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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 30₁₆ (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.
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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

	<i>Description of ADS-B Version 2 Changes</i>	<i>Backward Compatibility Impact to Version 1 Receiver</i>
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.

	<i>Description of ADS-B Version 2 Changes</i>	<i>Backward Compatibility Impact to Version 1 Receiver</i>
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.

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:

<i>Transponder register number</i>	<i>Assignment</i>	<i>Maximum update interval</i> ^{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

<i>Transponder register number</i>	<i>Assignment</i>	<i>Maximum update interval</i> ^{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 0A₁₆ is not to be used for GICB or ACAS crosslink readout.
3. If Extended Squitter is implemented, then register 08₁₆ 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 08₁₆ 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 08₁₆.
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 10₁₆) 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 10₁₆ 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 17₁₆) being set to "ONE"; and

Note 1.— The intent of the capability bits in register 17₁₆ 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 18₁₆ to 1C₁₆ 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 17₁₆ (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 AB₁₆.

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 ν , 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	$\mu < 3$ m	No altitude information	9
6	Surface position	HPL < 25 m	$3 \text{ m} \leq \mu < 10 \text{ m}$	No altitude information	8
7	Surface position	HPL < 185.2 m (0.1 NM)	$10 \text{ m} \leq \mu < 92.6 \text{ m}$ (0.05 NM)	No altitude information	7
8	Surface position	HPL > 185.2 m (0.1 NM)	(0.05 NM) $92.6 \text{ m} \leq \mu$	No altitude information	6
9	Airborne position	HPL < 7.5 m	$\mu < 3$ m	Barometric altitude	9
10	Airborne position	$7.5 \text{ m} \leq \text{HPL} < 25 \text{ m}$	$3 \text{ m} \leq \mu < 10 \text{ m}$	Barometric altitude	8
11	Airborne position	$25 \text{ m} \leq \text{HPL} < 185.2 \text{ m}$ (0.1 NM)	$10 \text{ m} \leq \mu < 92.6 \text{ m}$ (0.05 NM)	Barometric altitude	7
12	Airborne position	$185.2 \text{ m (0.1 NM)} \leq \text{HPL} < 370.4 \text{ m (0.2 NM)}$	$92.6 \text{ m (0.05 NM)} \leq \mu < 185.2 \text{ m (0.1 NM)}$	Barometric altitude	6
13	Airborne position	$370.4 \text{ m (0.2 NM)} \leq \text{HPL} < 926 \text{ m (0.5 NM)}$	$185.2 \text{ m (0.1 NM)} \leq \mu < 463 \text{ m (0.25 NM)}$	Barometric altitude	5
14	Airborne position	$926 \text{ m (0.5 NM)} \leq \text{HPL} < 1\,852 \text{ m (1.0 NM)}$	$463 \text{ m (0.25 NM)} \leq \mu < 926 \text{ m (0.5 NM)}$	Barometric altitude	4
15	Airborne position	$1\,852 \text{ m (1.0 NM)} \leq \text{HPL} < 3\,704 \text{ m (2.0 NM)}$	$926 \text{ m (0.5 NM)} \leq \mu < 1\,852 \text{ m (1.0 NM)}$	Barometric altitude	3
16	Airborne position	$3\,704 \text{ km (2.0 NM)} \leq \text{HPL} < 18.52 \text{ km (10 NM)}$	$1.852 \text{ km (1.0 NM)} \leq \mu < 9.26 \text{ km (5.0 NM)}$	Barometric altitude	2
17	Airborne position	$18.52 \text{ km (10 NM)} \leq \text{HPL} < 37.04 \text{ km (20 NM)}$	$9.26 \text{ km (5.0 NM)} \leq \mu < 18.52 \text{ km (10.0 NM)}$	Barometric altitude	1
18	Airborne position	HPL $\geq 37.04 \text{ km (20 NM)}$	$18.52 \text{ km (10.0 NM)} \leq \mu$	Barometric altitude	0

TYPE Code	Format	Horizontal protection limit (HPL)	95% containment radius, μ and ν , 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	$\mu < 3$ m and $\nu < 4$ m	GNSS height (HAE)	9
21	Airborne position	HPL < 25 m	$\mu < 10$ m and $\nu < 15$ m	GNSS height (HAE)	8
22	Airborne position	HPL ≥ 25 m	$\mu > 10$ m or $\nu \geq 15$ 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:

- 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.
- 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.
- 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:

- 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.
- The Type Code allows users to determine whether the quality of the position is good enough for the intended application.
- Airborne Position Messages with Type Code 18 or 22 (NUC_P = 0), and Surface Position Messages with Type Code 8 (NUC_P = 6, HPL ≥ 185.2 m, $\mu \geq 92.6$ m) 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 05₁₆. 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 $+87 \pm 1.0$ 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 $\pm$ 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 06₁₆ 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 06₁₆ 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 06₁₆ 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 $+87 \pm 1.0$ 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 08₁₆.

A.2.3.5 AIRBORNE VELOCITY FORMAT

The airborne velocity squitter shall be formatted as specified in the definition of transponder register 09₁₆ 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 09₁₆ 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 09₁₆ 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 40₁₆ to 42₁₆. 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 43₁₆ 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 07₁₆ 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 07₁₆ 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 0A₁₆ 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 61₁₆ 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 65₁₆ 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	<i>Reserved</i>
	0 1	<i>Reserved</i>
	1 0	<i>Reserved</i>
	1 1	<i>Reserved</i>
0 1	0 0	<i>Reserved</i>
	0 1	<i>Reserved</i>
	1 0	<i>Reserved</i>
	1 1	<i>Reserved</i>
1 0	0 0	<i>Reserved</i>
	0 1	<i>Reserved</i>
	1 0	<i>Reserved</i>
	1 1	<i>Reserved</i>
1 1	0 0	<i>Reserved</i>
	0 1	<i>Reserved</i>
	1 0	<i>Reserved</i>

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		MEANING
Bit 17, 18	Bit 19, 20	
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		MEANING
Bit 21, 22	Bit 23, 24	
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.

<i>OM-3 ENCODING: TERMINAL AREA OPERATIONAL CAPABILITY STATUS</i>		
<i>OM-3 CODING</i>		
<i>Bit 29, 30</i>	<i>Bit 31, 32</i>	<i>MEANING</i>
0 0	0 0	<i>Reserved</i>
	0 1	<i>Reserved</i>
	1 0	<i>Reserved</i>
	1 1	<i>Reserved</i>
0 1	0 0	<i>Reserved</i>
	0 1	<i>Reserved</i>
	1 0	<i>Reserved</i>
	1 1	<i>Reserved</i>
1 0	0 0	<i>Reserved</i>
	0 1	<i>Reserved</i>
	1 0	<i>Reserved</i>
	1 1	<i>Reserved</i>
1 1	0 0	<i>Reserved</i>
	0 1	<i>Reserved</i>
	1 0	<i>Reserved</i>
	1 1	<i>Reserved</i>

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.

<i>OM-2 ENCODING: APPROACH AND LANDING OPERATIONAL CAPABILITY STATUS</i>		
<i>OM-2 CODING</i>		
<i>Bit 33, 34</i>	<i>Bit 35, 36</i>	<i>MEANING</i>
0 0	0 0	<i>Reserved</i>
	0 1	<i>Reserved</i>
	1 0	<i>Reserved</i>
	1 1	<i>Reserved</i>

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 05₁₆, 06₁₆, 09₁₆ and 08₁₆, respectively. This determination shall be made individually for each squitter type. The insertion of altitude or surveillance status data into transponder register 05₁₆ 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 05₁₆) and all 56 bits of the surface position, squitter status and airborne velocity registers (transponder registers 06₁₆, 07₁₆ and 09₁₆) 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 05₁₆ and 06₁₆, 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 05₁₆, 06₁₆, 07₁₆ and 09₁₆) 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 10₁₆, and 18₁₆ to 1C₁₆. It shall also clear individual bits in register 17₁₆ 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.