4).

b) The ADS-B Transmitting Subsystem shall clear all 56-bits of the Surface Position Message if no new position data is received within 2 seconds of the previous input data update.

Notes:

1. During a timeout event the Format TYPE Code is set to ZERO (see §C.2.3.1.1.4).

2. When position data is available, the ADS-B Transmitting Subsystem manages the movement and the heading/ground track subfields such that the subfields and applicable status bits are set to ZERO (0) if no new data is received for the subfield within 2.6 seconds of the last data update of the subfield.

3. When position data is not received, all bits of the Surface Position Message are set to ZERO to avoid confusion with altitude data in the Airborne Position Message sent with TYPE Code ZERO (0).

c) The ADS-B Transmitting Subsystem shall clear all 56-bits of the Airborne Velocity Message if no data is received within 2.6 seconds of the previous input data update.

Note.— The Intent Change information is not sufficient to consider that new data has been received (see §C.2.3.5.3).

d) The ADS-B Transmitting Subsystem shall not clear the Aircraft Identification Message (see §C.2.3.4).

Note.— The Aircraft Identification and Category Message, is not cleared since it contains data that rarely changes in flight and is not frequently updated. With Extended Squitter installed, the Aircraft Identification and Category Message is not cleared or ZEROed once either Flight Identification or Aircraft Registration data has been loaded into register 08_{16} during the current ADS-B Transmitting Subsystem power-on cycle. The Aircraft Identification and Category Message is not cleared since it provides information that is fundamental to track file management in the ADS-B environment. Implementation of register 08_{16} should also consider the following:

1) If valid Flight Identification data is available, then the data should be used to populate the character subfields in the Aircraft Identification and Category Message.

2) After using Flight Identification data to populate the character subfields in the Aircraft Identification and Category Message in a given power-on cycle, if Flight Identification data becomes invalid or not available, then the last known valid Flight Identification data should be retained and used to continue population of the character subfields in the Aircraft Identification and Category Message for the duration of the power-on cycle.

3) If valid Flight Identification data is not available, but valid Aircraft Registration data is available in a given power-on cycle, then the valid Aircraft Registration data should be used to populate the character subfields in the Aircraft Identification and Category Message for the duration of the power-on cycle.

4) If the Aircraft Identification and Category Message have been populated using Aircraft Registration data in a given power-on cycle, and valid Flight Identification data becomes available, then the Flight Identification data should be used to populate the character subfields in the Aircraft Identification and Category Message for the remainder of the power-on cycle.

5) *Once valid Flight Identification data has been used to populate the Aircraft Identification and Category Message in a given power-on cycle, Aircraft Registration data should not be used to populate the character subfields of the Aircraft Identification and Category Message, even if Flight Identification data becomes invalid or not available during the power-on cycle.*

e) The ADS-B Transmitting Subsystem shall clear each of the Selected Altitude, Selected Heading, or Barometric Pressure Setting subfields of the Target State and Status Message (see §C.2.3.9) if no new data is received within 2.0 seconds of the previous input data update for the respective subfield. Each of the subfields shall be cleared independently of the other subfields. That is, each of the three specified subfields shall be processed mutually exclusively of the other two specified subfields. The remaining subfields of the Target State and Status Message shall not be cleared, as they contain other integrity, mode, or status information.

f) The ADS-B Transmitting Subsystem shall not clear the Operational Status Messages (see §C.2.3.10) since the subfields of the Message contain various integrity, mode, or status information.

g) The ADS-B Transmitting Subsystem shall not clear the Event-Driven Messages (see §C.2.3.7).

Note.— The Event-Driven Messages do not need to be cleared since contents of such messages are only broadcast once each time that new data is received.

C.2.4.4 TERMINATION OF EXTENDED SQUITTER BROADCASTS

Note.— The subsections below contain requirements for terminating transmissions of ADS-B Messages. These requirements are in response to data timeout conditions or in response to terminating transmissions of other ADS-B Messages. Requirements in the subparagraphs of §C.2.4.3 relate to the treatment of data subfields in specific ADS-B Messages after the data in that subfield has not been refreshed for some specified time period, known as a "timeout."

a) The ADS-B Transmitting Subsystem shall terminate broadcast transmissions of the Airborne Position Message when position (latitude/longitude) and altitude data are not available for a period of 60 seconds.

Note.— For the Airborne Position Message, altitude data alone is sufficient to maintain broadcast of the Message once the Message has been initiated. When only altitude data is available, the Airborne Position Message continues to be transmitted even after 60 seconds. However, if the altitude data is not available for 60 seconds, then the Airborne Position Message transmission is terminated and the conditions for start-up require horizontal position data to be available in order to resume the transmission of Airborne Position Messages.

b) The ADS-B Transmitting Subsystem shall terminate the transmission of Surface Position Messages if position data that is necessary to update the Message is not available for a period of 60 seconds. Transmission termination of Surface Position Messages does not apply to Non-Transponder Devices on aircraft that are on the surface, or on surface vehicles.

Note.— For the Surface Position Message, the receipt of new Movement, or Heading/Ground Track data is not sufficient to maintain broadcast of the message once the message has been initiated.

c) The ADS-B Transmitting Subsystem shall not terminate broadcast transmissions of Aircraft Identification and Category Message even if the input data necessary to update the Message is not available.

d) The ADS-B Transmitting Subsystem shall terminate broadcast transmissions of the Airborne Velocity Message if input data necessary to update the subfields of the Airborne Velocity Message, other than the Intent Change Flag, is not available for a period of 2.6 seconds.

Notes:

1. The receipt of new data necessary to update any single subfield, other than the Intent Change Flag, is sufficient to maintain broadcast of the Airborne Velocity Message.

2. Previous versions of this manual required the Airborne Velocity Message to be transmitted for an additional 60 seconds with ALL ZEROs including the TYPE Code field. In the event of a loss of GPS data, the Airborne Position Message would have barometric altitude in it, the Airborne Velocity Message would not. However, a receiver could not determine the difference between these cases; therefore, the transmitted altitude was not usable.

e) The ADS-B Transmitting Subsystem shall continue to broadcast the Target State and Status Message for as long as Airborne Position Messages are being broadcast.

Note.— The broadcast of Target State and Status (Subtype = 1) Messages may be terminated either: (1) if the target state information is no longer available or valid, or (2) if the broadcast of the Airborne Position Message has been terminated (see §C.2.4.4 a)), since the Target State and Status Messages contain various integrity, mode, or status information that is applicable to the Airborne Position Messages, data which becomes irrelevant if the broadcast of the Airborne Position Message has been terminated.

f) The ADS-B Transmitting Subsystem shall continue to broadcast the Operational Status Messages for as long as respective Airborne Position Messages or Surface Position Messages are being broadcast.

Note.— The broadcast of the Aircraft Operational Status Messages (either Subtype 0 or 1) may be terminated only after the termination of the respective Airborne (see §C.2.4.4 a)) or Surface (see §C.2.4.4 b)) Position Messages, since the Operational Status Messages contain various integrity, mode, version number, or status information that is applicable to the respective Position Messages, data which becomes irrelevant if the broadcast of that Position Message has been terminated.

C.2.4.5 REQUIREMENTS FOR NON-TRANSPONDER DEVICES

Non-transponder devices shall provide the same functionality for initialization, register timeout and broadcast termination as specified for the transponder case in §C.2.4.1 through §C.2.4.3.

a) A non-transponder device shall not broadcast acquisition squitters; and

b) A non-transponder device operating on the surface shall continue to broadcast DF = 18 messages with the 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 multi-lateration systems.

C.2.5 GENERAL FORMATTER/MANAGER (GFM)

Note.— The General Formatter/Manager (GFM) is the name that will be used to refer to the function that formats messages for insertion in the Extended Squitter registers. In addition to data formatting, there are other tasks that have to be performed by this function.

C.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.

C.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 is unavailable for a time equal to twice the update interval or 2 seconds (whichever is greater), the GFM shall ZERO old data (on a per field basis) and insert the resulting message into the appropriate register.

Note.— For registers 05_{16} and 06_{16}, a loss of position data would cause the GFM to set the Format TYPE Code to ZERO as the means of indicating "no position data" since ALL ZEROs in the lat/lon fields is a legal value.

C.2.5.3 SPECIAL PROCESSING FOR FORMAT TYPE CODE ZERO

C.2.5.3.1 SIGNIFICANCE OF FORMAT TYPE CODE EQUAL TO ZERO

Notes:

1. Format TYPE Code ZERO (0) is labelled "no position information." This is intended to be used when the lat/lon information is not available or invalid and still permits the reporting of baro altitude loaded by the transponder. The principal use of this message case is to provide ACAS the ability to passively receive altitude.

2. Special handling is required for the airborne and Surface Position Messages because a CPR encoded value of ALL ZEROs in the Lat/Lon field is a valid value.

C.2.5.3.2 BROADCAST OF FORMAT TYPE CODE EQUAL TO ZERO

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

a) Airborne Position or Surface Position (register 05_{16} and 06_{16}) has not been loaded by the GFM for 2 seconds. In this case the transponder clears the entire 56 bits of the register that timed out. (In the case of the Airborne Position register, the altitude subfield is only ZEROed if no altitude data is available.) Transmission of the Airborne and Surface Position Extended Squitter that broadcasts the timed out register shall itself stop in 60 seconds except for the Airborne Position Message when Altitude is still available. Broadcast of this Extended Squitter shall resume when the GFM begins to insert data into the register.

b) 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 can clear the Format TYPE Code and all other fields of the airborne position and surface position, and insert this zeroed message into the appropriate register. This should 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 format types, since a ZERO value in any of the fields indicates no information. No other squitter types are broadcast with TYPE Code equal ZERO (0).

C.2.5.3.3 RECEPTION OF FORMAT TYPE CODE EQUAL TO ZERO

If a squitter with format TYPE Code equal to ZERO (0) is received, it shall be checked to see whether altitude is present. If altitude is not present, the message shall be discarded. If altitude is present, it may be used to update altitude. An Extended Squitter containing Format TYPE Code ZERO shall only be used to update the altitude of an aircraft already in track.

Note.— For ACAS, this could be an aircraft that was being maintained via hybrid surveillance when the position data input failed. In this case, altitude only could be used for a short time period. Interrogation would have to begin at the update rate for that track to ensure the update of range and bearing information on the display.

C.2.5.4 HANDLING OF EVENT-DRIVEN PROTOCOL

The Event-Driven interface protocol shall provide a general purpose interface into the transponder function for either those messages beyond those that are regularly transmitted all the time (provided input data is available), or those that are transmitted at a fixed periodic rate. 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.

C.2.5.4.1 TRANSPONDER SUPPORT FOR THE EVENT DRIVEN PROTOCOL

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

Note.— Delay times are short, with a maximum of several milliseconds for the longest transponder transaction.

The maximum transmission rate for the Event-Driven protocol shall 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. A summary of the transmission rates for all extended squitters is shown in Table C-35.

Note.— The squitter transmission rate and the duration of squitter transmissions is application dependent. Choices made should be the minimum rate and duration consistent with the needs of the application.

C.2.5.4.2 GFM USE OF THE EVENT-DRIVEN PROTOCOL

Note.— More than one application at a time may be supported by the Event-Driven protocol. The GFM handles requests for broadcast by these applications and is the only function that is capable of inserting data into register $0A_{16}$. In this way, the GFM can provide the pseudo random timing for all applications using this protocol and maintain a maximum insertion rate that does not exceed the transponder imposed limit.

An application that wants to use 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 $0A_{16}$ 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 readout of this information by air-ground or air-air register readout. When broadcast of a format type ceases, the GFM shall clear the corresponding register assigned to this message.

The maximum rate that can be supported by the Event-Driven protocol shall be 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 $0A_{16}$. The next insertion shall be scheduled at a random interval that is uniformly distributed over the range of the update interval ±0.1 second relative to the previous insertion into register $0A_{16}$ for this format type.

The GFM shall monitor the number of insertions scheduled in any 1-second interval. If more than two would occur, the GFM shall schedule the pending messages based on message priorities and queue management rules defined in §C.2.5.4.3 in order to ensure that the limit of two messages per second is observed while ensuring that high priority Extended Squitter Messages are broadcast at the required rates.

C.2.5.4.3 Event-Driven Message Transmission Scheduling Function

The Event-Driven Message Scheduling Function shall ensure that the total Event-Driven Message rate does not exceed two 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) The broadcast of the Extended Squitter Aircraft Status Message TCAS/ACAS RA Broadcast (TYPE = 28, Subtype = 2).

   2) The broadcast of the Extended Squitter Aircraft Status Message Emergency/Priority Condition (TYPE = 28, Subtype = 1).

   3) 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 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) results in a queue of messages awaiting delivery to the transponder, then pending messages, 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 Table C-36.

Table C-36. Event-Driven Message Lifetime

Message type	*Message Subtype*	*Message Lifetime (seconds)*
23	= 0	5.0 s (±0.2 s)
	= 1 – 7	Reserved (see Note)
24		Reserved (see Note)
25		Reserved (see Note)
26		Reserved (see Note)
27		Reserved (see Note)
28	= 1	5.0 s (±0.2 s)
	= 2	24 ±1 s after RAT transitions from 0 to 1
	0 and >2	Reserved (see Note)
30		Reserved (see Note)

Note.— A default message lifetime of 20 seconds will be used for queue management unless otherwise specified.

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

C.2.6.1 PRINCIPLE OF THE CPR ALGORITHM

Notes:

1. The Mode S Extended Squitters use Compact Position Reporting (CPR) to encode Latitude and Longitude efficiently into messages. 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 for airborne formats and 50 seconds for surface formats), 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.

C.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:

For airborne encoding used in the ADS-B Airborne Position Message and the TIS-B Fine Airborne Position Message:	*Nb* = 17
For surface encoding used in the ADS-B Surface Position Message and the TIS-B Fine Surface Position Message:	*Nb* = 19
For intent encoding:	*Nb* = 14
For TIS-B encoding used only in the TIS-B Coarse Airborne Position Message:	*Nb* = 12

Note.— The Nb parameter determines the encoded position precision (approximately 5 m for the airborne encoding, 1.25 m for the surface encoding, 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.— 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.

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

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

b) 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 $x < 0$.

c) 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.—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°.

d) 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 of 1 to 59. **NL**(*x*) is defined for most latitudes by the equation,

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

where *lat* denotes the latitude argument in degrees. For latitudes at or near the N or S pole, or the equator, the following points are 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.— This equation for NL( ) is impractical for a real-time implementation. A table of transition latitudes can be pre-computed using the following equation:

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

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.

C.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 always uses the even format (*i* = 0), whereas the airborne, surface, and TIS-B encoding 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:

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

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

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

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

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

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

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

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

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

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

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

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

Note.— When performing the NL function, the encoding process must ensure that the NL value is established in accordance with the Note in §C.2.6.2 d).

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

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

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

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

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

f) Finally, limit the values of XZ_i and YZ_i to fit in the 17-bit, 14-bit or 12-bit field allotted to each coordinate:

For *Nb* = 17:
$$YZ_i = MOD(YZ_i, 2^{17}),$$
$$XZ_i = MOD(XZ_i, 2^{17})$$

For *Nb* = 19:
$$YZ_i = MOD(YZ_i, 2^{17}),$$
$$XZ_i = MOD(XZ_i, 2^{17})$$

For *Nb* = 14:
$$YZ_0 = MOD(YZ_0, 2^{14}),$$
$$XZ_0 = MOD(XZ_0, 2^{14})$$

For *Nb* = 12:
$$YZ_i = MOD(YZ_i, 2^{12}),$$
$$XZ_i = MOD(XZ_i, 2^{12})$$

C.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 (*lats*, *lons*) 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 (§C.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 §C.2.6.5 for the airborne and intent format types and in §C.2.6.6 for the surface format type.

C.2.6.5 LOCALLY UNAMBIGUOUS CPR DECODING FOR AIRBORNE, TIS-B AND INTENT LAT/LON

The following computations shall be performed to obtain the decoded lat/lon for the airborne, intent, and TIS-B messages. For intent lat/lon, *i* is always 0 (even encoding), whereas airborne and TIS-B lat/lon use both even (*i* = 0) and odd (*i* = 1) encodings. For airborne lat/lon, *Nb* = 17, for intent, *Nb* = 14, and for TIS-B *Nb* = 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:

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

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:

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

Note.— When performing the NL function, the encoding process must ensure that the NL value is established in accordance with the Note in §C.2.6.2 d).

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

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

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

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

C.2.6.6 LOCALLY UNAMBIGUOUS DECODING FOR SURFACE POSITION

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:

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

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:

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

Note.— When performing the NL function, the encoding process must ensure that the NL value is established in accordance with the Note in §C.2.6.2 d).

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

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

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

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

C.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 not longer than 10 seconds for airborne formats.

Notes:

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.

2. The time difference limit of 10 seconds between the even- and odd-format position reports for airborne formats is determined by the maximum permitted separation of 3 NM. Positions greater than 3 NM apart cannot be used for a unique global position. An aircraft capable of a speed of 1 850 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.

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:

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

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

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

Southern hemisphere values of $Rlat_i$ shall fall in the range of 270 to 360 degrees. Subtract 360 degrees from such values, thereby restoring $Rlat_i$ to the range of −90 to +90 degrees.

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.

Note.— When performing the NL function, the encoding process must ensure that the NL value is established in accordance with the Note in §C.2.6.2 d). This is more important in the Global Unambiguous Decode because large longitude errors are induced when the decode function is not selecting the NL value properly as discussed in the Note in §C.2.6.2 d).

e) If **NL**($Rlat_0$) is equal to **NL**($Rlat_1$), then proceed with computation of $Dlon_i$, 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:

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

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 ($i = 1$):

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

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

h) A reasonableness test shall be applied to the resulting decoded position in accordance with §C.2.6.10.2.

C.2.6.8 GLOBALLY UNAMBIGUOUS CPR DECODING OF SURFACE POSITION

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 prior history of 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 Position 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 appears 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 §C.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 case X = 25 seconds.

Note.— 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:

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

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($Rlat_1$). 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.

Note.— When performing the NL function, the encoding process must ensure that the NL value is established in accordance with the Note in §C.2.6.2 d). This is more important in the Global Unambiguous Decode because large longitude errors are induced if the decode function is not selecting the NL value properly as discussed in the Note in §C.2.6.2 d).

e) Compute the longitude zone size $Dlon_i$, 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:

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

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 ($i = 1$):

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

where n_i is the greater of [$NL(Rlat_i) - i$] and 1.

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

h) A reasonableness test shall be applied to the resulting decoded position in accordance with §C.2.6.10.2.

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.

C.2.6.9 CPR DECODING OF RECEIVED POSITION REPORTS

C.2.6.9.1 OVERVIEW

Note.— The techniques described in the preceding paragraphs (locally and globally unambiguous decoding) are used together to decode the lat/lon contained in airborne, surface intent and TIS-B position reports. The process begins with globally unambiguous decoding based upon the receipt of an even and an odd encoded position squitter. Once the globally unambiguous position is determined, the emitter centred local decoding technique is used for subsequent decoding based on a single position report, either even or odd encoding.

C.2.6.9.2 EMITTER CENTRED 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 360 NM between position updates.

C.2.6.10 REASONABLENESS TEST FOR CPR DECODING OF RECEIVED POSITION MESSAGES

C.2.6.10.1 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.

C.2.6.10.2 REASONABLENESS TEST APPLIED TO POSITION DETERMINED FROM GLOBALLY UNAMBIGUOUS DECODING

A reasonableness test shall be applied to a position computed using the Globally Unambiguous CPR decoding per §C.2.6.7 for Airborne Participants, or per §C.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 performing 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 reception range of the receiver. If the validation fails, the receiver shall discard the decoded position that 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 §C.2.6.7 for an Airborne Participant, or per §C.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 metres for an airborne decode and 1.25 metres 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 Position 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 Position Message. These two positions should agree since they are computed from the same message.

C.2.6.10.3 REASONABLENESS TEST APPLIED TO POSITION DETERMINED FROM LOCALLY UNAMBIGUOUS DECODING

A reasonableness test shall be applied to a position computed using the Locally Unambiguous CPR decoding per §C.2.6.5 for Airborne, TIS-B or Intent Participants, or per §C.2.6.6 for Surface Participants. Upon receipt of the even or odd encoded Position Message that completes the Locally Unambiguous CPR decode, the receiver shall perform a reasonableness test on the most recently received position decode by performing the following test:

If the difference between the TOMRs of the previously received Position Message and the most recently received Position Message is 30 seconds or less, and the difference in the reported position in the most recently received Position Message is greater than or equal to **X** NM, where:

X = 6 for Airborne Participants receiving Airborne Position Messages, or
X = 2.5 for Airborne Participants that have received a Surface Position Message, or
X = 2.5 for Surface Participants that have received an Airborne Position Message, or
X = 0.75 for Surface Participants receiving Surface Position Messages,

then the validation shall be considered failed, and:

1) the most recently received position shall **no**t be used to update the track, and

2) the received position shall be used to initiate or update a candidate duplicate address track or update a duplicate address track in accordance with §C.2.6.10.4.

Notes:

1. If no duplicate address or candidate duplicate address report exists for this ICAO 24-bit address, the position message is used to initiate a candidate duplicate address report. If a candidate duplicate address report exists, the position message is used to update the candidate duplicate address report. Otherwise, the position message is used to update the duplicate address report unless the position message fails this validation test (see §C.2.6.10.4).

*2. The position threshold value is based on the assumption of a maximum aircraft velocity of **V** knots (where **V** = 600 for Airborne and **V** = 50 for Surface) over a maximum time period of 30 seconds. This yields a maximum positional difference of approximately 5 NM for Airborne, and 0.5 NM for Surface. An additional measure of 1 NM for Airborne, and 0.25 NM for Surface are added to account for additional ADS-B positional measurement uncertainty. The position threshold of 2.5 NM between surface and airborne participants was derived from the assumption of 250 knots maximum speed for a target transitioning from the surface state to an airborne state over 30 seconds, yielding approximately 2 nautical miles, with an additional 0.5 NM being added to allow for positional errors.*

C.2.6.10.4 Duplicate Address Processing

The ICAO 24-bit address transmitted in each ADS-B Message and the derived Address Qualifier is used to identify and associate the messages for a particular aircraft/vehicle. Though each aircraft/vehicle should have a unique ICAO 24-bit address, there may be occasions in which more than one aircraft/vehicle is transmitting the same ICAO 24-bit address. It is important for ADS-B applications that receive 1 090 ES ADS-B reports to have knowledge of aircraft within receiving range. The requirements in the following subparagraphs enable detection of a duplicate address aircraft/vehicle when horizontal position separation is outside of the local CPR reasonableness test criteria of §C.2.6.10.3.

Notes:

1. Without duplicate address detection, an aircraft/vehicle that enters the range of the receiver with the same ICAO 24-bit address as that of an existing ADS-B report would go undetected, and message data from the undetected aircraft/vehicle could be erroneously associated with the existing ADS-B report.

2. Duplicate Address processing is not required for TIS-B targets. The assumption is that the ADS-B Ground Stations will protect against any Duplicate Address situation.

C.2.6.10.4.1 Candidate Duplicate Address Report

A candidate duplicate address report shall be initiated when a position message is received for an ICAO 24-bit address that fails the local CPR reasonableness test validation of §C.2.6.10.3, and no candidate duplicate address report or duplicate address report is currently active for the received ICAO 24-bit address. If initiated, the candidate duplicate address report is set to Initialization State as per RTCA DO-260B, §2.2.10.2, and the position message is stored for this candidate duplicate address report. The ADS-B report for which the position message did not pass the validation test of §C.2.6.10.3, the local CPR reasonableness test, is the primary ADS-B report for this ICAO 24-bit address. Once a candidate duplicate address report is initiated, association of subsequent position messages with this ICAO 24-bit address shall be first attempted on the primary ADS-B report for this ICAO 24-bit address. If the position message does not pass the validation test of §C.2.6.10.3 on the primary ADS-B report, the position message shall be used to attempt Track Initialization on the candidate duplicate address report as per RTCA DO-260B, §2.2.10.2.

Notes:

1. TIS-B reports and ADS-R reports are separate and distinct from ADS-B reports as per §C.3 and §C.4, so there are no duplicate address issues between these report types and ADS-B reports.

2. Inter-source correlation is addressed in RTCA DO-317.

C.2.6.10.4.2 Duplicate Address Condition

A duplicate address condition shall be declared for an ICAO 24-bit address when a global CPR decode is completed by the receipt of both an even and odd position message within 10 seconds for the candidate duplicate address and passes the global CPR reasonableness test. Once declared, a duplicate address condition shall result in the Duplicate Address Flag in the State Vector Report set to “ON” in the ADS-B report upon output of either ADS-B report in the duplicate address condition. ADS-B Position Messages shall be associated with the ADS-B report in the duplicate address condition that passes the local CPR reasonableness test in §C.2.6.10.3. Each ADS-B report in the duplicate address condition shall be updated upon receipt of other Extended Squitter Messages containing the duplicate ICAO 24-bit address since there is no means to associate these messages with the correct aircraft.

ADS-B Position, Velocity, Aircraft Identification and Category and Emergency/Priority Status (Subtype = 1) Messages from aircraft/vehicles with ICAO 24-bit addresses identified as Duplicate Addresses shall be processed as Version ZERO (0) format messages. Since Target State and Status Messages can be associated with the appropriate MOPS Version Number based on the Subtype, and Operational Status Messages contain the MOPS Version Number, these messages can be decoded directly.

Notes:

1. The Duplicate Address Flag is used to indicate to ADS-B applications that information associated with that address cannot be correctly associated with either ADS-B report in the duplicate address condition. Additionally, the correct MOPS Version Number for each of the aircraft/vehicles cannot be readily determined, so interpretation of message data defaults to Version ZERO (0).

2. The update and output of both ADS-B reports when Extended Squitter Messages are received with the duplicate ICAO 24-bit address results in additional overhead since the output of both ADS-B reports possibly occurs upon message reception. However, this approach gives ADS-B applications the ability to associate information with the correct ADS-B report if the applications choose to attempt to correlate using the additional provided information.

The duplicate address condition shall be cleared after 60 seconds has elapsed with no Position Message update for a Participant with an ADS-B report identified in the duplicate address condition. The relevant ADS-B report for the Participant shall be deleted from the Report Output Storage Buffer. Output of the remaining ADS-B report shall contain a State Vector Report with the Duplicate Address Flag set to “OFF”.

Note.— After clearing the duplicate address condition, the ADS-B report for the aircraft/vehicle that continues to receive Position Messages that pass the local CPR reasonableness test, as well as other 1 090 ES ADS-B Messages, is retained and updated as per RTCA DO-260B, §2.2.10.4.

C.2.6.10.4.3 Duplicate Address Report Capacity

The ADS-B Receiving Subsystem shall be capable of maintaining and processing a minimum of three concurrent duplicate address reports.

Note.— The required capacity includes duplicate address reports from both ADS-B and ADS-R targets. Since duplicate address situations are expected to be infrequent events, the ability to handle three duplicate address reports is expected to be sufficient.

C.2.7 FORMATS FOR EXTENDED SQUITTER

The Extended Squitter messages shall be formatted as defined in the following tables.

Note.— In some cases, ARINC 429 labels are referenced for specific message fields. These references are only intended to clarify the field content and are not intended as a requirement to use these ARINC 429 labels as the source for the message field.

Figure C-1. Extended Squitter Airborne Position

Register 05_{16}

1–5	FORMAT TYPE CODE (§C.2.3.1)
6–7	SURVEILLANCE STATUS
8	NIC SUPPLEMENT-B (§C.2.3.2.5)
9–20	ALTITUDE Specified by the Format TYPE Code (1) the altitude code (AC) as specified in §2.2.13.1.2 of DO-181E (EUROCAE ED-73E §3.17.1.b), but with the M-bit removed (Ref ARINC 429 Label 203), or (2) GNSS Height (HAE) (Ref. ARINC 429 Label 370)
21	TIME (T) (§C.2.3.2.2)
22	CPR FORMAT (F) (§C.2.3.2.1)
23–39	MSB (23) CPR ENCODED LATITUDE (CPR Airborne Format §C.2.6.1 to §C.2.6.10) LSB (39)
40–56	MSB (40) CPR ENCODED LONGITUDE (CPR Airborne Format §C.2.6.1 to §C.2.6.10) LSB (56)

Purpose: To provide accurate airborne position information.

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.

Note.— When horizontal position information is unavailable, but altitude information is available, the Airborne Position Message is transmitted with a Format TYPE Code of ZERO 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 register 05_{16} are ZEROed. The ZERO Format TYPE Code field indicates that Latitude and Longitude information is unavailable, while the ZERO altitude field indicates that altitude information is unavailable.

Figure C-2. Extended Squitter Surface Position

Register 06_{16}

1	
2	
3	FORMAT TYPE CODE
4	(§C.2.3.1)
5	
6	
7	
8	
9	MOVEMENT
10	(§C.2.3.3.1)
11	
12	
13	STATUS for Heading/Ground Track (1 = valid, 0 = not valid)
14	MSB
15	
16	HEADING/GROUND TRACK (7 bits)
17	(§C.2.3.3.2)
18	Resolution = 360/128°
19	
20	LSB
21	TIME (T) (§C.2.3.2.2)
22	CPR FORMAT (F) (§C.2.3.2.1)
23	MSB
24	
25	
26	
27	
28	
29	
30	CPR ENCODED LATITUDE
31	
32	(CPR Surface Format §C.2.6.1 to §C.2.6.10)
33	
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	
47	CPR ENCODED LONGITUDE
48	
49	(CPR Surface Format §C.2.6.1 to §C.2.6.10)
50	
51	
52	
53	
54	
55	
56	LSB

Purpose: To provide accurate surface position information.

MOVEMENT

Coding	Meaning	Quantization
0	No movement information available	
1	A/C Stopped (GS = 0 kt)	
2	0 kt < GS ≤ 0.125 kt	
3–8	0.125 kt < GS ≤ 1.0 kt	0.2700833 km/h
9–12	1.0 kt < GS ≤ 2.0 kt	0.25 kt steps
13–38	2 kt < GS ≤ 15.0 kt	0.50 kt steps
39–93	15.0 kt < GS ≤ 70.0 kt	1.00 kt steps
94–108	70.0 kt < GS ≤ 100.0 kt	2.00 kt steps
109–123	100.0 kt < GS ≤ 175.0 kt	5.00 kt steps
124	175.0 kt < GS	
125	Reserved for A/C Decelerating	
126	Reserved for A/C Acelerating	
127	Reserved for A/C Backing Up	

Figure C-3. Extended Squitter Status

Register 07_{16}

1	TRANSMISSION RATE SUBFIELD (TRS)
2	
3	ALTITUDE TYPE SUBFIELD (ATS)
4	
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27	
28	RESERVED
29	
30	
31	
32	
33	
34	
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Purpose: To provide information on the capability and status of the Extended Squitter rate of the transponder.

Transmission Rate Subfield (TRS) coding:

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) coding:

0 = Barometric altitude
1 = GNSS Height (HAE), ARINC 429 Label 370

Note.— Aircraft determination of surface squitter rate. For aircraft that have the capability to automatically determine their surface squitter rate, the method that must be used to switch between the high and low transmission rates is as follows:

a) Switching from high to low rate: Aircraft must 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.

b) Switching from low to high rate: Aircraft must 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.

In all cases, the automatically selected transmission rate is subject to being overridden by commands received from ground control.

Figure C-4. Extended Squitter Identification and Category

Register 08_{16}

1–5	FORMAT TYPE CODE (§C.2.3.1)
6–8	AIRCRAFT EMITTER CATEGORY
9 (MSB) – 14 (LSB)	CHARACTER 1
15 (MSB) – 20 (LSB)	CHARACTER 2
21 (MSB) – 26 (LSB)	CHARACTER 3
27 (MSB) – 32 (LSB)	CHARACTER 4
33 (MSB) – 38 (LSB)	CHARACTER 5
39 (MSB) – 44 (LSB)	CHARACTER 6
45 (MSB) – 50 (LSB)	CHARACTER 7
51 (MSB) – 56 (LSB)	CHARACTER 8

Purpose: To provide aircraft identification and category.

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 Aircraft Emitter Category coding:

Set A

0 = No ADS-B Emitter Category Information
1 = Light (<15 500 lb)
2 = Small (15 500 to 75 000 lb)
3 = Large (75 000 to 300 000 lb)
4 = High Vortex Large (aircraft such as B-757)
5 = Heavy (>300 000 lb)
6 = High Performance (>5 g acceleration and 400 kt)
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 = Point Obstacle (includes tethered balloons)
4 = Cluster Obstacle
5 = Line Obstacle
6 = Reserved
7 = Reserved

Set D (Reserved)

Aircraft Identification coding:

Character coding as specified in §C.2.3.4.

Figure C-5. Extended Squitter Airborne Velocity (Subtypes 1 and 2: Velocity Over Ground)

Register 09_{16}

Bit				
1	MSB		**1**	
2			**0**	
3	FORMAT TYPE CODE = 19		**0**	
4	(§C.2.3.1)		**1**	
5	LSB		**1**	
6	Subtype 1	0	Subtype 2	0
7		0		1
8		1		0
9	INTENT CHANGE FLAG (§C.2.3.5.3)			
10	RESERVED-A			
11	NAVIGATION ACCURACY CATEGORY FOR VELOCITY			
12	(NAC_V) (§C.2.3.5.4)			
13				
14	DIRECTION BIT for E-W Velocity (**0 = East, 1 = West**)			
15	EAST-WEST VELOCITY (10 bits)			
16	NORMAL: LSB = 1 kt		SUPERSONIC: LSB = 4 kt	
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	1 023	>4 086 kt
25	DIRECTION BIT for N-S Velocity (**0 = North**, **1 = South**)			
26	NORTH – SOUTH VELOCITY (10 bits)			
27	NORMAL: LSB = 1 kt		SUPERSONIC: LSB = 4 kt	
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 = Geometric, 1 = Baro)			
37	SIGN BIT FOR VERTICAL RATE (0 = Up, 1 = Down)			
38	VERTICAL RATE (9 bits)			
39	All zeros – no vertical rate information, LSB = 64 ft/min			
40	Value	Vertical Rate	Reference	
41	1	0 ft/min	ARINC 429 labels	
42	2	64 ft/min	GPS: 165	
43	---	---	INS: 365	
44	510	32 576 ft/min		
45	511	>32 608 ft/min		
46				
47	RESERVED-B			
48				
49	DIFFERENCE SIGN BIT (0 = Above baro., 1 = Below baro. alt.)			
50	GEOMETRIC HEIGHT DIFFERENCE FROM BARO. ALT. (7 bits) (§C.2.3.5.6) (All zeros = no information) (LSB = 25 ft)			
51	Value		Difference	
52	1		0 ft	
53	2		25 ft	
54	---		---	
55	126		3 125 ft	
56	127		>3 137.5 ft	

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

Subtype Coding:

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

Reference ARINC Labels for Velocity:

East – West	North – South
GPS: 174	GPS: 166
INS: 367	INS: 366

Reference ARINC Labels:

GNSS Height (HAE): GPS 370
GNSS Altitude (MSL): GPS: 076

Figure C-6. Extended Squitter Airborne Velocity (Subtypes 3 and 4: Airspeed and Heading)

Register 09_{16}

Bit				
1	MSB		1	
2			0	
3	FORMAT TYPE CODE = 19		0	
4	(§C.2.3.1)		1	
5	LSB		1	
6	Subtype 3	0	Subtype 4	1
7		1		0
8		1		0
9	INTENT CHANGE FLAG (§C.2.3.5.3)			
10	RESERVED-A			
11	NAVIGATION ACCURACY CATEGORY FOR VELOCITY			
12	(NAC_V) (§C.2.3.5.4)			
13				
14	STATUS BIT (1 = Heading available, 0 = Not available)			
15	MSB			
16				
17				
18	HEADING (10 bits)			
19	(§C.2.3.5.5)			
20	Resolution = 360/1 024°			
21				
22			Reference ARINC Label	
23			INS: 320	
24	LSB			
25	AIRSPEED TYPE (0 = IAS, 1 = TAS)			
26	AIRSPEED (10 bits)			
27	NORMAL: LSB = 1 kt		SUPERSONIC: LSB = 4 kt	
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 = Geo, 1 = Baro)			
37	SIGN BIT FOR VERTICAL RATE (0 = Up, 1 = Down)			
38	VERTICAL RATE (9 bits)			
39	All zeros – no vertical rate information			
40	LSB = 64 ft/min			
41	Value	Vertical Rate	Reference	
42	1	0 ft/min	ARINC Labels	
43	2	64 ft/min	GPS: 165	
44	---	---	INS: 365	
45	510	32 576 ft/min		
46	511	>32 608 ft/min		
47	RESERVED-B			
48				
49	DIFFERENCE SIGN BIT (0 = Above baro., 1 = Below baro. alt.)			
50	GEOMETRIC HEIGHT DIFFERENCE FROM BARO. ALT. (7 bits) (§C.2.3.5.6) (All zeros = no information) (LSB = 25 ft)			
51	Value		Vertical Rate	
52	1		0 ft	
53	2		25 ft	
54	---		---	
55	126		3 125 ft	
56	127		>3 137.5 ft	

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

Note.— This format is only used if velocity over ground is not available.

Subtype Coding:

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

Reference ARINC 429 Labels for Air Data Source:

IAS: 206
TAS: 210

Reference ARINC Labels:

GNSS Height (HAE): GPS 370
GNSS Altitude (MSL): GPS: 076

Figure C-7. Extended Squitter Event-Driven Register

Register $0A_{16}$

1	
2	
3	
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24	
25	
26	
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28	
29	
30	
31	
32	
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35	
36	
37	
38	
39	
40	
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51	
52	
53	
54	
55	
56	

Purpose: To provide a flexible means to squitter messages other than position, velocity and identification.

Note.—The data in this register is not intended for extraction using GICB or ACAS cross-link protocols. The readout of this register is discouraged since the contents are indeterminate.

Figure C-8a. Extended Squitter Aircraft Status (Subtype 1: Emergency/Priority Status and Mode A Code)

Register 61_{16}

1	MSB	FORMAT TYPE CODE = 28 (§C.2.3.1)
2		
3		
4		
5	LSB	
6	MSB	SUBTYPE CODE = 1
7		
8	LSB	
9	MSB	EMERGENCY STATE
10		
11	LSB	
12	MSB	MODE A (4096) CODE (§C.2.3.7.3)
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24	LSB	
25–56		RESERVED

PURPOSE: To provide additional information on aircraft status.

Subtype shall be coded as follows:

0 = No information
1 = Emergency/Priority Status and Mode A Code
2 = TCAS/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

Notes:

1. *Message delivery is accomplished using the Event-Driven Protocol as specified in §C.2.3.7.3.1.*
2. *Termination of emergency state is detected by coding in the surveillance status field of the Airborne Position Message.*
3. *Subtype 2 message broadcasts take priority over Subtype 1 message broadcasts.*
4. *Emergency State value 1 is set when Mode A code 7700 is provided to the transponder.*
5. *Emergency State value 4 is set when Mode A code 7600 is provided to the transponder.*
6. *Emergency State value 5 is set when Mode A code 7500 is provided to the transponder.*
7. *The Mode A code shall be coded as defined in Annex 10, Volume IV, §3.1.2.6.7.1.*

Note.— The data in this register is not intended for extraction using GICB or ACAS cross-link protocols. The readout of this register is discouraged since the contents are indeterminate.

Figure C-8b. Extended Squitter Aircraft Status (Subtype 2: 1 090 ES TCAS/ACAS RA Broadcast)

Register 61_{16}

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 TCAS/ACAS equipment.

Subtype Coding:

0 = No information
1 = Emergency/Priority Status
2 = TCAS/ACAS RA Broadcast
3 to 7 = Reserved

TCAS/ACAS RA Broadcast Coding:

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

Notes:

1. *Message delivery is accomplished once per 0.8 second using the event-driven protocol.*

2. *RA Broadcast begins within 0.5 second after transponder notification of the initiation of an TCAS/ACAS RA.*

3. *RA Broadcast is terminated 24 ±1 second after the RAT flag (Annex 10, Volume IV, §4.3.8.4.2.2.1.3) transitions from ZERO (0) to ONE (1).*

4. *Subtype 2 message broadcasts take priority over subtype 1 message broadcasts.*

Figure C-9. Target State and Status Information
(Subtype = 1: Compatible with ADS-B Version Number = 2)

Register 62_{16}

PURPOSE: To provide aircraft state and status information.

1	
2	
3	FORMAT TYPE CODE = 29
4	
5	
6	MSB SUBTYPE CODE = 1
7	LSB
8	SIL SUPPLEMENT (0 = Per Hour, 1 = Per Sample)
9	SELECTED ALTITUDE TYPE (0 = MCP/FCU, 1 = FMS)
10	MSB = 32 768 ft
11	MCP/FCU SELECTED ALTITUDE
12	(when Selected Altitude Type = 0)
13	FMS SELECTED ALTITUDE
14	(when Selected Altitude Type = 1)
15	Coding: 111 1111 1111 = 65 472 ft
16	*** **** ****
17	000 0000 0010 = 32 ft
18	000 0000 0001 = 0 ft
19	000 0000 0000 = No data or Invalid
20	LSB = 32 ft
21	MSB = 204.8 millibars
22	BAROMETRIC PRESSURE SETTING (MINUS 800 millibars)
23	Range = [0, 408.0] Resolution = 0.8 millibars
24	Coding: 1 1111 1111 = 408.00 millibars
25	* **** ****
26	0 0000 0010 = 0.800 millibars
27	0 0000 0001 = 0.000 millibars
28	0 0000 0000 = No Data or Invalid
29	LSB = 0.8 millibars
30	STATUS (0 = Invalid, 1 = Valid)
31	Sign (0 = Positive, 1 = Negative)
32	MSB = 90.0°
33	
34	SELECTED HEADING
35	Range = [+/–180]°, Resolution = 0.703125°
36	(Typical Selected Heading Label = “101”)
37	
38	
39	LSB = 0.703125° (180/256)
40	MSB
41	NAVIGATION ACCURACY CATEGORY FOR POSITION (NAC_P)
42	(§C.2.3.9.9)
43	LSB
44	NAVIGATION INTEGRITY CATEGORY FOR BARO (NIC_{BARO})
45	MSB SOURCE INTEGRITY LEVEL (SIL)
46	LSB
47	STATUS OF MCP/FCU MODE BITS (0 = Invalid, 1 = Valid)
48	AUTOPILOT ENGAGED (0 = Not Engaged, 1 = Engaged)
49	VNAV MODE ENGAGED (0 = Not Engaged, 1 = Engaged)
50	ALTITUDE HOLD MODE (0 = Not Engaged, 1 = Engaged)
51	Reserved for ADS-R Flag
52	APPROACH MODE (0 = Not Engaged, 1 = Engaged)
53	TCAS/ACAS OPERATIONAL (0 = Not Operational, 1 = Operational)
54	LNAV MODE (0 = Not Engaged, 1 = Engaged)
55	MSB RESERVED
56	LSB

Figure C-10. Aircraft Operational Status

Register 65_{16}

Bit	Subtype 0	Subtype 1
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	(§C.2.3.10.3)	(§C.2.3.10.3)
18		
19		
20		LSB
21		MSB
22		LENGTH/WIDTH CODES
23		(§C.2.3.10.11)
24	LSB	LSB
25	MSB	MSB
26		
27		
28		
29		
30	AIRBORNE	SURFACE
31	OPERATIONAL	OPERATIONAL
32	MODE (OM) CODES	MODE (OM) CODES
33	(§C.2.3.10.4)	(§C.2.3.10.4)
34		
35		
36		
37		
38		
39		
40	LSB	LSB
41	MSB	
42	VERSION NUMBER (§C.2.3.10.5)	
43	LSB	
44	NIC SUPPLEMENT-A (§C.2.3.10.6)	
45	MSB	
46	NAVIGATIONAL ACCURACY CATEGORY – POSITION	
47	(NAC_P) (§C.2.3.10.7)	
48	LSB	
49	MSB GVA	RESERVED
50	LSB (§C.2.3.10.8)	
51	MSB SOURCE INTEGRITY LEVEL (SIL)	
52	LSB (§C.2.3.10.9)	
53	NIC_{BARO} (§C.2.3.10.10)	TRK/HDG (§C.2.3.10.12)
54	HRD (§C.2.3.10.13)	
55	SIL SUPPLEMENT (§C.2.3.10.15)	
56	RESERVED for ADS-R	

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

C.3 TRAFFIC INFORMATION SERVICES – BROADCAST (TIS-B) FORMATS AND CODING

C.3.1 INTRODUCTION

Notes:

1. This section defines the formats and coding for a Traffic Information Service Broadcast (TIS-B) based on the same 112-bit 1 090 MHz signal transmission that is used for ADS-B on 1 090 MHz.

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. The basis for this ground surveillance data may be an 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. TIS-B data content on the 1 090 MHz signal does not include all of the parameters, such as the System Design Assurance (SDA) and the SIL Supplement, which are normally associated with ADS-B transmissions from aircraft. Those parameters that are not broadcast will need to be provided by the TIS-B Service Provider.

4. TIS-B service is the means for providing 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.

C.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 Figure C-11.

TIS-B Format Definition					
Bit #	1 ---- 5	6 --- 8	9 ----- 32	33 ------------------------- 88	89 ---- 112
DF = 18 Field Names	DF[5]	CF[3]	AA[24]	"ME"[56]	PI[24]
	10010				
	MSB	MSB	MSB	MSB	MSB
	LSB	LSB	LSB	LSB	LSB

Figure C-11. TIS-B Format Definition

C.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 Table C-37.

Table C-37. CF Field Code Definitions in DF = 18 ADS-B and TIS-B Messages

CF Value	*ICAO/Mode A Flag (IMF)*	*Meaning*
0	N/A	ADS-B Message from a non-transponder device, AA field holds 24-bit ICAO aircraft address
1	N/A	Reserved for ADS-B Message in which the AA field holds anonymous address or ground vehicle address or fixed obstruction address
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
4	N/A	TIS-B and ADS-R Management Message, AA field contains TIS-B/ADS-R management information
5	0	Fine TIS-B Message, AA field contains a non-ICAO 24-bit address
	1	Reserved
6	0	Rebroadcast of ADS-B Message from an alternate data link, AA field holds 24-bit ICAO aircraft address
	1	Rebroadcast of ADS-B Message from an alternate data link, AA field holds anonymous address or ground vehicle address or fixed obstruction address
7	N/A	Reserved

C.3.4 TIS-B SURVEILLANCE MESSAGE DEFINITION

C.3.4.1 TIS-B FINE AIRBORNE POSITION MESSAGE

The TIS-B fine airborne position "ME" field shall be formatted as specified in Figure C-12, and described in the following paragraphs.

C.3.4.1.1 ICAO/MODE A FLAG (IMF)

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.

Notes:

1. *The AA field is coded differently for 24-bit addresses and Mode A codes as specified in Table C-24.*
2. *A target with a ZERO "Mode A" code and a reported altitude is an SSR target.*

C.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). ALL ZEROs in this field shall indicate that there is no altitude data.

C.3.4.1.3 Compact Position Reporting (CPR) Format (F)

This field shall be set as specified in §C.2.3.2.1.

C.3.4.1.4 Latitude/Longitude

The Latitude/Longitude fields in the TIS-B fine Airborne Position Message shall be set as specified in §C.2.3.2.3.

C.3.4.2 TIS-B Surface Position Message

The TIS-B surface position "ME" field shall be formatted as specified in Figure C-13, and described in the following paragraphs.

C.3.4.2.1 Movement

This field shall be set as specified in §C.2.3.3.1.

C.3.4.2.1.1 Ground Track (True)

C.3.4.2.1.1.1 Ground Track Status

This field shall be set as specified in §C.2.3.3.2.1.

C.3.4.2.1.1.2 Ground Track Angle

This field shall be set as specified in §C.2.3.3.2.2.

C.3.4.2.1.2 ICAO/Mode A Flag (IMF)

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 §C.3.4.1.1.

C.3.4.2.1.3 Compact Position Reporting (CPR) Format (F)

This field shall be set as specified in §C.2.3.3.3.

C.3.4.2.1.4 Latitude/Longitude

The Latitude/Longitude fields in the TIS-B Fine Surface Position Message shall be set as specified in §C.2.3.3.5.

C.3.4.3 Identification and Category Message

The TIS-B Identification and Category "ME" field shall be formatted as specified in Figure C-14, and described in the following paragraphs. This message shall only be used for aircraft identified with an ICAO 24-bit address.

C.3.4.3.1 AIRCRAFT IDENTIFICATION CODING

This field shall be set as specified in §C.2.3.4.1.

C.3.4.4 VELOCITY MESSAGE

The TIS-B Velocity "ME" field shall be formatted as specified in the Figure C-15 and described in the following paragraphs for Subtypes 1 and 2, and in Figure C-16 for Subtypes 3 and 4.

C.3.4.4.1 SUBTYPE FIELD

Subtypes 1 through 4 shall be used for the TIS-B Velocity Message. Subtype 1 shall be used for velocities over ground under 1 000 knots and Subtype 2 shall be used for aircraft capable of supersonic flight when the velocity over ground might exceed 1 022 knots.

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 the normal velocity coding shall be made if both the East-West AND North-South velocities drop below 1 000 knots.

Subtypes 3 and 4 shall be used when Airspeed and Heading are substituted for velocity over ground. Subtype 3 shall be used at subsonic airspeeds, while Subtype 4 shall be used for aircraft capable of supersonic flight when the Airspeed might exceed 1 022 knots.

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

C.3.4.4.2 ICAO/MODE A FLAG (IMF)

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 §C.3.4.1.1.

C.3.4.5 COARSE AIRBORNE POSITION MESSAGE

The TIS-B coarse airborne position "ME" field shall be formatted as specified in Figure C-17, and described in the following paragraphs.

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.

C.3.4.5.1 ICAO/MODE A FLAG (IMF)

This one-bit field (bit 1) shall indicate the type of identity associated with the aircraft data reported in the TIS-B message. Coding is specified in §C.3.4.1.1.

C.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.— In the case where TIS-B messages are being received from more than one TIS-B ground station, the SVID can be used to select coarse messages from a single source. This will prevent the TIS-B track from wandering due to the different error biases associated with different sources.

C.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).

C.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.

C.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.

C.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 Table C-38.

Table C-38. TIS-B Aircraft Speed Over-the-Ground

Coding		*Meaning (Ground Speed)*
(Binary)	*(Decimal)*	
00 0000	0	No Ground Speed information available
00 0001	1	Ground Speed <16 kt
00 0010	2	16 kt ≤ GS < 48 kt
00 0011	3	48 kt ≤ GS < 80 kt
***	***	***
11 1110	62	1 936 kt ≤ GS < 1 968 kt
11 1111	63	GS ≥ 1 968 kt

Notes:

1. The encoding shown in Table C-38 represents Positive Magnitude data only.

2. Raw data used to establish the Ground Speed Subfield will normally have more resolution (i.e. more bits) than that required by the Ground Speed Subfield. When converting such data to the Ground Speed Subfield, the accuracy of the data must be maintained such that it is not worse than ±1/2 LSB where the LSB is that of the Ground Speed Subfield.

C.3.4.5.7 LATITUDE/LONGITUDE

The Latitude/Longitude fields in the TIS-B Coarse Airborne Position Message shall be set as specified in §C.2.3.2.3, except that the 12-bit form of CPR coding shall be used.

C.3.5 TIS-B AND ADS-R MANAGEMENT MESSAGES

The TIS-B/ADS-R Management Messages shall use Extended Squitter format DF = 18 and CF = 4 to provide information related to the provision of the TIS-B and/or ADS-R Service Volume in the specific airspace being serviced by the local ground broadcast site(s).

The TIS-B/ADS-R Management Message shall be used to provide a specific announcement of the Service Volume and the service availability in local airspace where the TIS-B and/or ADS-R service is being supported by the ground infrastructure.

C.3.6 TIS-B REPORT GENERATION

The information received in TIS-B Messages shall be reported directly to applications, with one exception. The exception is latitude-longitude position information, which is CPR-encoded when it is received, and must be decoded before reporting. In order to accomplish CPR decoding, it is necessary to track received messages so that even-format and odd-format messages can be combined to determine the latitude and longitude of the target.

In the most common case, a particular target will result in TIS-B Message receptions or ADS-B Message receptions, but not both. It is possible, however, for both types of messages to be received for a single target. If this happens, the TIS-B information is processed and reported independently of the ADS-B receptions and reporting.

As TIS-B Messages are received, the information is reported to applications. All received information elements, other than position, shall be reported directly, including all reserved fields for the TIS-B fine format messages and the entire message content (i.e. including the complete 88-bit content of the DF, CF, AA and "ME" fields of the Extended Squitter Message) of any received TIS-B Management Message (Table C-37, for CF = 4). The reporting format is not specified in detail, except that the information content shall be the same as the information content received. The report shall be issued within 0.5 second of the message reception.

C.3.7 FORMATS FOR 1 090 MHZ TIS-B MESSAGES

Figure C-12. TIS-B Fine Airborne Position Message

1	
2	
3	FORMAT TYPE CODE
4	(See §C.2.3.1 and Note 1)
5	
6	MSB SURVEILLANCE STATUS
7	LSB
8	IMF (§C.3.4.1.1)
9	
10	
11	
12	
13	PRESSURE ALTITUDE
14	
15	
16	The altitude code (AC) as specified in §2.2.13.1.2 of
17	DO-181E (EUROCAE ED-73E, §3.17.1.b),
18	but with the M-bit removed.
19	
20	
21	RESERVED
22	CPR FORMAT (F) (§C.2.3.2.1)
23	MSB
24	
25	
26	
27	
28	
29	CPR ENCODED LATITUDE
30	CPR Airborne Format
31	(§C.2.6.1 to §C.2.6.10)
32	
33	
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	CPR ENCODED LONGITUDE
47	CPR Airborne Format
48	(§C.2.6.1 to §C.2.6.10)
49	
50	
51	
52	
53	
54	
55	
56	LSB

Purpose: To provide airborne position information for aircraft that are not equipped with 1 090 MHz ADS-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.

Figure C-13. TIS-B Fine Surface Position Message

Purpose: To provide surface position information for aircraft that are not equipped with 1 090 MHz ADS-B.

1–5	FORMAT TYPE CODE (§C.2.3.1)
6–12	MOVEMENT (§C.2.3.3.1)
13	STATUS for Heading/Ground Track (1 = valid, 0 = not valid)
14	MSB
14–20	HEADING/GROUND TRACK (7 bits) (Referenced to true north) Resolution = 360/128°
20	LSB
21	IMF (§C.3.4.2.1.2)
22	CPR FORMAT (F) (§C.2.3.2.1)
23	MSB
23–39	CPR ENCODED LATITUDE CPR Surface Format (§C.2.6.1 to §C.2.6.10)
39	LSB
40	MSB
40–56	CPR ENCODED LONGITUDE CPR Surface Format (§C.2.6.1 to §C.2.6.10)
56	LSB

Figure C-14. TIS-B Identification and Category Message

1–5	FORMAT TYPE CODE (§C.2.3.1)
6–8	AIRCRAFT EMITTER CATEGORY
9	MSB
9–14	CHARACTER 1
14	LSB
15	MSB
15–20	CHARACTER 2
20	LSB
21	MSB
21–26	CHARACTER 3
26	LSB
27	MSB
27–32	CHARACTER 4
32	LSB
33	MSB
33–38	CHARACTER 5
38	LSB
39	MSB
39–44	CHARACTER 6
44	LSB
45	MSB
45–50	CHARACTER 7
50	LSB
51	MSB
51–56	CHARACTER 8
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 Aircraft Emitter Category coding:

Set A

0 = No ADS-B Emitter Category Information
1 = Light (<15 500 lb)
2 = Small (15 500 to 75 000 lb)
3 = Large (75 000 to 300 000 lb)
4 = High Vortex Large (aircraft such as B-757)
5 = Heavy (>300 000 lb)
6 = High Performance (>5 g acceleration and 400 kt)
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 = Point Obstacle (includes tethered balloons)
4 = Cluster Obstacle
5 = Line Obstacle
6 = Reserved
7 = Reserved

Set D

(Reserved)

Aircraft Identification coding:

Character coding as specified in §C.2.3.4.

Figure C-15. TIS-B Velocity Messages (Subtypes 1 and 2: Velocity Over Ground)

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 Coding:

Code	Velocity	Type
1	Ground	Normal
2	Speed	Supersonic

Note.— The "Vertical Rate" and "Geometric Height Difference From Barometric" fields for surface aircraft do not need to be processed by TIS-B receivers.

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 (§C.3.4.4.2)			
10	MSB			
11	NAVIGATION ACCURACY CATEGORY FOR POSITION			
12	(NAC_P) (§C.2.3.10.7)			
13	LSB			
14	DIRECTION BIT for E-W Velocity (**0 = East, 1 = West**)			
15	EAST-WEST VELOCITY (10 bits)			
16	NORMAL: LSB = 1 kt		SUPERSONIC: LSB = 4 kt	
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	4084 kt
24	1 023	>1 021.5 kt	1 023	>4 086 kt
25	DIRECTION BIT for N-S Velocity (**0 = North**, **1 = South**)			
26	NORTH – SOUTH VELOCITY (10 bits)			
27	NORMAL: LSB = 1 kt		SUPERSONIC: LSB = 4 kt	
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 BIT (1 bit) (**GEO = 0**)		GEO FLAG BIT (1 bit) (**GEO = 1**)	
37	SIGN BIT FOR VERTICAL RATE (**0 = Up, 1 = Down**)		SIGN BIT FOR VERTICAL RATE (**0 = Up, 1 = Down**)	
38	VERTICAL RATE (9 bits)		VERTICAL RATE (9 bits)	
39	All zeros – no vertical rate information, LSB = 64 ft/min		All zeros – no vertical rate information, LSB = 64 ft/min	
40	Value	Vertical Rate	Value	Vertical Rate
41	1	0 ft/min	1	0 ft/min
42	2	64 ft/min	2	64 ft/min
43	---	---	---	---
44	510	32 576 ft/min	510	32 576 ft/min
45	511	>32 608 ft/min	511	>32 608 ft/min
46				
47	NIC SUPPLEMENT-A (§C.2.3.10.6)		NIC SUPPLEMENT-A (§C.2.3.10.6)	
48	NAVIGATION ACCURACY CATEGORY FOR VELOCITY		RESERVED (1 bit)	
49			DIFFERENCE SIGN BIT (0 = Above baro., 1 = Below baro. alt.)	
50	(NAC_V) (§C.2.3.5.4)		GEOMETRIC HEIGHT DIFFERENCE FROM BARO. ALT. (7 bits) (§C.2.3.5.6) (All zeros = no information) (LSB = 25 ft)	
51	SOURCE INTEGRITY LEVEL (SIL)		Value	Difference
52	(§C.2.3.10.9)		1	0 ft
53	RESERVED (4 bits)		2	25 ft
54			---	---
55			126	3 125 ft
56			127	>3 137.5 ft

Figure C-16. TIS-B Velocity Messages (Subtypes 3 and 4: Air Referenced Velocity)

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 Coding:

Code	**Velocity**	**Type**
3	Airspeed, Heading	Normal
4		Supersonic

Note.— The "Vertical Rate" and "Geometric Height Difference From Barometric" fields for surface aircraft do not need to be processed by TIS-B receivers

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 (§C.3.4.4.2)			
10				
11				
12	NAVIGATION ACCURACY CATEGORY FOR POSITION (NAC_P) (§C.2.3.10.7)			
13				
14	HEADING STATUS BIT (**1 = Available, 0 = Not Available**)			
15	MSB			
16				
17				
18	HEADING (10 bits)			
19	(§C.2.3.5.5)			
20	Resolution = 360/1 024°			
21				
22				
23				
24	LSB			
25	AIRSPEED TYPE (**0 = IAS, 1 = TAS**)			
26	AIRSPEED (10 bits)			
27	NORMAL: LSB = 1 kt		SUPERSONIC: LSB = 4 kt	
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 Bit (**GEO = 0**)		GEO FLAG Bit (**GEO = 1**)	
37	SIGN BIT FOR VERTICAL RATE (**0 = Up, 1 = Down**)		SIGN BIT FOR VERTICAL RATE (**0 = Up, 1 = Down**)	
38	VERTICAL RATE (9 bits)		VERTICAL RATE (9 bits)	
39	All zeros – no vertical rate information		All zeros – no vertical rate information	
40	LSB = 64 ft/min		LSB = 64 ft/min	
41	Value	Vertical Rate	Value	Vertical Rate
42	1	0 ft/min	1	0 ft/min
43	2	64 ft/min	2	64 ft/min
44	---	---	---	---
45	510	32 576 ft/min	510	32 576 ft/min
46	511	>32 608 ft/min	511	>32 608 ft/min
47	NIC SUPPLEMENT-A (§C.2.3.10.6)		NIC SUPPLEMENT-A (§C.2.3.10.6)	
48			RESERVED (1 bit)	
49	NAVIGATION ACCURACY CATEGORY FOR VELOCITY (NAC_V) (§C.2.3.5.4)		DIFFERENCE SIGN BIT (0 = Above baro., 1 = Below baro. alt.)	
50			GEOMETRIC HEIGHT DIFFERENCE FROM BARO. ALT. (7 bits) (§C.2.3.5.6) (All zeros = no information) (LSB = 25 ft)	
51	SOURCE INTEGRITY LEVEL		Value	Vertical Rate
52	(§C.2.3.10.9)		1	0 ft
53	RESERVED		2	25 ft
54	RESERVED		---	---
55	TRUE/MAGNETIC HEADING (**0 = True, 1 = Magnetic**)		126	3 125 ft
56	RESERVED		127	>3 137.5 ft

Figure C-17. TIS-B Coarse Airborne Position Message

1	IMF (§C.3.4.5.1)
2	SURVEILLANCE STATUS
3	
4	MSB
5	SERVICE VOLUME ID (SVID)
6	
7	LSB
8	MSB
9	
10	
11	
12	
13	PRESSURE ALTITUDE
14	
15	
16	
17	
18	
19	LSB
20	GROUND TRACK STATUS (**1 = Valid, 0 = Invalid**)
21	
22	
23	GROUND TRACK ANGLE
24	(§C.3.4.5.5)
25	
26	
27	
28	GROUND SPEED
29	(§C.3.4.5.6)
30	
31	
32	CPR FORMAT (F) (**0 = Even, 1 = Odd**)
33	MSB
34	
35	
36	
37	
38	CPR ENCODED LATITUDE
39	(§C.3.4.5.7)
40	
41	
42	
43	
44	LSB
45	MSB
46	
47	
48	
49	
50	CPR ENCODED LONGITUDE
51	(§C.3.4.5.7)
52	
53	
54	
55	
56	LSB

Purpose: To provide airborne position information for aircraft that are not equipped with 1 090 MHz ADS-B when TIS-B service is based on moderate quality surveillance data.

C.4 ADS-B REBROADCAST (ADS-R) FORMATS AND CODING

C.4.1 INTRODUCTION

The TIS-B MASPS, RTCA/DO-286B defines an “ADS-B Rebroadcast Service” as a “Fundamental TIS-B Service” that may be provided. The Messages of the ADS-B Rebroadcast Service are not transmitted by aircraft, but by ADS-B ground stations.

Notes:

1. This section of Appendix C defines the formats and coding for an ADS-B Rebroadcast Service (see the TIS-B MASPS, RTCA/DO-286B, §1.4.1) based on the same 112-bit 1 090 MHz Extended Squitter signal transmission that is used for DF = 17 ADS-B Messages on 1 090 MHz.

2. The ADS-B Rebroadcast Service complements the operation of ADS-B and the Fundamental TIS-B Service (see the TIS-B MASPS, RTCA/DO-286B, §1.4.1) 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-B Rebroadcast 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-B Rebroadcast ground-to-air transmissions use the same signal formats as the DF = 17 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.

C.4.2 ADS-B REBROADCAST FORMAT DEFINITION

ADS-B Rebroadcast information is transmitted using the 112-bit Mode S DF = 18 format specified in Figure C-11.

C.4.3 CONTROL FIELD ALLOCATION

The content of the DF = 18 transmission is defined by the value of the Control Field (CF). As specified in Table C-37, ADS-B Rebroadcasts (i.e. ADS-R) transmissions shall use CF = 6 and ADS-R Management information transmissions (i.e. defining ADS-R Service Volume and service availability) shall use CF = 4.

C.4.4 ADS-B REBROADCAST SURVEILLANCE MESSAGE DEFINITIONS

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 Figures C-1 through C-10, 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 was previously discussed in §C.3.4.1.1 for the TIS-B transmissions.

The insertion of this one bit into the ADS-B Messages identified below allows the ADS-B Receiving Subsystem to interpret the Address Field (AF) in the following manner:

IMF = 0 indicates that the ADS-B Rebroadcast data is identified by an ICAO 24-bit Address

IMF = 1 indicates that the ADS-B Rebroadcast data is identified by an anonymous 24-bit Address

C.4.4.1 REBROADCAST OF ADS-B AIRBORNE POSITION MESSAGES

The ADS-B Receiving Subsystem receives, decodes and processes the "ME" Field of the ADS-R Airborne Position Messages, and updates and maintains ADS-R reports with the decoded data in accordance with §C.3.5. The format is identical to the Airborne Position Message specified in section §C.2.3.2 and Figure C-1, except that "ME" bit 8 is redefined to be the ICAO/Mode A Flag (IMF).

C.4.4.2 ADS-R SURFACE POSITION MESSAGE

The ADS-B Receiving Subsystem receives, decodes and processes the "ME" Field of the ADS-R Surface Position Messages, and updates and maintains ADS-R reports with the decoded data in accordance with §C.3.5. The format is identical to the ADS-B Surface Position Message specified in section §C.2.3.3 and Figure C-2, except that "ME" bit 21 is redefined to be the ICAO/Mode A Flag (IMF).

C.4.4.3 ADS-R AIRCRAFT IDENTIFICATION AND CATEGORY MESSAGE

The ADS-B Receiving Subsystem receives, decodes and processes the "ME" Field of the ADS-R Aircraft Identification and Category Messages, and updates and maintains ADS-R reports with the decoded data in accordance with §C.3.5. The format is as specified in section §C.2.3.4 and Figure C-4.

Note.— Any 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.

C.4.4.4 ADS-R AIRBORNE VELOCITY MESSAGE

The ADS-B Receiving Subsystem receives, decodes and processes the "ME" Field of the ADS-R Airborne Velocity Messages, and updates and maintains ADS-R reports with the decoded data in accordance with §C.3.5. The formats are identical to the ADS-B Airborne Velocity Messages specified in section §C.2.3.5.1 and Figure C-5 for Subtype 1 and 2 Messages, and in section §C.2.3.5.2 and Figure C-6 for Subtype 3 and 4 Messages, except that "ME" bit 9 is redefined to be the ICAO/Mode A Flag (IMF).

Note.— Bit 10 of the "ME" field in ADS-B Version One (1) is the IFR Capability Flag which is not conveyed in ADS-B Version Two (2) ADS-B Transmitting Subsystems.

C.4.4.5 ADS-R EXTENDED SQUITTER AIRCRAFT STATUS MESSAGE

The ADS-B Receiving Subsystem receives, decodes and processes the "ME" Field of the ADS-R Extended Squitter Aircraft Status Messages, and updates and maintains ADS-R reports with the decoded data in accordance with §C.3.5. The format is identical to the Aircraft Emergency/Priority Status Message specified in section §C.2.3.7.3 and Figure C-8a, except that "ME" bit 56 is redefined to be the ICAO/Mode A Flag (IMF).

C.4.4.6 ADS-R TARGET STATE AND STATUS MESSAGE

The ADS-B Receiving Subsystem receives, decodes and processes the "ME" Field of the Rebroadcast Target State and Status Messages, and updates and maintains ADS-R reports with the decoded data in accordance with §C.3.5. The format is identical to the ADS-B Target State and Status Message (Subtype = 1) in section §C.2.3.9 and Figure C-9, except that "ME" bit 51 is redefined to be the ICAO/Mode A Flag (IMF).

C.4.4.7 ADS-R Aircraft Operational Status Message

The ADS-B Receiving Subsystem receives, decodes and processes the "ME" Field of the Rebroadcast Aircraft Operational Status Messages, and updates and maintains ADS-R reports with the decoded data in accordance with §C.3.5. The format is identical to the ADS-B Aircraft Operational Status Message specified in section §C.2.3.10 and Figure C-10, except that "ME" bit 56 is redefined to be the ICAO/Mode A Flag (IMF) and bit 20 of the Capability Class Code conveys the NIC Supplement-B.

C.4.5 ADS-R REPORT PROCESSING

ADS-R reports are to be maintained and output for DF = 18, with CF = 6 ADS-R Messages. ADS-R reports are to be provided for both ADS-B Version ONE (1) and Version TWO (2) formatted ADS-R Messages in accordance with the message formats provided in §C.4.

C.5 PROVISIONS FOR BACKWARD COMPATIBILITY WITH VERSION 0 AND VERSION 1 ADS-B SYSTEMS

C.5.1 INTRODUCTION

C.5.1.1 Purpose of this Section

This section defines:

a) the formats and coding for Extended Squitter ADS-B Messages that are broadcast by ADS-B Version Zero (0), RTCA DO-260/EUROCAE ED-102 conformant 1 090 MHz ADS-B Subsystems;

b) the formats and coding for extended squitter ADS-B Messages that are broadcast by ADS-B Version One (1), RTCA DO-260A conformant 1 090 MHz ADS-B Subsystems;

c) how the ADS-B report generation function of ADS-B Version Two (2) 1 090 MHz ADS-B Receiving Subsystems is to utilize messages received from targets that are broadcasting with either ADS-B Version Zero (0) or ADS-B Version One (1) message formats.

C.5.1.2 Message Version Number

The ADS-B Version Number for all 1 090 MHz ADS-B Messages originating for each specific ADS-B target shall be determined from the decoding of the ADS-B Version Number subfield of the Aircraft Operational Status Message. An ADS-B Version Two (2) Receiving Subsystem shall initially assume that the messages conform to ADS-B Version Zero (0) message formats, until or unless, a received ADS-B Version Number data indicates otherwise. The ADS-B Version Number shall be retained and associated with all messages from that specific target. This ADS-B Version Number shall be used for determining the applicable message formats to be applied for the decoding of all 1 090 MHz ADS-B Messages received from that target.

C.5.2 1 090 MHZ ADS-B VERSION ZERO (0) MESSAGE PROCESSING

C.5.2.1 ADS-B VERSION ZERO (0) MESSAGE TYPES

Table C-39 specifies those ADS-B Version Zero (0) (i.e. originating from a 1 090 MHz ADS-B Transmitting Subsystem conformant to the requirements of Appendix A) 1 090 MHz ADS-B Messages that shall be used for ADS-B report generation by an ADS-B Version Two (2) conformant 1 090 MHz ADS-B Receiving Subsystem.

Note.— Table C-39 lists only those ADS-B Version Zero (0) 1 090 MHz ADS-B Message types that are required to be received and used for ADS-B report generation by an ADS-B Version Two (2) 1 090 MHz ADS-B Receiving Subsystems. The other ADS-B Version Zero (0) ADS-B Message Types defined in Appendix A, including Messages Types 29 and 30, are not to be used by ADS-B Version Two (2) ADS-B Receiving Subsystems for the purpose of ADS-B report generation.

Table C-39. Version Zero (0) ADS-B Message Types

Message Format TYPE Code(s)	*Assignment*	*Nominal Broadcast Rate*
1 through 4	Extended Squitter Identification and Category	5.0 s airborne/10.0 s surface
5 through 8	Extended Squitter Surface Position	0.5 s in motion/5.0 s stationary
9 through 18 and 20 through 22	Extended Squitter Airborne Position	0.5 s
19	Extended Squitter Airborne Velocity	0.5 s
28	Extended Squitter Aircraft Status (e.g. emergency/priority)	1.0 s
31	Aircraft Operational Status	1.7 s

C.5.2.1.1 MESSAGE TYPE CODES

The first 5-bit field in every 1 090 MHz ADS-B Message shall contain the message format TYPE. As shown in Table C-40, the TYPE Code (i.e. format type) shall be used to differentiate the ADS-B Messages into several classes: airborne position, airborne velocity, surface position, identification, aircraft status, etc.

Notes:

1. The general definition for all ADS-B Message Types used for ADS-B Version Zero (0) ADS-B Messages has been retained for ADS-B Version One (1) and ADS-B Version Two (2) Messages. It must be noted for ADS-B Version Zero (0) ADS-B Messages, format TYPE Code 29 was defined, but the corresponding messages are not to be transmitted. For ADS-B Version Zero (0) ADS-B Subsystems, TYPE Code 29 was associated with intent messages conveying Trajectory Change Point (TCP) information. Although the message formats for TCP-related messages were defined within Appendix A, the requirements and the associated test procedures prohibited the broadcast of such messages.

2. Appendix A defined TYPE Code 30 for Aircraft Operational Coordination Messages. The requirements and associated provisions for Aircraft Operational Coordination Messages have now been withdrawn in this edition. Although Appendix A (i.e. Version Zero) conformant implementations are not prohibited from transmitting Aircraft Operational Coordination Messages (i.e. using TYPE Code 30), ADS-B Version Two (2) conformant ADS-B Receiving Subsystems have no requirement for the reception and processing of these broadcasts.

ADS-B Version Two (2) ADS-B Receiving Subsystems shall process ADS-B Messages based only on the reception of ADS-B Version Zero (0) ADS-B Messages with ADS-B Message TYPE Code values of 0 through 22, 28 and 31.

C.5.2.2 VERSION TWO (2) ADS-B REPORTS USING VERSION ZERO (0) MESSAGES

Notes:

1. The following subparagraphs summarize the ADS-B report requirements for ADS-B Version Two (2) systems when receiving ADS-B Version Zero (0) ADS-B Messages with ADS-B Message TYPE Code values of 0 through 22, 28 and 31.

2. The ADS-B reports of ADS-B Version 2, received from an ADS-B Version Zero transmitting subsystem, are composed primarily from the information received from airborne aircraft through Airborne Position Messages and Airborne Velocity Messages, or from aircraft/vehicles on the airport surface through Surface Position Messages. Many of the parameters contained within these messages are encoded the same, and occupy the same bit positions within the overall message structure, for both ADS-B Version Zero (0) and for ADS-B Version Two (2) messages. However, in a few cases the decoding process must be handled differently for ADS-B Version Zero (0) messages as compared to that required by this manual for ADS-B Version Two (2) messages. The following subparagraphs describe the required use of ADS-B Version Zero (0) message data for ADS-B reports by an ADS-B Version Two (2) compliant ADS-B Receiving Subsystem.

C.5.2.2.1 ADS-B REPORT TO 1 090 MHZ ADS-B MESSAGE MAPPING

Notes:

1. There are some minor differences in the specific names applied to certain otherwise identical ADS-B Version Zero (0) versus ADS-B Version Two (2) message subfields. For example, a changed ADS-B report parameter between Version Zero (0) described in Appendix A, and Version One (1) described in Appendix B, and Version Two (2) described in this Appendix, is the Navigation Integrity Category (NIC) parameter, which replaced the Navigation Uncertainty Category (NUC) from ADS-B Version Zero (0). The following subparagraphs discuss the NIC parameter and its mapping from ADS-B Version Zero (0) messages to the Version Two (2) ADS-B report. Additional differences in ADS-B Version Zero (0) and Version Two (2) are also described below.

2. The formats of the ADS-B Version Zero (0) 1 090 MHz ADS-B Messages are specified in Tables A-2-5 through A-2-10, Table A-2-97 and Table A-2-101.

Table C-40. Format TYPE Codes for Version 0 and Version 2 Messages

TYPE Code	*Version Zero (0) Message Format*	*Version Two (2) Message Format*
0	No Position Information	No Position Information
1	Identification (Category Set D)	Identification (Category Set D)
2	Identification (Category Set C)	Identification (Category Set C)
3	Identification (Category Set B)	Identification (Category Set B)
4	Identification (Category Set A)	Identification (Category Set A)
5	Surface Position	Surface Position
6	Surface Position	Surface Position
7	Surface Position	Surface Position
8	Surface Position	Surface Position
9	Airborne Position	Airborne Position
10	Airborne Position	Airborne Position
11	Airborne Position	Airborne Position
12	Airborne Position	Airborne Position
13	Airborne Position	Airborne Position
14	Airborne Position	Airborne Position
15	Airborne Position	Airborne Position
16	Airborne Position	Airborne Position
17	Airborne Position	Airborne Position
18	Airborne Position	Airborne Position
19	Airborne Velocity	Airborne Velocity
20	Airborne Position	Airborne Position
21	Airborne Position	Airborne Position
22	Airborne Position	Airborne Position
23	Reserved for Test Purposes	Test Message
24	Reserved for Surface System Status	Surface System Status
25	Reserved	Reserved
26	Reserved	Reserved
27	Reserved	Reserved for Trajectory Change
28	Extended Squitter Aircraft Status	Extended Squitter Aircraft Status
29	Reserved for Trajectory Intent	Target State and Status
30	Operational Coordination	Reserved
31	Operational Status	Operational Status

C.5.2.2.2 NAVIGATION INTEGRITY CATEGORY (NIC)

Note.— The ADS-B Version Zero (0) Surface and Airborne Position Messages have associated with each specific TYPE Code a corresponding Horizontal Protection Limit and a 95 per cent Containment Radius (R_C). For the purpose of generating an ADS-B report, ADS-B Version Zero mapped these message parameters to a Navigation Uncertainty Category (NUC). As defined by Table C-2, ADS-B Version Two (2) Surface and Airborne Position Messages associate the ADS-B Message TYPE Code with the parameters of Horizontal Containment Limit (R_C) and Navigation Integrity Category (NIC). Although ADS-B Version Zero (0) ADS-B Messages were not defined in Appendix A to directly include a value for NIC, the values defined by Table C-2 for R_C and NIC have been selected such that it is possible to map the TYPE Code values from ADS-B Version Zero (0) ADS-B Message to a corresponding value for NIC.

The Surface and Airborne Position Message TYPE Codes associated with ADS-B Version Zero (0) 1 090 MHz ADS-B Messages shall be mapped to the NIC values shown in Table C-41 for the purpose of generating ADS-B Version Two (2) ADS-B reports.

Table C-41. Version Zero (0) Format Type Code Mapping to Navigation Source Characteristics

"TYPE" Subfield Code Definitions (DF = 17 or 18)				
TYPE Code	*Format*	*Horizontal Protection Limit, HPL (R_C)*	*Altitude Type*	*Reported NIC*
0	No Position Information		Baro Altitude or No Altitude Information	0
5	Surface Position	HPL < 7.5 m	No Altitude Information	11
6	Surface Position	HPL < 25 m	No Altitude Information	10
7	Surface Position	HPL < 185.2 m (0.1 NM)	No Altitude Information	8
8	Surface Position	HPL > 185.2 m (0.1 NM)	No Altitude Information	0
9	Airborne Position	HPL < 7.5 m	Baro Altitude	11
10	Airborne Position	7.5 m < HPL < 25 m	Baro Altitude	10
11	Airborne Position	25 m < HPL < 185.2 m (0.1 NM)	Baro Altitude	8
12	Airborne Position	185.2 m (0.1 NM) < HPL < 370.4 m (0.2 NM)	Baro Altitude	7
13	Airborne Position	380.4 m (0.2 NM) < HPL < 926 m (0.5 NM)	Baro Altitude	6
14	Airborne Position	926 m (0.5 NM) < HPL < 1 852 m (1.0 NM)	Baro Altitude	5
15	Airborne Position	1 852 m (1.0 NM) < HPL < 3 704 m (2.0 NM)	Baro Altitude	4
16	Airborne Position	7.704 km (2.0 NM) < HPL < 18.52 km (10 NM)	Baro Altitude	1
17	Airborne Position	18.52 km (10 NM) < HPL < 37.04 km (20 NM)	Baro Altitude	1
18	Airborne Position	HPL > 37.04 km (20 NM)	Baro Altitude	0
20	Airborne Position	HPL < 7.5 m	GNSS Height (HAE)	11
21	Airborne Position	HPL < 25 m	GNSS Height (HAE)	10
22	Airborne Position	HPL > 25 m	GNSS Height (HAE)	0

Notes:

1. "Baro altitude" refers to barometric pressure altitude, relative to a standard pressure of 1 013.25 millibars (29.92 in Hg). It does not refer to baro-corrected altitude.

2. The GNSS height (HAE) defined in Type Codes 20 to 22 is used when baro altitude is not available.

3. The radius of containment (R_C), is derived from ARINC 429 label 130, which is variously called HIL (Horizontal Integrity Limit) or HPL (Horizontal Protection Level).

C.5.2.2.3 MOVEMENT

Notes:

1. The quantization in the Movement subfield conveyed in Version Two (2) Surface Position Messages is different than the Movement subfield contained in Version Zero (0). The encoding of the Version Zero (0) Movement subfield is contained in §A.2.3.3.1.

2. ADS-B Applications must use the version number to properly decode the Movement subfield.

C.5.2.2.4 ADS-B VERSION NUMBER

Note.— The format of the Aircraft Operational Status Message substantially differs between the ADS-B Version Zero (0) ADS-B Message format shown in Figure A-2-101 and the ADS-B Version Two (2) ADS-B Message format specified in §C.2.3.10 of this manual. The ADS-B Version Two (2) Aircraft Operational Status Message format includes an explicit ADS-B Version Number subfield (ME bits 41-43). For an ADS-B Version Zero (0) ADS-B Aircraft Operational Status Message, these same bits were reserved and were expected to be set to a value of ZERO (0).

An ADS-B Version Two (2) Receiving Subsystem shall, as a default, assume the received messages are using ADS-B Version Zero (0) ADS-B Message format unless, or until, an Aircraft Operational Status Message is received and the ADS-B Version Number is confirmed to be other than Zero (0). In the case of an ADS-B Version Two (2) ADS-B Subsystem's reception of an Aircraft Operational Status Message, the ADS-B Receiving Subsystem shall decode "ME" bits 41-43 and determine whether the target aircraft is broadcasting messages that are ADS-B Version Zero (0), or Version One (1), or Version Two (2), and then decode the remainder of the message in accordance with the message format applicable to that ADS-B Version Number.

Note.— The ADS-B Version Number determined from the decoding of the ADS-B Version Number subfield of the Aircraft Operational Status Message must be retained and associated with the specific target since it is used in determining the applicable formats to be used for the decoding of the other message types.

C.5.2.2.5 EMITTER CATEGORY

The ADS-B Report Assembly Function shall extract "TYPE" and "ADS-B Emitter Category" from the Aircraft Identification and Category Message (Table A-2-8) and encode the "Emitter Category" field. The Emitter Category conveyed in the Aircraft Identification and Category Message shall be mapped into the ADS-B report, Emitter Category field as specified by Table A-2-8.

Note.—In the ADS-B Version Zero (0) Aircraft Identification and Category Message, the Emitter Category subfield conveys a subset of the Emitter Categories allowed by the ADS-B report.

C.5.2.2.6 A/V LENGTH AND WIDTH CODE

The A/V Length and Width Code is not conveyed by ADS-B Version Zero (0) 1 090 MHz ADS-B Messages. This parameter is only included in the ADS-B report when reporting on an aircraft or vehicle that is on the airport surface. When no A/V Length and Width Code is available, as is the case for target A/Vs that are broadcasting ADS-B Version Zero (0) ADS-B Messages, the A/V Length and Width Code parameter shall not be included in the ADS-B report.

C.5.2.2.7 EMERGENCY/PRIORITY STATUS

The Emergency/Priority Status conveyed in the Aircraft Status Message (Table A-2-97) shall be directly mapped into the ADS-B report, Emergency/Priority Status field as specified in §C.2.3.7.3.

Note.— In the ADS-B Version Zero (0) Aircraft Extended Squitter Status Message, the Emergency/Priority Status subfield conveys a subset of the Emergency/Priority Status categories allowed by an ADS-B report.

C.5.2.2.8 CAPABILITY CODES

The ADS-B Version Zero (0) Operational Status Message (Table A-2-101) conveys Control Codes with information limited to TCAS/ACAS and CDTI capabilities, as shown in Table C-42. The ADS-B Version Zero (0) Aircraft Operational Status Message format specifies coding only for the case of CC-4 (En Route Operational Capabilities). Therefore the CC-1, CC-2 and CC-3 subfields, as specified in Table A-2-101, shall be considered reserved and not used for ADS-B Version Zero (0) ADS-B Messages.

For the case of CC-4, this 4-bit (bits 9-12) subfield shall be mapped to the Capability Code field of the ADS-B report as shown in Table C-42. The remaining bits within the ADS-B Report Capability Code field shall be set to Zero (0). If no Aircraft Operational Status Message has been received, then the Capability Code field shall be omitted from the ADS-B report.

Table C-42. En-Route Operational Capabilities Encoding

CC-4 Encoding: En-Route Operational Capabilities			
CC-4 Coding (Version Zero (0) Messages)		*Meaning (Version Zero (0) Messages)*	*Mapping to ADS-B Report Capability Code field*
Bits 9,10	*Bits 11,12*		*CC Field Bits 11, 12*
0 0	0 0	TCAS/ACAS Operational or unknown; CDTI not Operational or unknown	10
	0 1	TCAS/ACAS Operational or unknown; CDTI Operational	11
	1 0	TCAS/ACAS not Operational; CDTI not Operational or unknown	00
	1 1	TCAS/ACAS not Operational; CDTI Operational	01

C.5.2.2.9 OPERATIONAL MODES

ADS-B Version Zero (0) messages conformant to formats in Appendix A do not define coding for the Operational Mode subfield of the Operational Status Message (Table A-2-101). Therefore the OM-1, OM-2, OM-3 and OM-4 subfields, as shown in Table A-2-101, shall be considered reserved and not used for ADS-B Version Zero (0) Messages. ADS-B reports for target aircraft/vehicles broadcasting ADS-B Version Zero (0) ADS-B Messages shall not include the Operational Mode field in the report.

C.5.2.2.10 NAVIGATION ACCURACY CATEGORY FOR POSITION (NAC_P)

The ADS-B Version Zero (0) ADS-B Surface and Airborne Position Messages have associated with each specific TYPE code a corresponding Horizontal Protection Limit and a 95 per cent Containment Radius (i.e. position error). For an ADS-B Version Two (2) Receiving Subsystem, the TYPE codes of the received ADS-B Version Zero (0) Messages shall be mapped into the value of the Navigation Accuracy Category for Position (NAC_P) as shown in Table C-43 for the purpose of generating the ADS-B report.

Table C-43. Type Code to NAC_P Mapping

Version 0 Message TYPE CODE	*Message Format*	*Position Error (95%)*	*ADS-B Report NAC_P value*
0	No Position Information	Unknown	0
5	Surface Position	<3 m	11
6	Surface Position	<10 m	10
7	Surface Position	<0.05 NM	8
8	Surface Position	>0.05 NM	0
9	Airborne Position	<3 m	11
10	Airborne Position	<10 m	10
11	Airborne Position	<0.05 NM	8
12	Airborne Position	<0.1 NM	7
13	Airborne Position	<0.25 NM	6
14	Airborne Position	<0.5 NM	5
15	Airborne Position	<1 NM	4
16	Airborne Position	<5 NM	1
17	Airborne Position	<10 NM	1
18	Airborne Position	>10 NM	0
20	Airborne Position	<4 m	11
21	Airborne Position	<15 m	10
22	Airborne Position	>15 m	0

Note.— The Position Error column of the table indicates the greater of the horizontal or vertical 95 per cent containment radius as listed in Table C-41 for ADS-B Version Zero (0) messages.

C.5.2.2.11 NAVIGATION ACCURACY CATEGORY FOR VELOCITY (NAC_V)

The ADS-B Version Zero (0) Airborne Velocity Message includes a subfield that conveys the Navigation Uncertainty Category for Velocity (NUC_R) (see Tables A-2-9a and A-2-9b). The received value of NUC_R shall be mapped directly one-for-one to the Navigation Accuracy Category for Velocity (NAC_V) field of an ADS-B report.

C.5.2.2.12 SOURCE INTEGRITY LEVEL (SIL)

The Source Integrity Level (SIL) defines the probability of the integrity containment region described by the NIC parameter being exceeded for the selected geometric position source, including any external signals used by the source. The value of SIL can only be inferred from the information conveyed in ADS-B Version Zero (0) Messages. Table C-44 shall be used to provide the mapping between the message TYPE Code for an ADS-B Version Zero (0) Transmitting Subsystem and the value of SIL to be reported by an ADS-B Version Two (2) Receiving Subsystem within the ADS-B report.

Table C-44. SIL Reporting

Version 0 Message TYPE CODE	*Message Format*	*Probability of Exceeding the Horizontal Containment Radius (R_C)*	*ADS-B Report SIL value*
0	No Position Information	No Integrity	0
5	Surface Position	1×10^{-5} per flight hour or per sample	2
6	Surface Position	1×10^{-5} per flight hour or per sample	2
7	Surface Position	1×10^{-5} per flight hour or per sample	2
8	Surface Position	1×10^{-5} per flight hour or per sample	2
9	Airborne Position	1×10^{-5} per flight hour or per sample	2
10	Airborne Position	1×10^{-5} per flight hour or per sample	2
11	Airborne Position	1×10^{-5} per flight hour or per sample	2
12	Airborne Position	1×10^{-5} per flight hour or per sample	2
13	Airborne Position	1×10^{-5} per flight hour or per sample	2
14	Airborne Position	1×10^{-5} per flight hour or per sample	2
15	Airborne Position	1×10^{-5} per flight hour or per sample	2
16	Airborne Position	1×10^{-5} per flight hour or per sample	2
17	Airborne Position	1×10^{-5} per flight hour or per sample	2
18	Airborne Position	No Integrity	0
20	Airborne Position	1×10^{-5} per flight hour or per sample	2
21	Airborne Position	1×10^{-5} per flight hour or per sample	2
22	Airborne Position	No Integrity	0

C.5.2.2.13 Barometric Altitude Integrity Code (NIC_{BARO})

The Barometric Altitude Integrity Code (NIC_{BARO}) parameter of the ADS-B report is a 1-bit flag used to indicate whether the barometric altitude being reported in the ADS-B report has been cross-checked against another source of pressure altitude. The ADS-B Version Zero (0) Messages do not include information related to the cross-checking of barometric altitude. Therefore, ADS-B reports for target aircraft/vehicles broadcasting ADS-B Version Zero (0) Messages shall not include the NIC_{BARO} field in the report.

C.5.2.2.14 Track/Heading and Horizontal Reference Direction (HRD)

ADS-B Version Zero (0) Airborne Velocity Messages with Subtype equal to 3 or 4 include a “Magnetic Heading Status Bit” as shown in Table A-2-9b. A Version Two (2) 1 090 MHz ADS-B Receiving Subsystem, upon receiving an Airborne Velocity Message with a Subtype of 3 or 4, must decode the Magnetic Heading Status Bit to determine whether Magnetic Heading Data is “Available.” The ADS-B Receiving Subsystem shall set the value of the True/Magnetic Heading subfield, as specified in Table C-45.

Table C-45. Track/Heading and HRD Subfield

Version 0 Airborne Velocity Message SUBTYPE	*Airborne Velocity Message “Magnetic Heading Status Bit”*	*Surface Position Message “Ground Track Status Bit”*	*Meaning*	*ADS-B Report True/Magnetic Heading subfield encoding*
N/A	N/A	0	No Valid Track/ Heading or Heading Direction Reference information available	00
1 or 2	N/A	1	Ground Track being reported	01
3 or 4	0	N/A	Heading relative to true north being reported	00
3 or 4	1	N/A	Heading relative to magnetic north being reported	11

Notes:

1. When no valid data is available, the “Track/Heading and HRD” parameter may be reported as ALL ZEROs.

2. When receiving ADS-B Version Two (2) Messages, the Track/Heading and HRD information are conveyed within the Operation Status Message. However, when receiving ADS-B Version Zero (0) Messages, the equivalent information can be determined for airborne aircraft from the value of the “Subtype” subfield, and for Subtype = 3 or 4 messages, from the value of the “Magnetic Heading Status Bit” of the Airborne Velocity Message (Table A-2-9b). When a target aircraft/vehicle is on the surface, a value of 01 should be reported when a Surface Position Message (Table A-2-6) is received with the “Heading/Ground Track Status Bit” set to a value of ONE (1) indicating that the valid ground track data is provided.

3. ADS-B Version Zero (0) Airborne Velocity Messages, Subtypes 3 and 4, always report Heading relative to magnetic north, never relative to true north.

C.5.2.3 AIR REFERENCED VELOCITY REPORTS

The requirements for Air Referenced Velocity (ARV) reports shall apply to the ARV Report Assembly requirements when the target aircraft is broadcasting either ADS-B Version Zero (0) or Version Two (2) Message formats (Table A-2-9b).

C.5.2.4 TARGET STATUS REPORTS

Appendix A defines a message format using message TYPE Code 29 to convey Aircraft Trajectory Intent information in the form of Trajectory Change Point (TCP) information. A 1 090 MHz ADS-B Receiving Subsystem conforming to this manual shall not use any message with a TYPE Code of 29 that is received from an ADS-B Version Zero (0) Transmitting Subsystem for the purpose of report generation.

Note.— Prior to generation of a Target Status Report, the 1 090 MHz ADS-B Receiving Subsystem must positively confirm that any received message with a TYPE Code of 29 has originated from a target aircraft with an ADS-B Version Number other than Zero (0). The ADS-B Version Number can be determined from the contents of the ADS-B Version Number subfield (see §C.2.3.10.5) of the Aircraft Operational Status Message.

C.5.3 1 090 MHZ ADS-B VERSION 1 MESSAGE PROCESSING

C.5.3.1 ADS-B VERSION ONE (1) MESSAGE TYPES

Note.— ADS-B Version One (1) (i.e. 1 090 MHz ADS-B Transmitting Subsystem conformant to Appendix B) 1 090 MHz ADS-B Messages are the same basic message types as ADS-B Version Two (2). Some messages have different formats and contain additional or eliminated message subfields.

*For example, the Target State and Status Message changed between ADS-B Version One (1) to ADS-B Version Two (2). ADS-B Version One (1) Transmitting Subsystems use Subtype Zero (0) for the Target State and Status Message, and ADS-B Version Two (2) Transmitting Subsystems use Subtype One (1) to maintain backward compatibility. ADS-B Version Two (2) Receiving Subsystems do not generate ADS-B reports from ADS-B Version One (1) Target State and Status Messages, but utilize the accuracy and integrity parameters in the Message. See Appendix B for ADS-B Version One (1) Message formats. ADS-B Version One (1) Transmitting Subsystems do not broadcast the Extended Squitter Aircraft Status Message (Subtype 2), the 1 090 ES TCAS/*ACAS *Resolution Advisory (RA) Message.*

C.5.3.1.1 MESSAGE TYPE CODES

The first 5-bit field in every 1 090 MHz ADS-B Message contains the message format TYPE. The TYPE Code (i.e. format type) shall be used to differentiate the messages into several classes: airborne position, airborne velocity, surface position, identification, aircraft status, etc. The general definition for all ADS-B Message Types used for ADS-B Version One (1) Messages has been retained for ADS-B Version Two (2) Messages.

C.5.3.2 VERSION TWO (2) ADS-B REPORTS GENERATED USING VERSION ONE (1) MESSAGES

Note.— The following subparagraphs summarize the ADS-B report generation requirements for ADS-B Version Two (2) systems when receiving ADS-B Version One (1) ADS-B Messages.

The contents of ADS-B reports are composed primarily from the information received from airborne aircraft in Airborne Position Messages and Airborne Velocity Messages or from aircraft/vehicles on the airport surface in Surface Position

Messages. Many of the parameters contained within these messages are encoded the same, and occupy the same positions with the overall message structure, for both ADS-B Version One (1) and for ADS-B Version Two (2) Messages. However, in a few cases the decoding and/or report assembly processing must be handled differently for ADS-B Version One (1) Messages as compared to that required by this manual for ADS-B Version Two (2) Messages. The following subparagraphs describe the required use of ADS-B Version One (1) Messages for ADS-B report generation by an ADS-B Version Two (2) compliant ADS-B Receiving Subsystem.

C.5.3.2.1 NAVIGATION INTEGRITY CATEGORY (NIC)

As defined by Table C-2, ADS-B Version Two (2) Surface and Airborne Position Messages have associated with each specific ADS-B Message TYPE Code a corresponding Horizontal Containment Limit (R_C) and Navigation Integrity Category (NIC). The TYPE Code is used along with the NIC Supplement-A in the Operational Status Message to decode the NIC. The Surface and Airborne Position Message TYPE Codes associated with ADS-B Version One (1) 1 090 MHz ADS-B Messages along with the NIC Supplement-A shall be used to map to the NIC values shown in Table B-2 for the purpose of generating ADS-B reports.

C.5.3.2.2 MOVEMENT

Notes:

1. The quantization in the Movement subfield conveyed in Version Two (2) Surface Position Messages is different than the Movement subfield contained in Version One (1). The encoding of the Version One (1) Movement subfield is the same as that contained in Version Zero (0) and is defined in §A.2.3.3.1.

2. ADS-B Applications must use the version number to properly decode the Movement subfield.

C.5.3.2.3 ADS-B VERSION NUMBER

Note.— The format of the Aircraft Operational Status Message differs between the ADS-B Version One (1) Message format shown in Table B-2-101 and the ADS-B Version Two (2) Message format specified in §C.2.3.10 of this manual. There are additional parameters in ADS-B Version Two (2) Aircraft Operational Status Messages that are not contained in ADS-B Version One (1) Messages.

An ADS-B Version Two (2) Receiving Subsystem shall, as a default, assume that the received messages are using an ADS-B Version Zero (0) Message format unless, or until, an Aircraft Operational Status Message is received, and the ADS-B Version Number is confirmed to be other than Zero (0). In the case of an ADS-B Version Two (2) Subsystem's reception of an Aircraft Operational Status Message, the ADS-B Receiving Subsystem shall decode "ME" bits 41-43 and determine whether the target aircraft is broadcasting messages that are ADS-B Version Zero (0), Version One (1), or Version Two (2), or higher, and then decode the remainder of the message in accordance with the message format applicable to that ADS-B Version Number.

Note.— The ADS-B Version Number determined from the decoding of the Version Number subfield of the Aircraft Operational Status message must be retained and associated with the specific target since it is used in determining the applicable formats to be used for the decoding of the other message types.

C.5.3.2.4 EMITTER CATEGORY

The ADS-B Report Assembly Function shall extract "TYPE" and "ADS-B Emitter Category" from the Aircraft Identification and Category Message (Table A-2-8) and encode the "Emitter Category" field. The Emitter Category conveyed in the

Aircraft Identification and Category Message shall be mapped into the ADS-B report, Emitter Category field as specified by Table A-2-8.

Note.— In the ADS-B Version One (1) Aircraft Identification and Category Message, the Emitter Category subfield conveys a subset of the Emitter Categories allowed by the ADS-B report.

C.5.3.2.5 A/V LENGTH AND WIDTH CODE

This parameter shall be included in the ADS-B report when reporting on an aircraft or vehicle that is on the airport surface using the coding specified in Table C-46. When no A/V Length and Width Code is available, the A/V Length and Width Code parameter shall not be included in the ADS-B report.

Table C-46. Version One (1) "Aircraft/Vehicle Length and Width Code" Decoding

	Length Code			*Width Code*	*Upper-Bound Length and Width for Each Length/Width Code*	
A/V – L/W Code (Decimal)	*ME Bit 21*	*ME Bit 22*	*ME Bit 23*	*ME Bit 24*	*Length (metres)*	*Width (metres)*
0	0	0	0	0	No Data or Unknown	
1	0	0	0	1	15	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

Note.— In Appendix B, encoding of decimal ZERO (0) A/V Length/Width Code was specified as Length = 15 metres and Width = 11.5 metres. However, there may be ADS-B Transmitting Subsystems implemented that are consistent with the interpretation of the ICAO SARPs of defining an ALL ZERO condition to be interpreted as "No Data or Unknown." Version TWO (2) ADS-B reports based on receiving an ALL ZERO A/V Length/Width Code from a Version One (1) Transmitting Subsystem will be reported as "Unknown."

C.5.3.2.6 EMERGENCY/PRIORITY STATUS

The Emergency/Priority Status conveyed in the Aircraft Status Message (Table B-2-101) and the Target State and Status Message (Table B-2-98) shall be directly mapped into the ADS-B report, Emergency/Priority Status field.

C.5.3.2.7 CAPABILITY CODES

The ADS-B report Assembly Function shall extract the "Capability Class Codes" data from Aircraft Operational Status Messages and the Target State and Status Messages and provide the Capability Class Codes to the user application in the ADS-B report.

When valid "Capability Class" data is not available for a given parameter, then the Capability Class data sent to the user application for that parameter shall be set to ALL ZEROs.

When an ADS-B report is generated, and when the only received update to the "Capability Class" data has come from a Target State and Status Message, the reported value of all Capability Class parameters shall be based on the most recently received Operational Status Message, except updated with the data (i.e. TCAS/ACAS parameter) received in the subsequent Target State and Status Message.

C.5.3.2.8 SOURCE INTEGRITY LEVEL (SIL)

The Source Integrity Level (SIL) defines the probability of the integrity containment region described by the NIC parameter as being exceed for the selected geometric position source, including any external signals used by the source. In ADS-B Version One (1), the Surveillance Integrity Level parameter represented this probability as well as other elements of integrity. The Surveillance Integrity Level may have also included the reliability of the aircraft systems given by a failure rate corresponding to the equipment design assurance. In ADS-B Version Two (2), this aspect of integrity is represented by the System Design Assurance (SDA) parameter. The ADS-B Report Assembly Function shall extract the Surveillance Integrity Level data from Aircraft Operational Status Messages and the Target State and Status Messages and provide the Source Integrity Level to the user application in the Mode Status Report in the binary format.

Note.— Applications using reports from ADS-B Version One (1) participants may be able to use the Surveillance Integrity Level to derive both Source Integrity Level and System Design Assurance (SDA).

C.5.3.2.9 TRACK/HEADING AND HORIZONTAL REFERENCE DIRECTION (HRD)

The ADS-B Report Assembly Function shall extract the Track Angle/Heading (see §C.2.3.10.12) and the Horizontal Reference Direction (HRD) (see §C.2.3.10.13) flag bits from the Aircraft Operational Status Message (see §C.2.3.10) and set the True/Magnetic Heading field in the ADS-B report. This item within the ADS-B report is used to indicate the nature of the Horizontal Direction information being reported in the ADS-B reports and Target State Reports. This applies to the aircraft reported Horizontal Direction (in the ADS-B report).

C.5.3.2.10 AIR REFERENCED VELOCITY REPORTS

The requirements for Air Referenced Velocity (ARV) Reports shall apply to the ARV Report Assembly requirements when the target aircraft is broadcasting either ADS-B Version One (1) or Version Two (2) Message formats (Table A-2-9b).

C.5.3.2.11 TARGET STATE REPORTS

Note.— Since the content and use of Target State Reports changed between ADS-B Version One (1) and Version Two (2), there is no requirement for an ADS-B Version Two (2) receiving subsystem to output ADS-B Version One (1) Target State Reports.

Appendix D

IMPLEMENTATION GUIDELINES

D.1 INTRODUCTION

D.1.1 GENERAL

D.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, B and C of this document.

D.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.

D.1.1.3 The appendix is intended for use by the avionics industry and by the developers of air traffic services (ATS) applications.

D.1.2 MODE S SPECIFIC SERVICES OVERVIEW

D.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.

D.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.

D.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.

D.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.

D.2 Data formats for transponder registers

D.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.

D.2.2 GENERAL CONVENTIONS ON DATA FORMATS

D.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 D-1 is a summary of the provisions contained in Appendix A with respect to the loading and clearing of data into the transponder register.

D.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.

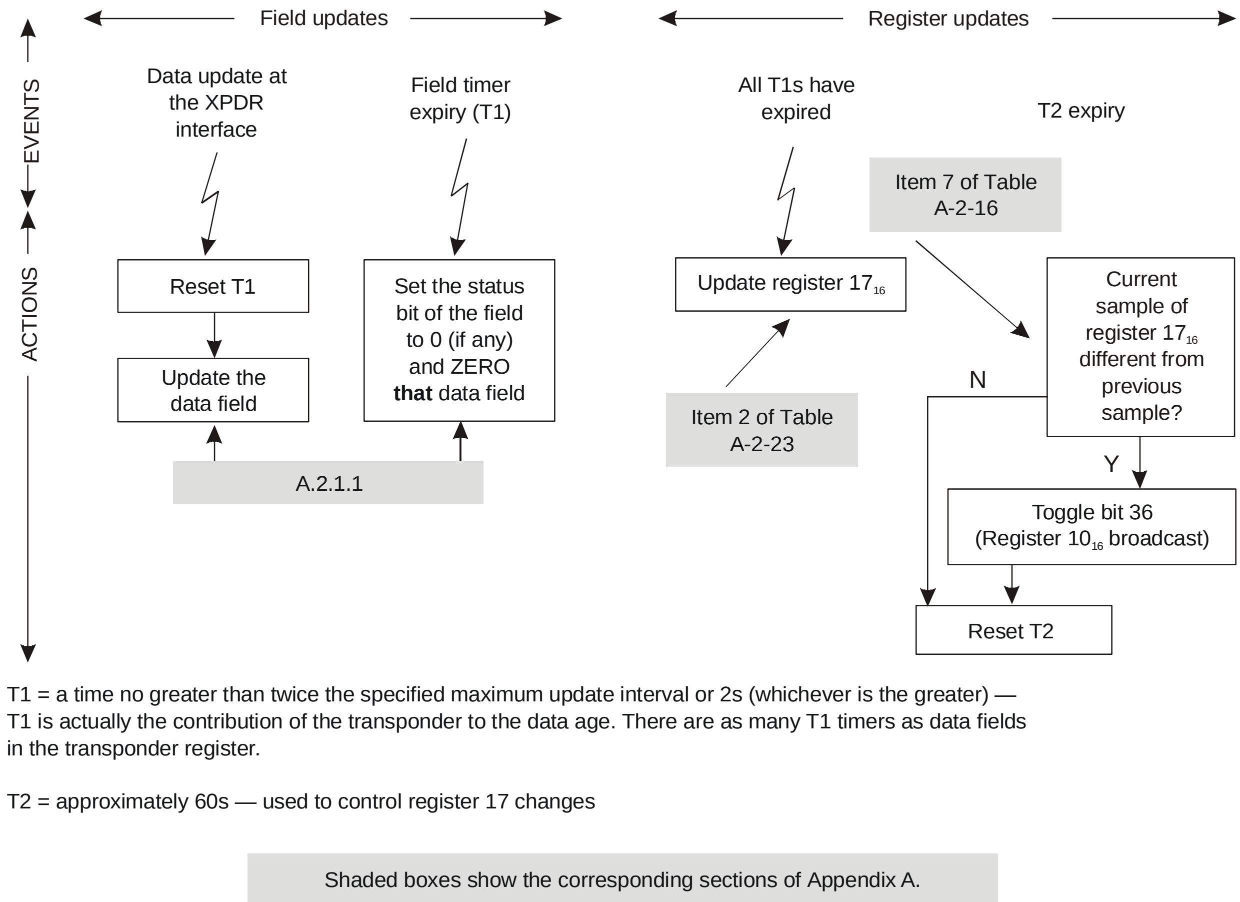


Figure D-1. Detailed process for the clearing and loading of data in the fields of transponder register

D.2.3 DATA SOURCES FOR TRANSPONDER REGISTERS

Typical ARINC labelled data sources that can be used to derive the required data fields in the transponder GICB registers are detailed in the latest published version of ARINC 718A. Data sources are identified with the parameter range, resolution and update interval for typical Air Transport transponder applications. Alternatives are given where they have been identified.

D.2.4 FOR TRANSPONDER REGISTER FORMATTING

D.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.

D.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.

D.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.

These bits should be set as specified in Table A-2-16.

Bit 16 should be set to ONE (1) to indicate that the transponder ACAS interface is operational and the transponder is receiving TCAS RI = 2, 3 or 4.

Bit 37 should be set to ONE (1) to indicate the capability of Hybrid Surveillance and set to ZERO (0) to indicate that there is no Hybrid Surveillance capability.

Bit 38 should be set to ONE (1) to indicate that the ACAS is generating both TAs and RAs and set to ZERO (0) to indicate the generation of TAs only.

Bits 39 and 40 should be set according to the ACAS version:

Bit 40	*Bit 39*	*Meaning*
0	0	RTCA DO-185 (6.04A) (see Note 2)
0	1	RTCA DO-185A (see Note 2)
1	0	RTCA DO-185B/EUROCAE ED-143
1	1	Reserved for future versions (see Note 1)

Note 1.— Future versions of ACAS will be identified using Part Numbers and Software Version Numbers specified in registers $E5_{16}$ and $E6_{16}$.

Note 2.— RTCA DO-185 equipment is also referenced as TCAS logic version 6.04A. Equipment compliant to RTCA DO-185A, or later versions, are SARPs compliant.

D.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 (Doc 9688 (1996))
2 = Version No. 2 (Doc 9688 (1998))
3 = Version No. 3 (Annex 10, Volume III, Amendment 77 (2002))
4 = Version No. 4, first edition of this document
5 = Version No. 5, second edition of this document
6–127 = 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 to Annex 10, Volume III, and Doc 9688 (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 to Annex 10, Volume III, (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 to Annex 10, Volume III, then the Mode S subnetwork number should be set to 3.

If the installed DTE or the Mode S specific services meet the requirements of Doc 9871, first edition, then the Mode S subnetwork version number should be set to 4.

If the installed DTE or the Mode S specific services meet the requirements of Doc 9871, second edition, which additionally complies with RTCA DO-181E and EUROCAE ED-73E, then the Mode S subnetwork version number should be set to 5.

The setting of these bits is static.

D.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.

D.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.

D.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.

D.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.

D.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 10 plus or minus 1 second. 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.

D.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.

D.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.

D.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 time period. 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.

D.2.4.3 TRANSPONDER REGISTER 20_{16}

D.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.

D.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.

D.2.4.3.3 IMPLEMENTATION CONSIDERATIONS FOR IDENTIFICATION REGISTER 08_{16}

If Extended Squitter is implemented, then §A.2.1, Note 3, and §A.2.4.2, Note 2, provide an introduction to register 08_{16} implementation. Implementation of register 08_{16} should also consider the following:

a) If valid Flight Identification data is available, then the data should be used to populate the character subfields in register 08_{16}.

b) After using the Flight Identification data to populate the character subfields in register 08_{16} in a given power-on cycle, if the Flight Identification data becomes invalid or not available, then the last known valid Flight Identification data should be retained and used to continue population of the character subfields in register 08_{16} for the duration of the power-on cycle.

c) If valid Flight Identification data is not available, but valid Aircraft Registration data is available in a given power-on cycle, then the valid Aircraft Registration data should be used to populate the character subfields in register 08_{16} for the duration of the power-on cycle.

d) If register 08_{16} has been populated using Aircraft Registration data in a given power-on cycle, and valid Flight Identification data becomes available, then the Flight Identification data should be used to populate the character subfields in register 08_{16} for the remainder of the power-on cycle.

e) Once valid Flight Identification data has been used to populate register 08_{16} in a given power-on cycle, Aircraft Registration data should not be used to populate the character subfields of register 08_{16}, even if Flight Identification data becomes invalid or not available during the power-on cycle.

D.2.4.4 TRANSPONDER REGISTER NUMBER 40_{16}

Paragraph D.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 D.2.4.4.2, D.2.4.4.3 and D.2.4.4.4 provide more detailed information for some specific platforms.

D.2.4.4.1 GENERAL EXAMPLE FOR THE LOADING OF DATA IN REGISTER 40_{16}

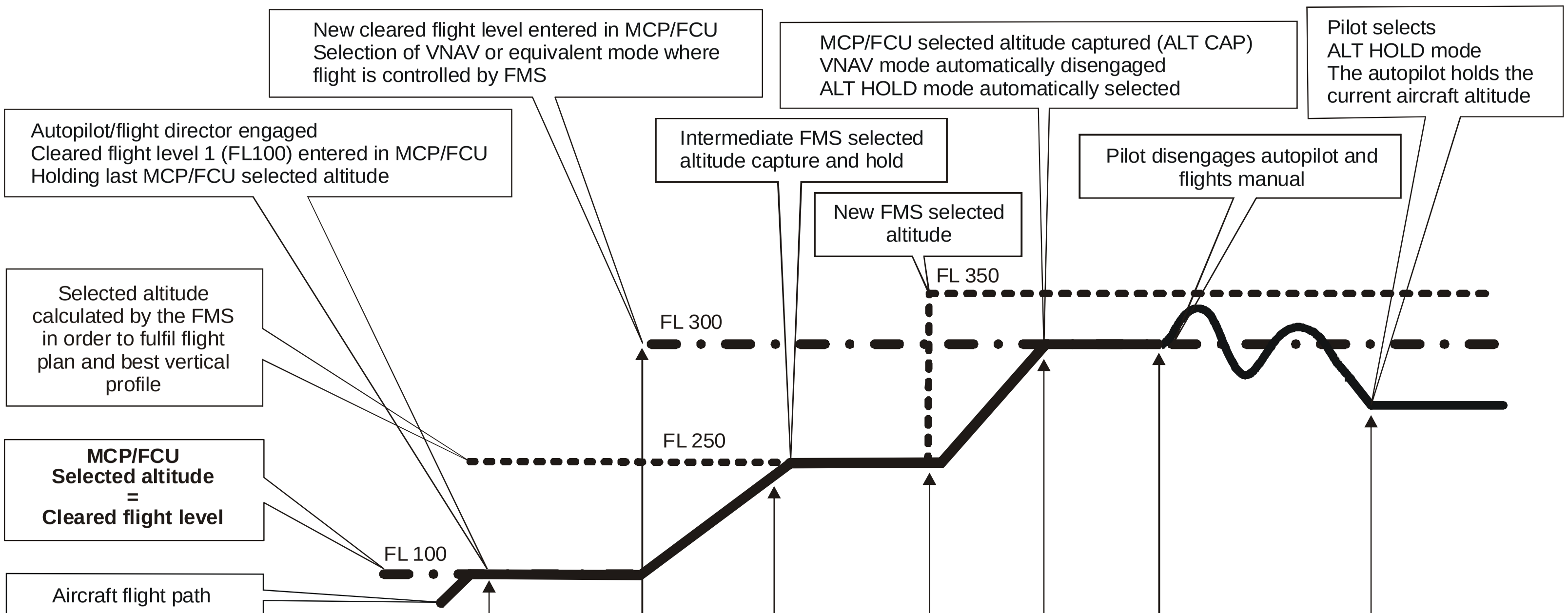
Figure D-2 provides a general example for the loading of data in register 40_{16}.

The goal of Figure D-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.

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			1	2	3	4	5	6	7
	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 D-2. General example for the loading of data in register 40_{16}

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 on-board 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 D-2:

Generally, Figure D-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.

D.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.

D.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.

D.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.

D.2.4.4.2 TRANSPONDER REGISTER NUMBER 40_{16} ON AIRBUS AIRCRAFT

D.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 D-1) 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.

D.2.4.4.2.1.1 A330/A340 family

Table D-1. 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
	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

D.2.4.4.2.1.2 A320 family

The A320 (see Table D-2) 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.

D.2.4.4.2.1.3 Synthesis

Tables D-1 and D-2 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 D-3.

Table D-2. 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
	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

D.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

D.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 (to be determined)
55 56	Target altitude source bits	New label (to be determined)

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.

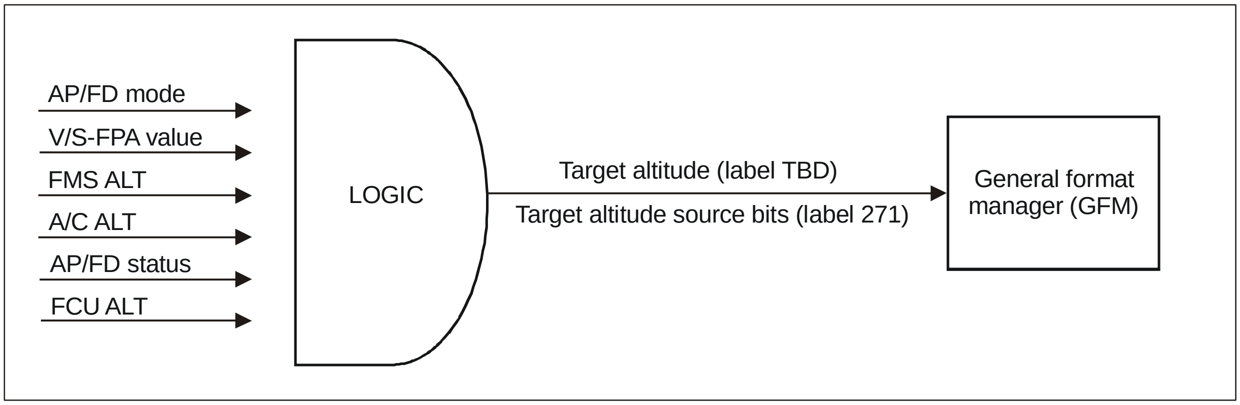


Figure D-3. Logic to derive the target altitude data information

D.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 §D.2.4.3.1 and §D.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).

D.2.4.4.5 Setting of the Reserved Bits (Bits 40 to 47, 52 & 53)

Bits 40 to 47, 52 and 53 of register 40_{16} “MB” field should be set to ZERO (0).

D.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°
4		
5		Roll angle
6		ARINC label 325
7		
8		Range = [-90, +90]
9		
10		
11		LSB = 45/256°
12	STATUS	1 = valid data
13	SIGN	1 = west (e.g. 315°= -45°)
14		MSB = 90°
15		
16		
17		True track angle
18		ARINC label 313
19		
20		Range = [-180, +180]
21		
22		
23		LSB = 90/512°
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
37		MSB = 8°/s
38		
39		Track angle rate
40		ARINC label 335
41		
42		Range = [-16, +16]
43		
44		
45		LSB = 8/256°
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		

BDS bit no.	Data bit no.	Description
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 ±1/2 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.

D.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 (e.g. 315°= -45°)
3		MSB = 90°
4		
5		
6		Magnetic heading
7		ARINC label 320
8		
9		Range = [-180, +180]
10		
11		
12		LSB = 90/512°
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
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		

BDS bit no.	Data bit no.	Description
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 ±1/2 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.

D.2.4.7 COMPACT POSITION REPORTING (CPR) TECHNIQUE

D.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.

D.2.4.7.2 LAT/LON ENCODING CONSIDERATIONS

D.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 (labelled 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.

D.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.

D.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.

D.2.4.7.4 CPR ENCODING TECHNIQUES

D.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 §D.2.4.7.2.1 and §D.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 D-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 centred 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 labelled 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.

D.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 D-5 for the area cells defined above. For simplicity, only two-bit encoding is shown.

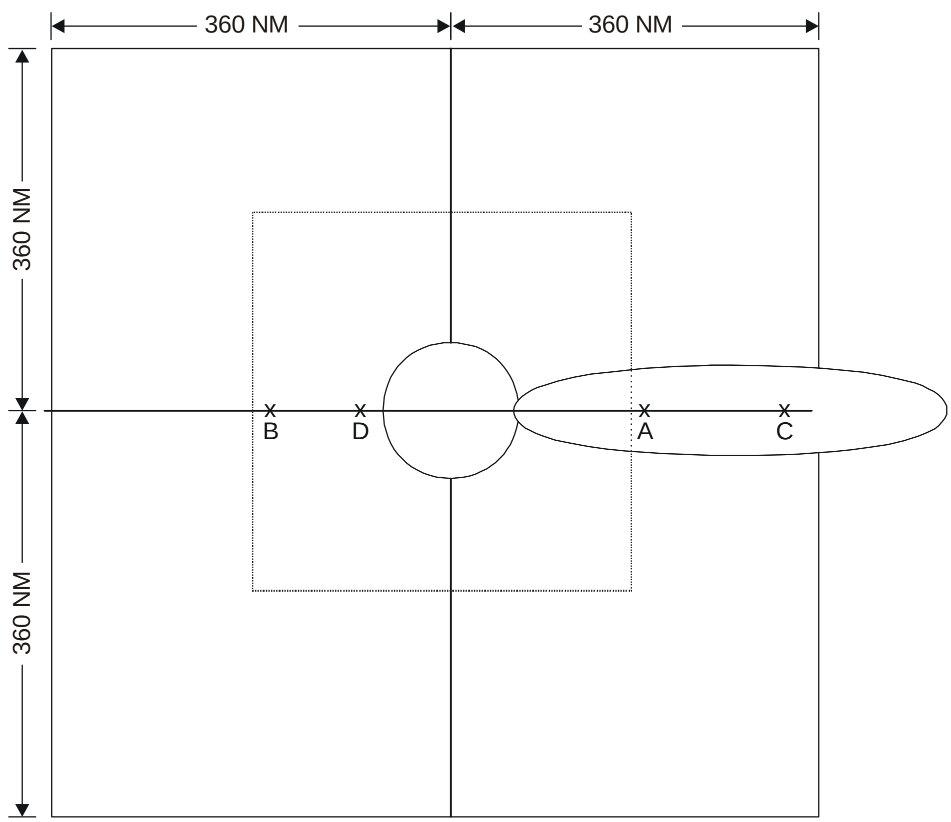


Figure D-4. Maximum range considerations for CPR encoding

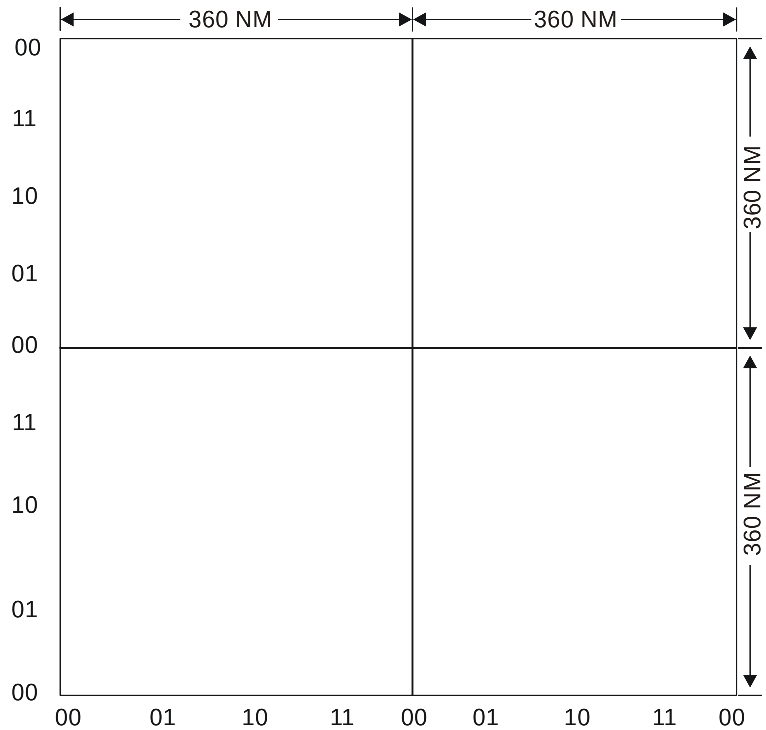


Figure D-5. CPR seamless encoding

D.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.

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 D-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.

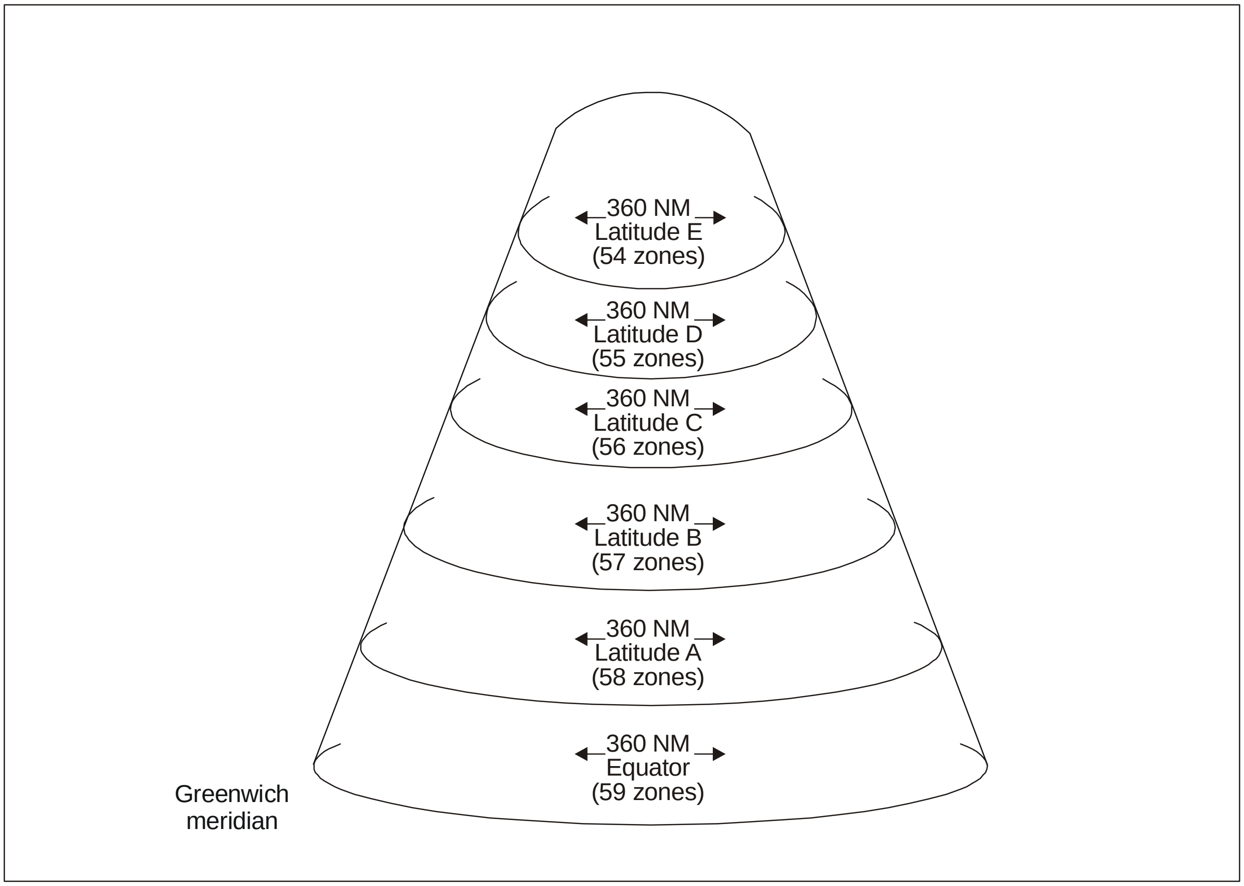


Figure D-6 Longitude zone size assignment versus latitude.

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 D-3.

D.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 labelled 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 D-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 D-8.

D.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 D-3. 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
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		

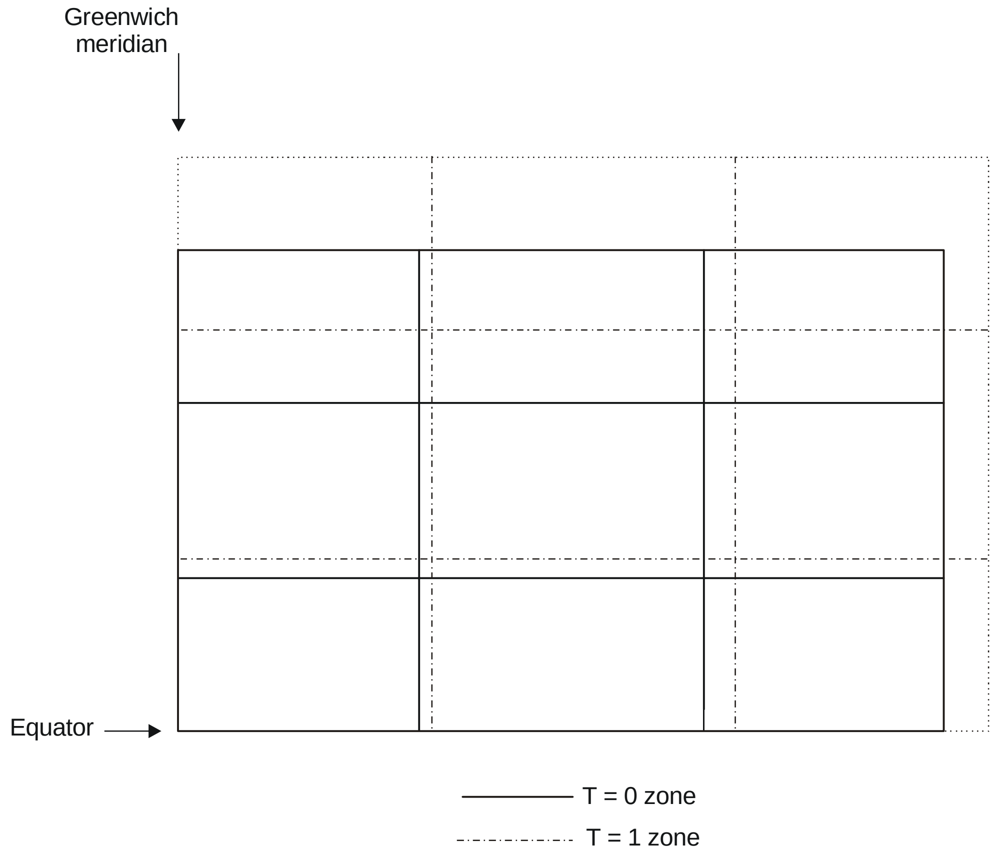


Figure D-7. Zone structure for globally unambiguous reporting.

D.3 IMPLEMENTATION GUIDELINES FOR APPLICATIONS

D.3.1 DATAFLASH

D.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.

D.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.

D.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 honoured 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 honoured by the airborne installation.

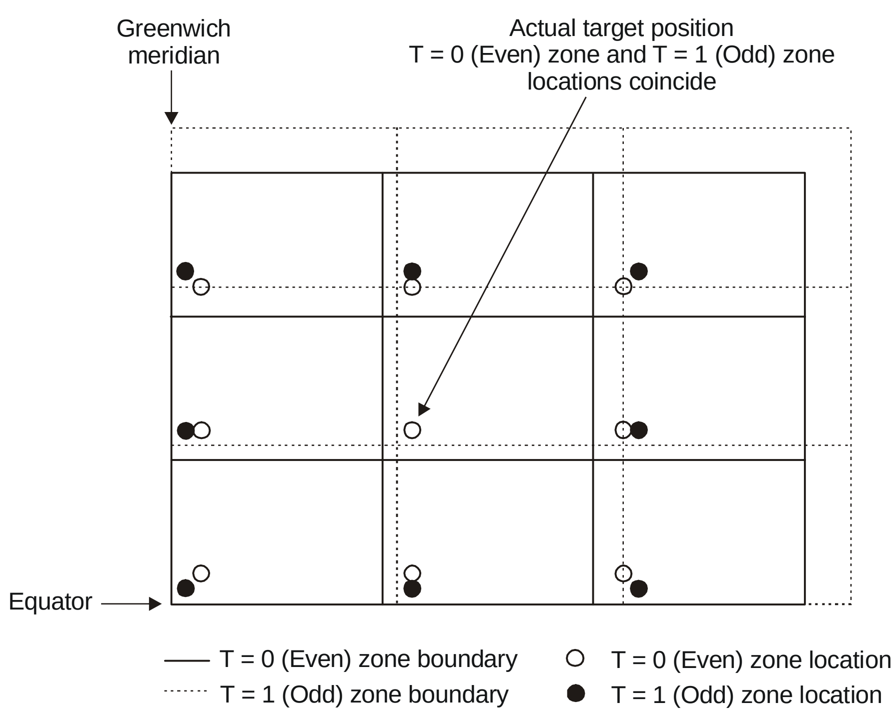


Figure D-8. Determination of globally unambiguous position from a *T* = 0 and *T* = 1 report.

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 analyse 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 analyse 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.

D.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.

D.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.

D.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.

D.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.

D.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 §D.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.

D.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.

D.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.

D.3.2 TRAFFIC INFORMATION SERVICE (TIS)

(TO BE DETERMINED)

D.3.3 EXTENDED SQUITTER

(TO BE DETERMINED)

D.4 IMPLEMENTATION GUIDELINES FOR EXTENDED SQUITTER GROUND SYSTEMS

D.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.

D.4.2 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.

D.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.

D.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 of 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 ms 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 of +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.

D.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.

D.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.

D.4.5.2 MESSAGE RECEPTION PERFORMANCE

D.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.

D.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.

D.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.

D.4.5.2.4 The ground station antenna used for reception should have the same characteristics as specified for transmission in D.4.4.

Appendix E

SERVICES UNDER DEVELOPMENT

E.1 INTRODUCTION

Appendix E presents the latest status of Mode S and extended squitter services that are under development. When these services are mature, they will be proposed as a revision to the technical provisions in Appendix C, and/or the relevant SARPs.

E.2 REVISED FORMATS FOR METEOROLOGICAL REGISTERS 44_{16} AND 45_{16}

E.2.1 In order to keep registers 44_{16} and 45_{16} in conformance with the definitions used over other data links, the format of registers 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 E-2-68. BDS Code 4,4 — Meteorological routine air report

MB FIELD

1	
2	RESERVED
3	
4	
5	STATUS
6	MSB = 256 kt
7	
8	
9	WIND SPEED
10	
11	Range = [0, 511] kt
12	
13	
14	LSB = 1 kt
15	STATUS
16	MSB = 180°
17	
18	WIND DIRECTION (True)
19	
20	Range = [0, 360]°
21	
22	
23	LSB = 180/128°
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 kt.

Note 5.— The requirement for the range of static air temperature in Annex 3 is from –80°C to +60°C.

Table E-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 ft
27	
28	
29	
30	
31	
32	RADIO HEIGHT
33	
34	Range = [0, 8 190] ft
35	
36	
37	LSB = 2 ft
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 min
52	TURBULENCE PEAK DELAY INTERVAL
53	Range = [0, 15] min
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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