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Manual on Mode S Specific Services

Approved by the Secretary General
and published under his authority

Second Edition — 2004

International Civil Aviation Organization

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AMENDMENTS

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

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS		
No.	Date	Entered by

CORRIGENDA		
No.	Date	Entered by

FOREWORD

Mode S secondary surveillance radar (SSR) was standardized in ICAO Annex 10 in 1985. Mode S has a data link capability which can only be taken advantage of when the Mode S subnetwork standards are supplemented with information on the applications that will use the data link.

The purpose of this manual is to provide guidance material on the detailed technical material on Mode S specific services contained in Annex 10 Volume III, Appendix to Chapter 5. The material in that appendix includes the definition of message formats and the detailed specification of algorithms used to format these messages, as well as requirements for the implementation of Mode S specific services including, *inter alia,* enhanced surveillance, dataflash and extended squitter. In addition, this manual will eventually contain both requirements and guidance material for Mode S specific services which are under development.

Any references to this manual should be interpreted as also referring to Annex 10 Volume III, Appendix to Chapter 5 for the Mode S specific services that are standardized.

Corrections or changes to existing material in this document require the approval of the relevant Working Group of the Panel responsible for secondary surveillance radar and collision avoidance systems.

Once approved through the above procedures, changes or new material will be incorporated into this manual by the ICAO Secretariat.

Comments on this manual would be appreciated from all parties concerned with the development of data link applications considered to be suitable for use across the Mode S subnetwork via the Mode S specific services. The comments should be addressed to:

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GLOSSARY

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

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

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 to one side of aircraft elements common to all data link systems and on the other side to the air-ground link itself.

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/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).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

ACRONYMS

ACAS	Airborne collision avoidance system
ADLP	Aircraft data link processor
ADS-B	Automatic dependent surveillance — Broadcast
ATN	Aeronautical telecommunication network
ATS	Air traffic services
A/V	Aircraft/vehicle
BDS	Comm-B data selector
BITE	Built-in test equipment
CFDIU	Centralized fault display interface unit
CPR	Compact position reporting
ELM	Extended length message
FCU	Flight control unit
FMS	Flight management system
GDLP	Ground data link processor
GICB	Ground-initiated Comm-B
GFM	General formatter/manager
GNSS	Global Navigation Satellite System
II	Interrogator identifier
MA	Message-Comm A
MB	Message-Comm B
MC	Message-Comm C
MD	Message-Comm D
MOPS	Minimum operational performance standards
MSP	Mode S specific protocol
NUC_P	Navigational uncertainty category — Position
NUC_R	Navigational uncertainty category — Rate
RNP	Required navigation performance
SI	Surveillance identifier
SLM	Standard length message
SPI	Special position identification
SSE	Specific services entity
SSR	Secondary surveillance radar
TIS	Traffic information service
UTC	Coordinated universal time

Chapter 1

INTRODUCTION

1.1 GENERAL

1.1.1 This manual provides guidance material on data formats for applications using Mode S specific services which are standardized in Annex 10 Volume III, Appendix to Chapter 5. These applications are, where possible, based on data already available on most modern aircraft or on information from current work on development and testing of data link applications.

1.1.2 This manual is intended to provide a focus for international coordination on the development and standardization of new applications which operate via the Mode S specific services. It will contain a brief description of each application under development together with the data formats to be transmitted and all the necessary control parameters to enable the application to function correctly. The intention is to accurately define the data to be transferred and the format in which they are transferred.

1.1.3 The manual contains the following material:

a) Guidance material for the transponder Comm-B registers and extended squitter;

b) Guidance material for the Mode S specific protocols;

c) Guidance material for the Mode S broadcast protocols; and

d) Formats for Mode S specific services.

1.1.4 The manual is intended for use by the avionics industry and by the developers of air traffic services (ATS) applications.

1.2 MODE S SPECIFIC SERVICES

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.

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 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.

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.

1.3 REFERENCE DOCUMENTS

Standards and Recommended Practices (SARPs) for the SSR Mode S system can be found in Annex 10, Volume IV, Chapters 2 and 3. SARPs for the Mode S subnetwork are contained in Annex 10, Volume III, Part 1, Chapter 5 and for ACAS, in Annex 10, Volume IV, Chapter 4.

Chapter 2

GUIDANCE FOR STANDARDIZED MODE S SPECIFIC SERVICES

2.1 Data formats for transponder registers

2.1.1 Transponder register allocation

Standardized applications that have been allocated transponder register numbers in Annex 10 Volume III Chapter 5 are shown in Table 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.— The details of the data to be entered into transponder registers for applications under development will be defined in this section and shown in Table 2-2.

Note 3.— BDS A,B is equivalent to transponder register number AB_{16}.

Note 4.— The time between the availability of data at the SSE and the time that the data must be processed is specified in Annex 10 Volume III, Appendix to Chapter 5.

2.1.2 General conventions on data formats

2.1.2.1 *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 Annex 10 Volume III, Appendix to Chapter 5.

2.1.2.2 *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.

— Where ARINC 429 data are used, the ARINC 429 status bits 30 and 31 should 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 “Normal Operation,” “plus sign,” or “minus sign,” or “Functional Test” then the status bit shall be set to “VALID” provided that the data are being updated at the required rate.

c) If the data are not being updated at the required rate, then the status bit shall be set to “INVALID.”

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

— In all cases where a status bit is used it shall be set to “ONE” to indicate VALID and to “ZERO” to indicate INVALID. This facilitates partial loading of the transponder registers.

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

— Bit numbering in the MB field is specified in Annex 10, Volume IV, Chapter 3, 3.1.2.3.1.3.

* All tables appear at the end of this chapter.

2.1.2.3 *Reserved Fields*

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

2.1.3 Data sources for transponder registers

Table 2-2 shows possible ARINC labelled data sources that can be used to derive the required data fields in the transponder registers. Alternatives are given where they have been identified.

2.1.4 Guidance material for transponder register formatting

2.1.4.1 *Transponder register 20_{16}*

2.1.4.1.1 *Airborne function*

Annex 10 Volume IV requirements (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.

The Appendix to Chapter 5, Annex 10 Volume III (2.5.2) states:

"If for any reason data are 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 transponder register."

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.

2.1.4.1.2 *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.

2.1.4.2 *Transponder register number 40_{16} on Airbus aircraft*

2.1.4.2.1 *Target altitude*

In order to clarify how aircraft intention information is reported in transponder register 40_{16} a mapping (Table 2-3) 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.

2.1.4.2.1.1 *A330/A340 family*

See Table 2-3.

2.1.4.2.1.2 *A320 family*

The A320 (see Table 2-4) has two additional modes compared to the A330/A340:

- The Expedite Mode: it climbs or descends at, respectively, "green dot" speed or Vmax speed.
- The Immediate Mode: it climbs or descends immediately while respecting the FMS constraints.

2.1.4.2.1.3 *Synthesis*

Tables 2-3 and 2-4 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 2-1.

2.1.4.2.2 *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

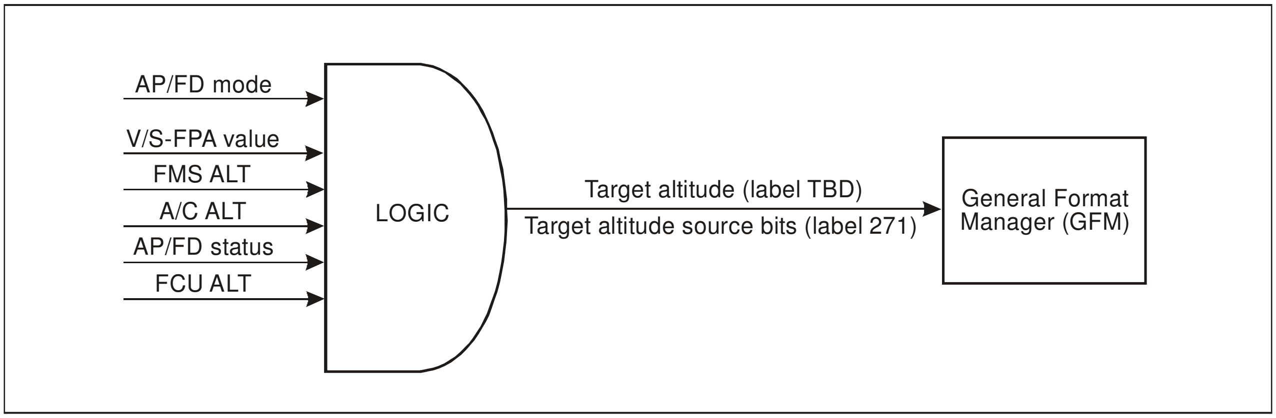

Figure 2-1. Dedicated label containing target altitude

2.1.4.3 *Transponder register number 40_{16} on Boeing 747-400, 757 and 767 aircraft*

In order to clarify how selected altitude information from the altitude control panel and target altitude is reported in transponder register 40_{16}, a mapping has been prepared to illustrate how the status and mode bits can be derived.

Transponder register bit No	Description	Label
48	Status of mode bits	SSM of 272 and 273
49	Managed Vertical Mode	272 bit 13
50	Altitude Hold Mode	272 bit 9 / 273 bit 19
51	Approach Mode	272 bit 9 / 273 bit 19
54	Status of Target Altitude source bits	SSM of new label (TBD)
55 56	Target altitude source bits	New label (TBD)

The selected altitude from the mode control panel may be obtained from label 102 (source ID 0A1). The status bit may be derived from the SSM of label 102.

2.1.4.4 *Compact position reporting (CPR) technique*

2.1.4.4.1 *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.

2.1.4.4.2 *Lat/lon encoding considerations*

2.1.4.4.2.1 *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.

2.1.4.4.2.2 *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.

2.1.4.4.3 *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.

2.1.4.4.4 *CPR encoding techniques*

2.1.4.4.4.1 *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 paragraphs 2.1.4.4.2.1 to 2.1.4.4.3 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.

Surveillance of airborne aircraft beyond about 180 km (100 nm) from a surface receiver requires 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 2-2. 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.

2.1.4.4.5 *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 2-3 for the area cells defined above. For simplicity, only two-bit encoding is shown.

2.1.4.4.6 *Encoding*

The above techniques would be sufficient for an encoding system if the Earth were a cube. However, to be consistent on a sphere, additional features must be applied to handle the change in longitude extent as latitudes increase away from the equator. The polar regions must also be covered by the coding.

All lines of longitude must have the same nominal radius, so the latitude extent of an area cell is constant. The use of a 360 nm minimum unambiguous range leads to 15 latitude zones from the equator to the poles.

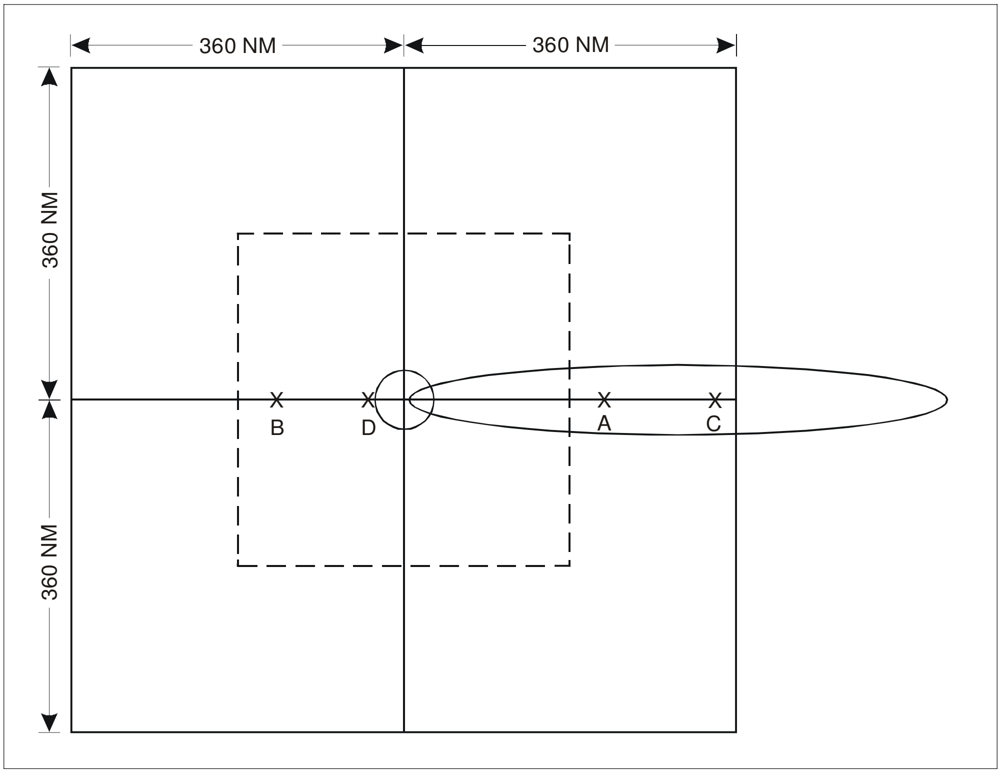

Figure 2-2. Maximum range considerations for CPR encoding

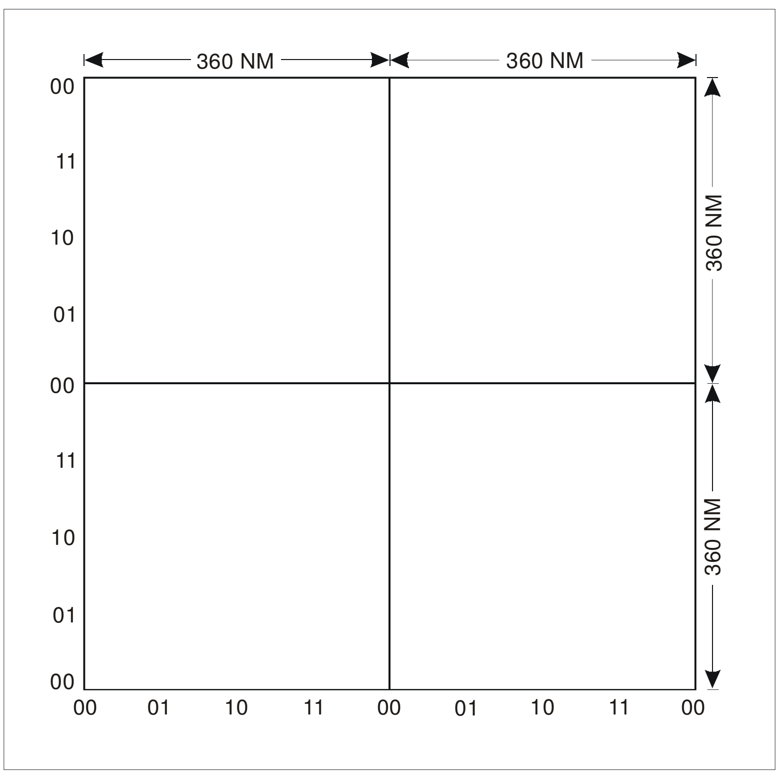

Figure 2-3. CPR seamless encoding

Circles of latitude become smaller with increasing latitude away from the equator. This means that the maintenance of a 360 nm unambiguous range 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 2-4 for a simple case showing five of the latitude bands in the northern hemisphere. At the equator 59 zones are used as required to obtain a minimum longitude dimension of 360 nm at the northern extent of the zone. In fact, it is that precise latitude at which the northern extent of the zone is 360 nm that defines the value of latitude A in the northern hemisphere (it would be the southern extent of the zone for the southern hemisphere). At latitude A, one less longitude zone is used. This number of zones is used until the northern (southern) extent of the longitude zone equals 360 nm, which defines latitude B. The process continues for each of the five bands.

For lines of longitude, 60 zones are used in the CPR system to give the desired cell size of 360 nm. For circles of latitude, only 59 zones can be used at the equator in order to assure that the zone size at the northern latitude limit is at least 360 nm. This process continues through each of 59 latitude bands, each defined by one less zone per latitude band than the previous. Finally, the polar latitude bands are defined as a single zone beyond 87 degrees north and south latitude. A complete definition of the latitude zone structure is given in Table 2-5.

2.1.4.4.7 *Globally unambiguous position*

Globally unambiguous position reports will be of benefit if ADS-B is applied over broad geographic areas. One application that has been given some consideration is oceanic surveillance based on the reception of Mode S extended squitters by low earth orbiting satellites. Globally unambiguous encoding can only be considered if it does not reduce the bit-efficiency of the encoding or significantly increase its complexity.

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 2-5.

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 2-6.

2.1.4.4.8 *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.

2.2 GUIDANCE MATERIAL FOR APPLICATIONS

2.2.1 Dataflash

2.2.1.1 *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

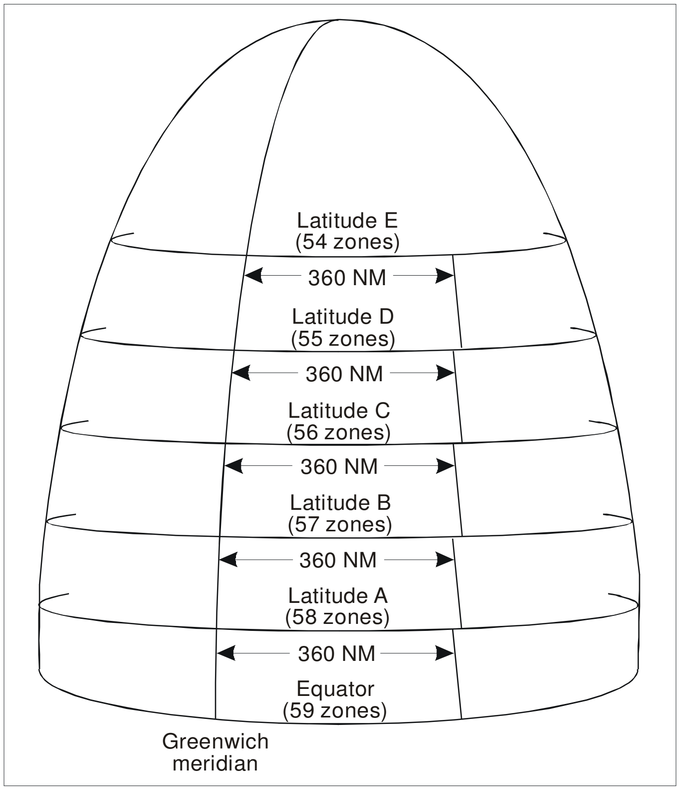

Figure 2-4. Longitude zone size assignment versus latitude

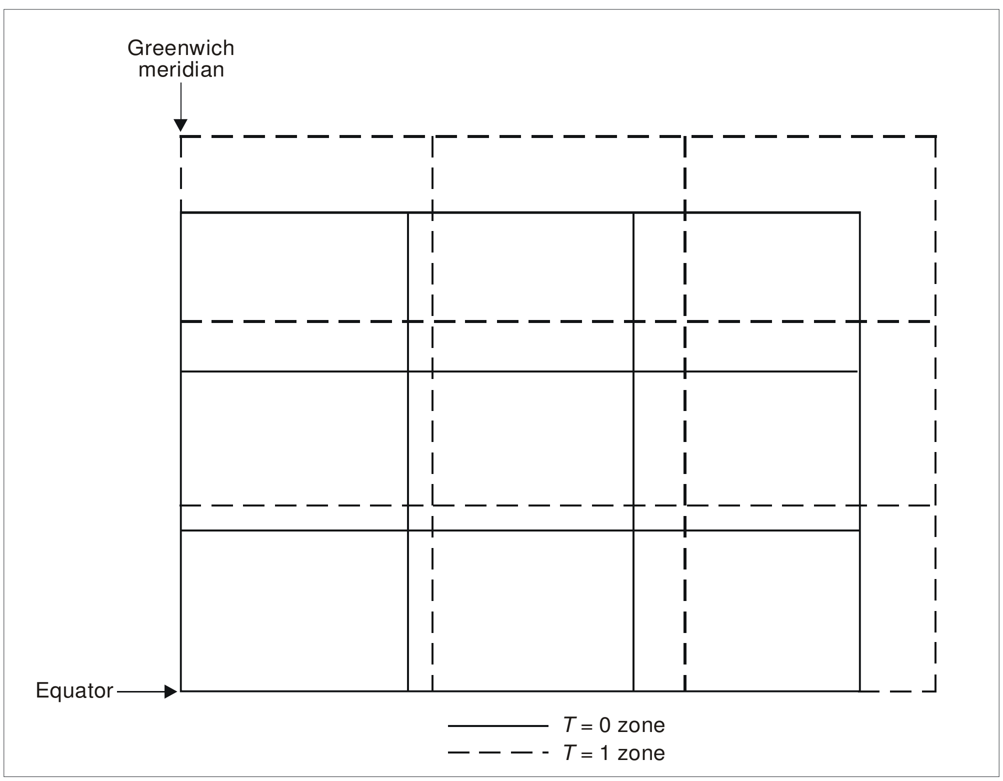

Figure 2-5. Zone structure for globally unambiguous reporting

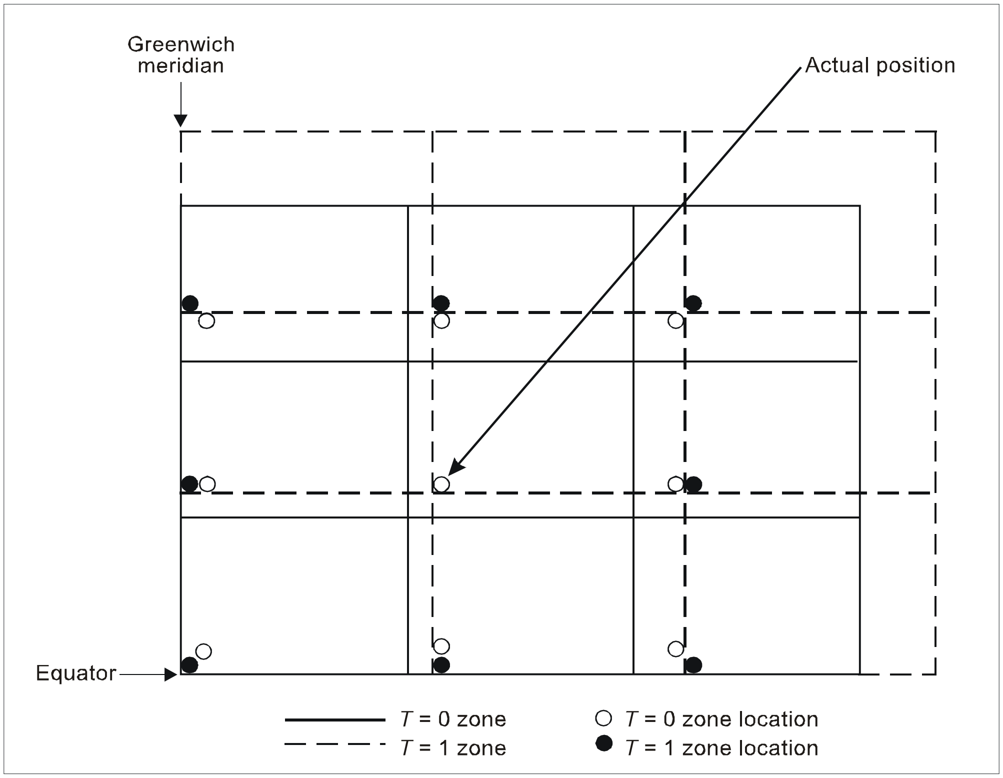

Figure 2-6. Determination of globally unambiguous position

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.

2.2.1.2 *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.

2.2.1.3 *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.

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.

2.2.1.4 *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.

2.2.1.4.1 *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.

2.2.1.4.2 *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.

2.2.1.5 *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.

2.2.1.6 *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 section 2.2.1.4. If the termination of the contract by 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.

2.2.1.7 *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.

2.2.1.8 *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.

2.2.2 Traffic Information Service (TIS)

TBD

2.2.3 Extended Squitter

TBD

Table 2-1. Standardized applications that have been allocated transponder register numbers

Transponder register No.	*Assignment*	*Minimum update rate*
00_{16}	Not valid	N/A
01_{16}	Unassigned	N/A
02_{16}	Linked Comm-B, segment 2	N/A
03_{16}	Linked Comm-B, segment 3	N/A
04_{16}	Linked Comm-B, segment 4	N/A
05_{16}	Extended squitter airborne position	0.2 s
06_{16}	Extended squitter surface position	0.2 s
07_{16}	Extended squitter status	1.0 s
08_{16}	Extended squitter identification and type	15.0 s
09_{16}	Extended squitter airborne velocity	0.2 s
$0A_{16}$	Extended squitter event-driven information	variable
$0B_{16}$	Air/air information 1 (aircraft state)	1.0 s
$0C_{16}$	Air/air information 2 (aircraft intent)	1.0 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 *Note 4*)
11_{16}-16_{16}	Reserved for extension to data link capability reports	5.0 s
17_{16}	Common usage GICB capability report	5.0 s
18_{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}-$2F_{16}$	Unassigned	N/A
30_{16}	ACAS active resolution advisory	see ACAS SARPs (Annex 10, Volume IV, Chapter 4, 4.3.8.4.2.2.)
31_{16}-$3F_{16}$	Unassigned	N/A
40_{16}	Aircraft 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

Transponder register No.	*Assignment*	*Minimum update rate*
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}-$4F_{16}$	Unassigned	N/A
50_{16}	Track and turn report	1.0 s
51_{16}	Position report coarse	0.5 s
52_{16}	Position report fine	0.5 s
53_{16}	Air-referenced state vector	0.5 s
54_{16}	Waypoint 1	5.0 s
55_{16}	Waypoint 2	5.0 s
56_{16}	Waypoint 3	5.0 s
57_{16}-$5E_{16}$	Unassigned	N/A
$5F_{16}$	Quasi-static parameter monitoring	0.5 s
60_{16}	Heading and speed report	1.0 s
61_{16}	Extended squitter emergency/priority status	1.0 s
62_{16}	Current trajectory change point	1.7 s
63_{16}	Next trajectory change point	1.7 s
64_{16}	Aircraft operational coordination message	2.0 s or 5.0 s (see Appendix to Chapter 5, Annex 10, Volume III, 2.3.10.1)
65_{16}	Aircraft operational status	1.7 s
66_{16}-$6F_{16}$	Reserved for extended squitter	N/A
70_{16}-75_{16}	Reserved for future aircraft downlink parameters	N/A
76_{16}-$E0_{16}$	Unassigned	N/A
$E1_{16}$-$E2_{16}$	Reserved for Mode S BITE	N/A
$E3_{16}$-$F0_{16}$	Unassigned	N/A
$F1_{16}$	Military applications	15 s
$F2_{16}$	Military applications	15 s
$F3_{16}$-FF_{16}	Unassigned	N/A

Table 2.2. Mode S transponder register data requirements and input availability

DATA REQUIREMENTS												INPUT DATA SOURCE AVAILABILITY (See Note 1)										
Register Number (HEX)	Assignment	Register Field	ARINC Word (Octal)	Parameter Description	Signal Format	UNITS	+ Sense	RANGE	Sig. Bits/ Dig.	RESOLUTION	MAX TX INTVL-ms	GPS	FMC/ GNSS	IRS/ FMS	FMC GEN	ADS	Control Panel	FCC/ MCP	DFS/ VHF	Weather	Maint Comp	Notes
00	Not Valid		N/A	N/A	N/A							N/A										
01	Unassigned		N/A	N/A	N/A							N/A										
02	Linked Comm-B, Segment 2		N/A	N/A	N/A							N/A										
03	Linked Comm-B, Segment 3		N/A	N/A	N/A							N/A										
04	Linked Comm-B, Segment 4		N/A	N/A	N/A							N/A										
05	Extended Squitter Airborne Position	Type	130	Autonomous Horiz. Integrity Limit	BNR	n.m.	+	16	17	0.000 122 1	1 200	1	2	3								2
			136	Vertical Figure of Merit	BNR	feet	+	32 768	18	0.125	1 200	1	2	3								2
			247	Horizontal Figure of Merit	BNR	n.m.	+	16	18	6.1035E-5	1 200	1	2	3								2
			167	Estimated Position Uncertainty	BNR	n.m	+	0-128	16	0.001 95	TBD		1	3	2							2
		Surveillance Status	N/A	N/A	N/A							N/A										3
		Single Antenna Flag	N/A	N/A	N/A							N/A										4
		Altitude	370	GNSS Height (HAE)	BNR	feet	UP	=/- 131 072	20	0.125	1 200	1	2	3								
			203	Altitude (1 013.25 hPa) (barometric)	BNR	feet	UP	+131 072	17	1.0	62.5			2		1						
		Encoded Latitude	110	GNSS Latitude, Coarse	BNR	degrees	N	+/- 180	20	0.000 171 66	1 200	1	2	3								
			120	GNSS Latitude, Fine	BNR	degrees	+	0.000 172	11	8.3819E-8	1 200	1	2	3								
			010	Latitude, Present Position	BCD	degrees	N	180N – 180S	6	0.1	500		1	3	2							
			310	Latitude, Present Position	BNR	degrees	N	0 – 180N/ 0 – 180S	20	0.000 171 66	200		1	3	2							
		Encoded Longitude	111	GNSS Longitude, Coarse	BNR	degrees	E	+/- 180	20	0.000 171 66	1 200	1	2	3								
			121	GNSS Longitude, Fine	BNR	degrees	+	0.000 172	11	8.3819E-8	1 200	1	2	3								
			011	Longitude, Present Position	BCD	degrees	E	180E – 180W	6	0.1	500		1	3	2							
			311	Longitude, Present Position	BNR	degrees	E	0 – 180E/ 0 – 180W	20	0.000 171 66	200		1	3	2							
		CPR Format	N/A	N/A	N/A								1	3	2							
		Time	150	UTC	BNR	hr:min:s	+	23:59:9	17	1.0 second	1 200	1	2	3								5
		Encoded Latitude/ Longitude	103	GNSS Track Angle	BNR	degrees	CW-N	+/- 180	15	0.054 931 6	1 200	1	2	3								5
			112	GNSS Ground Speed	BNR	knots	+	4 096	15	0.125	1 200	1	2	3								5
			312	Ground Speed	BNR	knots	+	4 096	15	0.125	50		1	3	2							5
			012	Ground Speed	BCD	knots	+	0 - 7 000	4	1.0	500		1	3	2							5
			313	True Track Angle	BNR	deg./180	+	+/- 180	12	0.05	50		1	3	2							5
			013	True Track Angle	BCD	degrees	+	0 – 359.9	4	0.1	500		1	3	2							5
			210	True Airspeed	BNR	knots	+	2 048	15	0.062 5	125			2	1							5
			206	Computed Airspeed	BNR	knots	+	1 024	14	0.062 5	125			2	1							5
			166	GNSS N/S Velocity	BNR	knots	N	+/- 4 096	15	0.125	1 200	1	2	3								6
			174	GNSS E/W Velocity	BNR	knots	E	+/- 4 096	15	0.125	1 200	1	2	3								6
			366	N/S Velocity	BNR	knots	N	+/- 4 096	15	0.125	200		1	3	2							6
			367	E/W Velocity	BNR	knots	E	+/- 4 096	15	0.125	200		1	3	2							6

Table 2.2. Mode S transponder register data requirements and input availability

DATA REQUIREMENTS												INPUT DATA SOURCE AVAILABILITY (See Note 1)										
Register Number (HEX)	Assignment	Register Field	ARINC Word (Octal)	Parameter Description	Signal Format	UNITS	+ Sense	RANGE	Sig. Bits/ Dig.	RESOLUTION	MAX TX INTVL-ms	GPS	FMC/ GNSS	IRS/ FMS	FMC GEN	ADS	Control Panel	FCC/ MCP	DFS/ VHF	Weather	Maint Comp	Notes
06	Extended Squitter Surface Position	Type	130	Autonomous Horiz. Integrity Limit	BNR	n.m.	+	16	17	0.000 122 1	1 200	1		2								2
			136	Vertical Figure of Merit	BNR	feet	+	32 768	18	0.125	1 200	1		2								2
			247	Horizontal Figure of Merit	BNR	n.m.	+	16	18	6.1035E-5	1 200	1		2								2
			167	Estimated Position Uncertainty	BNR	n.m	+	0-128	16	0.001 95	TBD		1	3	2							2
		Movement	112	GNSS Ground Speed	BNR	knots	+	4 096	15	0.125	1 200	1	2	3								5
			312	Ground Speed	BNR	knots	+	4 096	15	0.125	50		1	3	2							5
			012	Ground Speed	BCD	knots	+	0 - 7 000	4	1.0	500		1	3	2							5,7
		Ground Track	103	GNSS Track Angle	BNR	degrees	CW-N	+/- 180	15	0.054 931 6	1 200	1	2	3								5,8
			313	True Track Angle	BNR	deg./180	+	+/- 180	12	0.05	50		1	3	2							5,8
			013	True Track Angle	BCD	degrees	+	0 – 359.9	4	0.1	500		1	3	2							5,8
		Encoded Latitude	110	GNSS Latitude, Coarse	BNR	degrees	N	+/- 180	20	0.000 171 66	1 200	1	2	3								
			120	GNSS Latitude, Fine	BNR	degrees	+	0.000 172	11	8.3819E-8	1 200	1	2	3								
			010	Latitude, Present Position	BCD	degrees	N	180N – 180S	6	0.1	500		1	3	2							
			310	Latitude, Present Position	BNR	degrees	N	0 – 180N/ 0 – 180S	20	0.000 171 66	200		1	3	2							
		Encoded Longitude	111	GNSS Longitude, Coarse	BNR	degrees	E	+/- 180	20	0.000 171 66	1 200	1	2	3								
			121	GNSS Longitude, Fine	BNR	degrees	+	0.000 172	11	8.3819E-8	1 200	1	2	3								
			011	Longitude, Present Position	BCD	degrees	E	180E – 180W	6	0.1	500		1	3	2							
			311	Longitude, Present Position	BNR	degrees	E	0 – 180E/ 0 – 180W	20	0.000 171 66	200		1	3	2							
		CPR Format	N/A	N/A	N/A							N/A										
		Time	150	UTC	BNR	hr:min:s	+	23:59:9	17	1.0 second	1 200	1	2	3								
		Encoded Latitude/ Longitude	103	GNSS Track Angle	BNR	degrees	CW-N	+/- 180	15	0.054 931 6	1 200	1	2	3								5
			112	GNSS Ground Speed	BNR	knots	+	4 096	15	0.125	1 200	1	2	3								5
			312	Ground Speed	BNR	knots	+	4 096	15	0.125	50		1	3	2							5
			012	Ground Speed	BCD	knots	+	0 - 7 000	4	1.0	500		1	3	2							5
			313	True Track Angle	BNR	deg./180	+	+/- 180	12	0.05	50		1	3	2							5
			013	True Track Angle	BCD	degrees	+	0 – 359.9	4	0.1	500		1	3	2							5
			210	True Airspeed	BNR	knots	+	2 048	15	0.062 5	125			2		1						5
			206	Computed Airspeed	BNR	knots	+	1 024	14	0.062 5	125			2		1						5
			166	GNSS N/S Velocity	BNR	knots	N	+/- 4 096	15	0.125	1 200	1	2	3								6
			174	GNSS E/W Velocity	BNR	knots	E	+/- 4 096	15	0.125	1 200	1	2	3								6
			366	N/S Velocity	BNR	knots	N	+/- 4 096	15	0.125	200		1	3	2							6
			367	E/W Velocity	BNR	knots	E	+/- 4 096	15	0.125	200		1	3	2							6

Table 2.2. Mode S transponder register data requirements and input availability

DATA REQUIREMENTS												INPUT DATA SOURCE AVAILABILITY (See Note 1)										
Register Number (HEX)	Assignment	Register Field	ARINC Word (Octal)	Parameter Description	Signal Format	UNITS	+ Sense	RANGE	Sig. Bits/ Dig.	RESOLUTION	MAX TX INTVL-ms	GPS	FMC/ GNSS	IRS/ FMS	FMC GEN	ADS	Control Panel	FCC/ MCP	DFS/ VHF	Weather	Maint Comp	Notes
07	Extended Squitter Status	Transmission Rate Type Subfield	N/A	N/A	N/A							N/A										9
			370	GNSS Height (HAE)	BNR	feet	UP	=/- 131 072	20	0.125	1 200	1	2	3								
			203	Altitude (1 013.25 hPa) (Barometric)	BNR	feet	UP	+131 072	17	1.0	62.5			2		1						
08	Extended Squitter Aircraft Identification And Category	Characters 1–8	233	Flight Identification Word #1	See ARINC 718A							See Note 17										12
			234	Flight Identification Word #2	See ARINC 718A							See Note 17										
			235	Flight Identification Word #3	See ARINC 718A							See Note 17										
			236	Flight Identification Word #4	See ARINC 718A							See Note 17										
		Characters 9–10	237	Flight Identification Word #5	Reserved for Flight Identification Characters 9 and 10							See Note 17										
		Characters 1–8	301	Aircraft Identification Word #1	See Notes 13 and 14							See Notes 13 and 14										13, 14
			302	Aircraft Identification Word #2	See Notes 13 and 14							See Notes 13 and 14										
			303	Aircraft Identification Word #3	See Notes 13 and 14							See Notes 13 and 14										
		Characters 1–8	360	Flight Number Character 1 - 8	See ARINC 429P1, Attachment 6 Flight Identification							See Note 17										12
		Aircraft Cateegory	TBD	TBD	TBD							TBD										
09	Extended Squitter Airborne Velocity (Subtype 1 and 2)	Subtype	112	GNSS Ground Speed	BNR	knots	+	4 096	15	0.125	1 200	1	2	3								
			312	Ground Speed	BNR	knots	+	4 096	15	0.125	50		1	3	2							
			012	Ground Speed	BCD	knots	+	0 - 7 000	4	1.0	500		1	3	2							
		$NUC_{VELOCITY}$	TBD	Navigation Uncertainty Category_Velocity	TBD								1	3	2							
		E/W Velocity	174	GNSS E/W Velocity	BNR	knots	E	+/- 4 096	15	0.125	1 200	1	2	3								
			367	E/W Velocity	BNR	knots	E	+/- 4 096	15	0.125	200		1	3	2							
		N/S Velocity	166	GNSS N/S Velocity	BNR	knots	N	+/- 4 096	15	0.125	1 200	1	2	3								
			366	N/S Velocity	BNR	knots	N	+/- 4 096	15	0.125	200	1	2	3								
		Vertical Rate	165	GNSS Vertical Velocity	BNR	Ft./min.	UP	+/- 32 768	15	1.0	1 200	1	2	3								
			365	Inertial Vertical Velocity	BNR	Ft./min.	+	32 768	15	1.0	40		1	3	2							
			212	Altitude Rate, Barometric	BNR	Ft./min.	+	32 768	11	16	62.5			2		1						
			232	Altitude Rate	BCD	Ft./min.	UP	+/- 20 000	4	10.0	62.5			2		1						
		GNSS Alt Diff from Baro Alt	203	Altitude (1 013.25 hPa) (Barometric)	BNR	feet	UP	+131 072	17	1.0	62.5			2		1						
			370	GNSS Height (HAE)	BNR	feet	UP	=/- 131 072	20	0.125	1 200	1	2	3								
	Extended Squitter Airborne Velocity (Subtype 3 and 4)	Subtype	210	True Airspeed	BNR	knots	+	2 048	15	0.062 5	125			2		1						5
			206	Computed Airspeed	BNR	knots	+	1 024	14	0.062 5	125			2		1						5
		$NUC_{VELOCITY}$	TBD	Navigation Uncertainty Category_Velocity	TBD									1								
		E/W Velocity	174	GNSS E/W Velocity	BNR	knots	E	+/- 4 096	15	0.125	1 200	1	2	3								
			367	E/W Velocity	BNR	knots	E	+/- 4 096	15	0.125	200		1	3	2							
		N/S Velocity	166	GNSS N/S Velocity	BNR	knots	N	+/- 4 096	15	0.125	1 200	1	2	3								
			366	N/S Velocity	BNR	knots	N	+/- 4 096	15	0.125	200		1	3	2							
		Airspeed	210	True Airspeed	BNR	knots	+	2 048	15	0.062 5	125			2		1						
			206	Computed Airspeed	BNR	knots	+	1 024	14	0.062 5	125			2		1						

Table 2.2. Mode S transponder register data requirements and input availability

DATA REQUIREMENTS												INPUT DATA SOURCE AVAILABILITY (See Note 1)										
Register Number (HEX)	Assignment	Register Field	ARINC Word (Octal)	Parameter Description	Signal Format	UNITS	+ Sense	RANGE	Sig. Bits/ Dig.	RESOLUTION	MAX TX INTVL-ms	GPS	FMC/ GNSS	IRS/ FMS	FMC GEN	ADS	Control Panel	FCC/ MCP	DFS/ VHF	Weather	Maint Comp	Notes
0A	Extemded Squitter Event Driven Information	Vertical Rate	165	GNSS Vertical Velocity	BNR	Ft./min.	UP	+/- 32 768	15	1.0	1 200	1	2	3								
			365	Inertial Vertical Velocity	BNR	Ft./min.	+	32 768	15	1.0	40		1	3	2							
			212	Altitude Rate, Barometric	BNR	Ft./min.	+	32 768	11	16	62.5			2		1						
			232	Altitude Rate	BNR	Ft./min.	UP	+/- 20 000	4	10.0	62.5			2		1						
		GNSS Alt Diff From Baro Alt	203	Altitude (Barometric)	BNR	feet	UP	+131 072	17	1.0	62.5			2		1						
			076	GNSS Alt (MSL)	BNR	feet	UP	+/- 131 072	20	0.125	1 200	1	2	3								
			370	GNSS Height (HAE)	BNR	feet	UP	=/- 131 072	20	0.125	1 200	1	2	3								
		Magnetic	320	Magnetic Heading	BNR	Deg./180	+	+/- 180	15	0.054 931 6	50		1	3	2							
		Heading	014	Magnetic Heading	BCD	degrees	+	+/- 359.9	4	0.1	500		1	3	2							
		N/A	N/A	N/A	N/A							N/A										
0B	Air/Air State Information 1	True Airspeed	210	True Airspeed	BNR	knots	+	2 048	15	0.062 5	125			2		1						
			230	True Airspeed	BCD	knots	+	100 - 599	3	1.0	500			2		1						
		Heading	320	Magnetic Heading	BNR	Deg./180	+	+/- 180	15	0.054 931 6	50		1	3	2							
			014	Magnetic Heading	BCD	degrees	+	+/- 359.9	4	0.1	500		1	3	2							
			314	True Heading	BNR	Deg./180	+	+/- 180	15	0.054 931 6	50		1	3	2							
			044	True Heading	BCD	degrees	+	+/- 359.9	4	0.1	500		1	3	2							
		True Track Angle	103	GNSS Track Angle	BNR	degrees	CW-N	+/- 180	15	0.054 931 6	1 200	1	2	3								
			313	True Track Angle	BNR	deg./180	+	+/- 180	12	0.05	50		1	3	2							20
			013	True Track Angle	BCD	degrees	+	0 – 359.9	4	0.1	500		1	3	2							20
		Ground Speed	112	GNSS Ground Speed	BNR	knots	+	4 096	15	0.125	1 200	1	2	3								
			312	Ground Speed	BNR	knots	+	4 096	15	0.125	50		1	3	2							
			012	Ground Speed	BCD	knots	+	0 – 7 000	4	1.0	500		1	3	2							
0C	Air/Air State Information 2	Level Off Altitude	025	Selected Altitude	BCD	feet	+	0 – 50 000	5	1.0	200			2				1				
			102	Selected Altitude	BNR	feet	+	65 536	16	1.0	200			2				1				
		Next Course	024	Selected Course	BCD	degrees	+	0 - 359	3	1.0	200			2				1				
			023	Selected Heading	BCD	degrees	+	0 - 359	3	1.0	200			2				1				
			101	Selected Heading	BNR	Deg./180	+	+/- 180	12	0.05	62.5			2				1				
			100	Selected Course	BNR	Deg./180	+	+/- 180	12	0.05	333			2				1				
		Time to Next Waypoint	002	Time to Go (TTG)	BCD	Min.	+	0 – 399.9	4	0.1	200		1	3	2							
		Vertical	212	Altitude Rate, Barometric	BNR	Ft./min.	+	32 768	11	16	62.5			2		1						
		Velocity	365	Inertial Vertical Velocity	BNR	Ft./min.	+	32 768	15	1.0	40		1	3	2							
			165	GNSS Vertical Velocity	BNR	Ft./min.	UP	+/- 32 768	15	1.0	1 200	1	2	3								
		Roll Angle	325	Roll Angle	BNR	Deg./180	Right	+/- 180	14	0.01	20		1	3	2							
0D -to- 0E	Reserved for Air/ Air State Info	N/A	N/A	N/A	N/A							N/A										
0F	Reserved for ACAS	N/A	N/A	N/A	N/A							N/A										
10	Data Link Capability Report	N/A	N/A	N/A	N/A							See Note 18										

Table 2.2. Mode S transponder register data requirements and input availability

DATA REQUIREMENTS												INPUT DATA SOURCE AVAILABILITY (See Note 1)										
Register Number (HEX)	Assignment	Register Field	ARINC Word (Octal)	Parameter Description	Signal Format	UNITS	+ Sense	RANGE	Sig. Bits/ Dig.	RESOLUTION	MAX TX INTVL-ms	GPS	FMC/ GNSS	IRS/ FMS	FMC GEN	ADS	Control Panel	FCC/ MCP	DFS/ VHF	Weather	Maint Comp	Notes
11 -to- 16	Reserved for Extension to Data Link Capability Report	N/A	N/A	N/A	N/A							N/A										
17	Common Usage GICB CapabilityReport	N/A	N/A	N/A	N/A							N/A										
18 -to- 1F	Mode S Specific Services Capability Report	N/A	N/A	N/A	N/A							N/A										
20	Aircraft Identification	Characters 1 – 8	233	Flight Identification Word #1	See ARINC 718A							See Note 17										12
			234	Flight Identification Word #2	See ARINC 718A							See Note 17										
			235	Flight Identification Word #3	See ARINC 718A							See Note 17										
			236	Flight Identification Word #4	See ARINC 718A							See Note 17										
		Characters 9 – 10	237	Flight Identification Word #5	Reserved for Flight Identification Characters 9 and 10																	
		Characters 1 – 8	301	Aircraft Identification Word #1	See Notes 13 and 14							See Notes 13 and 14										13, 14
			302	Aircraft Identification Word #2	See Notes 13 and 14							See Notes 13 and 14										
			303	Aircraft Identification Word #3	See Notes 13 and 14							See Notes 13 and 14										
		Characters 1 – 8	360	Flight Number Character 1 - 8	See ARINC 429P1, Attachment 6 Flight Identification							See Note 17										12
21	Aircraft Registration Number	Characters 1 – 8	301	Aircraft Identification Word #1	See Notes 13 and 14							See Notes 13 and 14										13, 14
			302	Aircraft Identification Word #2	See Notes 13 and 14							See Notes 13 and 14										
			303	Aircraft Identification Word #3	See Notes 13 and 14							See Notes 13 and 14										
		Airline Registration Characters 1 – 2	N/A	Airline Registrations	N/A							N/A										
22	Antenna Position		N/A	Antenna 1–4 Position Information	TBD							TBD										
25	Aircraft Type	Model Description	N/A	Aircraft Type / Model Information	TBD							TBD										
26 -to- 2F	Unassigned	N/A	N/A	N/A	N/A							N/A										
30	ACAS Active Resolution Advisory		N/A	N/A	N/A							N/A										
31 to 3F	Unassigned	N/A	N/A	N/A	N/A							N/A										
40	SELECTED VERTICAL INTENTION	MCP/FCU Selected Altitude	102	MCP/FCU Selected Altitude	BNR	feet	+	65 536	16	1.0	200			2				1				15
			025	Selected Altitude	BCD	feet	+	0 – 50 000	5	1.0	200			2				1				15
		FMS Selected Altitude	102	Selected Altitude	BNR	feet	+	65 536	16	1.0	200		1	3	2							19
		Barometric pressure setting MINUS 800 mb	234	Barometric Pressure Setting Minus 800 mb	BCD	millibars	+	750-1 050	5	0.1	125							1				19
		VNAV MODE	272	From MCP of the FMC System	DISC	N/A					100 Min			2				1				16
		APPROACH MODE	273	From MCP of the FMC System	DISC	N/A					100 Min			2				1				16
		ALT HOLD MODE	272	From MCP of the FMC System	DISC	N/A					100 Min			2				1				16
		Status of Target Altitude Source Bits			N/A							N/A										16
		Target Altitude Source			N/A							N/A										16
41	Next Waypoint Details	Character 1 – 9	TBD	TBD	TBD							TBD										
42	Next Waypoint Details	Waypoint Latitude	TBD	TBD	TBD							TBD										
		Waypoint Longitude	TBD	TBD	TBD							TBD										
		Waypoint Crossing Altitude	TBD	TBD	TBD							TBD										

Table 2.2. Mode S transponder register data requirements and input availability

DATA REQUIREMENTS												INPUT DATA SOURCE AVAILABILITY (See Note 1)										
Register Number (HEX)	Assignment	Register Field	ARINC Word (Octal)	Parameter Description	Signal Format	UNITS	+ Sense	RANGE	Sig. Bits/ Dig.	RESOLUTION	MAX TX INTVL-ms	GPS	FMC/ GNSS	IRS/ FMS	FMC GEN	ADS	Control Panel	FCC/ MCP	DFS/ VHF	Weather	Maint Comp	Notes
43	Next Waypoint Details	Bearing to Waypoint	115	Waypoint Bearing	BNR	deg./180	+	+/- 180	12	0.05	200		1	3	2							
		Time to Go (TTG)	002	Time to Go (TTG) to Waypoint	BCD	min.	+	0 - 399.9	4	0.1	200		1	3	2							
		Distance to Go (DTG)	001	Distance to Go (DTG) to Waypoint	BCD	n.m.	+	+/- 3 999.9	5	0.1	200		1	3	2							
44	Meteorological Routine Air Report	Wind Speed	315	Wind	BNR	knots	+	256	8	1.0	100		1	3	2							
		Wind Speed	015	Speed	BCD	knots	+	0 - 399	3	1.0	500		1	3	2							
		True Wind Direction	316	Wind	BNR	deg./180	CW-N	+/- 180	8	0.7	100		1	3	2							
		True Wind Direction	016	Direction	BCD	degrees	+	0 - 359	3	1.0	500		1	3	2							
		Static Air Temperature	213	Static Air Temperature	BNR	deg. C	+	512	11	0.25	500			2		1						
		Average Static Pressure	217	Average Static Pressure	BNR	in. Hg.	+	64	16	0.000 976 562 5	62.5			2		1						
			TBD	Turbulence	TBD									3		2				1		
		Humidity	113	Humidity	BNR	%	+	100	9	0.195 312 5				3		2				1		
45	Meteorological Hazard Report	Turbulence	TBD	Turbulence	TBD							TBD										
		Wind Shear	TBD	Wind Shear	TBD							TBD										
		Microburst	TBD	Microburst	TBD							TBD										
		Icing	TBD	Icing	TBD							TBD										
		Wake Vortex	TBD	Wake Vortex	TBD							TBD										
		Static Air Temperature	213	Static Air Temperature	BNR	deg. C	+	512	11	0.25	500			2		1						
		Average Static Pressure	217	Average Static Pressure	BNR	in. Hg.	+	64	16	0.000 976 562 5	62.5			2		1						
		Radio	164	Radio Height	BNR	feet	+	8 192	16	0.125	50			2						1		
46	Reserved for Flight Management System _ Mode 1	Height	165	Radio Height	BCD	feet	+	+/- 7 999.9	5	0.1	200			2						1		
		TBD	TBD	TBD	TBD							TBD										
47	Reserved for Flight Management System_ Mode 2	TBD	TBD	TBD	TBD							TBD										
48	VHF Channel Report	VHF 1 – 3	030	VHF Comm Frequency	See ARINC 429									2					1			
			047	VHF Comm Frequency	See ARINC 429									2					1			
		Audio Status	N/A	Audio Status	N/A							N/A										
49 to 4F	Unassigned	N/A	N/A	N/A	N/A							N/A										
50	Track and Turn Report	Roll Angle	325	Roll Angle	BNR	deg./180	Right	+/- 180	14	0.01	20		1	3	2							
		True Track Angle	313	True Track Angle	BNR	deg./180	+	+/- 180	12	0.05	50		1	3	2							
			013	True Track Angle	BCD	degrees	+	0 – 359.9	4	0.1	500		1	3	2							
			103	GNSS Track Angle	BNR	degrees	CW-N	+/- 180	15	0.054 931 6	1 200	1	2	3								
		Ground Speed	112	GNSS Ground Speed	BNR	knots	+	4 096	15	0.125	1 200	1	2	3								
			312	Ground Speed	BNR	knots	+	4 096	15	0.125	50		1	3	2							
			012	Ground Speed	BCD	knots	+	0 - 7 000	4	1.0	500		1	3	2							
		Track Angle Rate	335	Track Angle Rate	BNR	deg./sec.	+	32	11	0.015	20		1	3	2							
		True Airspeed	210	True Airspeed	BNR	knots	+	2 048	15	0.062 5	125			2		1						
			230	True Airspeed	BCD	knots	+	100 - 599	3	1.0	500			2		1						

Table 2.2. Mode S transponder register data requirements and input availability

DATA REQUIREMENTS												INPUT DATA SOURCE AVAILABILITY (See Note 1)										
Register Number (HEX)	Assignment	Register Field	ARINC Word (Octal)	Parameter Description	Signal Format	UNITS	+ Sense	RANGE	Sig. Bits/ Dig.	RESOLUTION	MAX TX INTVL-ms	GPS	FMC/ GNSS	IRS/ FMS	FMC GEN	ADS	Control Panel	FCC/ MCP	DFS/ VHF	Weather	Maint Comp	Notes
51	Position Report Coarse	Latitude	110	GNSS Latitude, Coarse	BNR	degrees	N	+/- 180	20	0.000 171 66	1 200	1	2	3								
			010	Latitude, Present Position	BCD	degrees	N	180N – 180S	6	0.1	500		1	3	2							
			310	Latitude, Present Position	BNR	degrees	N	0 – 180N/ 0 – 180S	20	0.000 171 66	200		1	3	2							
		Longitude	111	GNSS Longitude, Coarse	BNR	degrees	E	+/- 180	20	0.000 171 66	1 200	1	2	3								
			011	Longitude, Present Position	BCD	degrees	E	180E – 180W	6	0.1	500			1								
			311	Longitude, Present Position	BNR	degrees	E	0 – 180E/ 0 – 180W	20	0.000 171 66	200		1	3	2							
		Pressure Altitude	203	Altitude (1 013.25 hPa) (Barometric)	BNR	feet	UP	+131 072	17	1.0	62.5			2		1						
52	Position Report Fine	Latitude, Fine	120	GNSS Latitude, Fine	BNR	degrees	+	0.000 172	11	8.3819E-8	1 200	1	2	3								
		Longitude, Fine	121	GNSS Longitude, Fine	BNR	degrees	+	0.000 172	11	8.3819E-8	1 200	1	2	3								
		Pressure / GNSS Altitude	203	Altitude (1 013.25 hPa) (Barometric)	BNR	feet	UP	+131 072	17	1.0	62.5			2		1						
			370	GNSS Height (HAE)	BNR	feet	UP	=/- 131 072	20	0.125	1 200	1	2	3								
53	Air Referenced State Vector	Magnetic	320	Magnetic Heading	BNR	Deg./180	+	+/- 180	15	0.054 931 6	50		1	3	2							
		Heading	014	Magnetic Heading	BCD	degrees	+	+/- 359.9	4	0.1	500		1	3	2							
		IAS	206	Computed Airspeed	BNR	knots	+	1 024	14	0.062 5	125			2		1						
		Mach	205	Mach	BNR	mach	+	4 096	16	0.000 625	125			2		1						
		True	210	True Airspeed	BNR	knots	+	2 048	15	0.062 5	125			2		1						
		Airspeed	230	True Airspeed	BCD	knots	+	100 - 599	3	1.0	500			2		1						
			212	Altitude Rate, Barometric	BNR	Ft./min.	+	32 768	11	16	62.5			2		1						
		Altitude	232	Altitude Rate	BNR	Ft./min.	UP	+/- 20 000	4	10.0	62.5			2		1						
		Rate	165	GNSS Vertical Velocity	BNR	Ft./min.	UP	+/- 32 768	15	1.0	1 200	1	2	3								
			365	Inertial Vertical Velocity	BNR	Ft./min.	+	32 768	15	1.0	40		1	3	2							
54	Waypoint #1	Char 1 – 5	130	TCP Identification	TBD							TBD										
		ETA	056	Estimated Time of Arrival (ETA)	BCD	hr.:min.	+	0 - 23.59.9	5	0.1	500		1	2								
		Estimated Flight Level	TBD	TBD	TBD							TBD										
		Time to Go	002	Time to Go (TTG)	BCD	min.	+	0 - 399.9	4	0.1	200		1	2								
55	Waypoint #2	Char 1 - 5	130	TCP Identification	TBD							TBD										
		ETA	056	Estimated Time of Arrival (ETA)	BCD	hr.:min.	+	0 - 23.59.9	5	0.1	500		1	2								
		Estimated Flight Level Time to Go	TBD	TBD	TBD							TBD										
			002	Time to Go (TTG)	BCD	min.	+	0 - 399.9	4	0.1	200		1	2								
56	Waypoint #3	Char 1 – 5	130	TCP Identification	TBD							TBD										
		ETA	056	Estimated Time of Arrival (ETA)	BCD	hr.:min.	+	0 - 23.59.9	5	0.1	500		1	2								
		Estimated Flight Level	TBD	TBD	TBD							TBD										
		Time to Go	002	Time to Go (TTG)	BCD	min.	+	0 - 399.9	4	0.1	200		1	2								
57 to 5E	Not Assigned	N/A	N/A	N/A	N/A							N/A										

Table 2.2. Mode S transponder register data requirements and input availability

DATA REQUIREMENTS												INPUT DATA SOURCE AVAILABILITY (See Note 1)										
Register Number (HEX)	Assignment	Register Field	ARINC Word (Octal)	Parameter Description	Signal Format	UNITS	+ Sense	RANGE	Sig. Bits/ Dig.	RESOLUTION	MAX TX INTVL-ms	GPS	FMC/ GNSS	IRS/ FMS	FMC GEN	ADS	Control Panel	FCC/ MCP	DFS/ VHF	Weather	Maint Comp	Notes
5F	Quasi-Static Parameter Monitoring	Selected Altitude	102	Selected Altitude	BNR	feet	+	65 536	16	1.0	200			2				1				
			025	Selected Altitude	BCD	feet	+	0 – 50 000	5	1.0	200			2				1				15
		Selected Heading	101	Selected Heading	BNR	Deg./180	+	+/- 180	12	0.05	62.5			2				1				15
			023	Selected Heading	BCD	degrees	+	0 - 359	3	1.0	200			2				1				15
		Selected Airspeed	103	Selected Airspeed	BNR	knots	+	512	11	0.25	200			2				1				15
			026	Selected Airspeed	BCD	knots	+	30 - 450	3	1.0	200			2				1				15
		Selected Mach	106	Selected Mach	BNR	m mach	+	4 096	12	1.0	200			2				1				15
			022	Selected Mach	BCD	mach	+	0 - 4	4	0.001	200			2				1				15
		Selected Altitude Rate	104	Selected Vertical Rate	BNR	ft./min.	UP	16 384	10	16	200			2				1				15
			020	Selected Vertical Rate	BCD	ft./min.	UP	+/- 6 000	4	1.0	500			2				1				15
		Sel Flt Path Angle	TBD	Selected Flight Path Angle	TBD							TBD										
		Next WayPt		Next Waypoint	See transponder register numbers 41_{16}, 42_{16}, and 43_{16} above							See transponder register numbers 41_{16}, 42_{16}, and 43_{16} above										
		FMS Horizontal Mode		FMS Horizontal Mode	TBD							TBD										
		FMS Vertical Mode		FMS Vertical Mode	See transponder register number 40_{16} above							See transponder register number 40_{16} above										
		VHF Channel Report		VHF Channel Report	See transponder register number 48_{16} above							See transponder register number 48_{16} above										
		Met Hazards		Meteorological Report	See transponder register number 45_{16} above							See transponder register number 45_{16} above										
60	Heading and Speed Report	Magnetic	320	Magnetic Heading	BNR	Deg./180	+	+/- 180	15	0.054 931 6	50		1	3	2							
		Heading	014	Magnetic Heading	BCD	degrees	+	+/- 359.9	4	0.1	500		1	3	2							
		IAS	206	Computed Airspeed	BNR	knots	+	1 024	14	0.062 5	125			2		1						
		Mach	205	Mach	BNR	mach	+	4 096	16	0.000 625	125			2		1						
		Baro Alt Rate	212	Altitude Rate, Barometric	BNR	Ft./min.	+	32 768	11	16	62.5			2		1						
		Inertial VerticalVelocity	365	Inertial Vertical Velocity	BNR	Ft./min.	+	32 768	15	1.0	40		1	3	2							
61	Extended Squitter Emergency/Priority Status		N/A	Emergency / Priority Status	N/A							N/A										
62 to 63	Current / Next Trajectory Change Point (TCP / TCP + 1)	TCP Latitude	TBD	Trajectory Change Point Latitude	TBD							TBD										
		TCP Longitude	TBD	Trajectory Change Point Longitude	TBD							TBD										
		TCP Crossing Altitude	TBD	Trajectory Change Point Crossing Altitude	TBD							TBD										
		Time to Go	TBD	Time to Go (TTG) -to- Trajectory Change Point	TBD							TBD										
64	Aircraft Operational Coordination Message	Paired Address	TBD	Paired Address	TBD							TBD										
		Runway Thresh Spd	TBD	Runway Threshold Speed	TBD							TBD										
		Roll Angle	325	Roll Angle	BNR	deg./180	Right	+/- 180	14	0.01	20		1	3	2							
		Go Around	TBD	Go Around Indication	TBD							TBD										
		Engine Out	TBD	Engine Out Indication	TBD							TBD										

Table 2.2. Mode S transponder register data requirements and input availability

DATA REQUIREMENTS												INPUT DATA SOURCE AVAILABILITY (See Note 1)										
Register Number (HEX)	Assignment	Register Field	ARINC Word (Octal)	Parameter Description	Signal Format	UNITS	+ Sense	RANGE	Sig. Bits/ Dig.	RESOLUTION	MAX TX INTVL-ms	GPS	FMC/ GNSS	IRS/ FMS	FMC GEN	ADS	Control Panel	FCC/ MCP	DFS/ VHF	Weather	Maint Comp	Notes
65	Aircraft Operational Status	Enroute Op Cap	TBD	Enroute Operational Capability	TBD							TBD										
		Term Area Op Cap	TBD	Terminal Area Operational Capability	TBD							TBD										
		App/Land Op Cap	TBD	Approach/Landing Operational Capability	TBD							TBD										
		Surface Op Capability	TBD	Surface Operational Capability	TBD							TBD										
		Enroute Op Cap Status	TBD	Enroute Operational Capability Status	TBD							TBD										
		Term Area Op Cap Status	TBD	Terminal Area Operational Capability Status	TBD							TBD										
		App/Land Op Cap Status	TBD	Approach/Landing Operational Capability Status	TBD							TBD										
		Surface Op Cap Status	TBD	Surface Operational Capability Status	TBD							TBD										
66 -to-F0	Unassigned	N/A	N/A	N/A	N/A							N/A										
F1	Reserved for Military Use	N/A	N/A	N/A	N/A							N/A										
F2 -to- FF	Unassigned	N/A	N/A	N/A	N/A							N/A										

NOTES.—

1. As a universal fit, this table provides many sources of potential data. The designer is to note that duplicate information is not necessary (i.e. once a supply for the needed data is found, no more dedicated inputs are required).

   The preferred priority of the data source to be used for each parameter is indicated by 1, 2, 3, etc., in the appropriate data source columns when such priority is applicable. The highest priority is given by 1 with priority decreasing to 3, etc.

   The Data Concentrator input ports should be monitored to determine the presence of an active ATSU Data Concentrator as shown below. If an active ATSU is detected, the transponder should modify the input port priorities such that the Data Concentrator port has the top priority of all data sources. Exceptions to this rule are: the Flight ID priority should remain as stated in Note 17, and the GPS input ports should remain the top priority for the applicable labels as listed in the table.

   If an active ATSU is detected, but certain data labels are not present on the ATSU Data Concentrator port, the transponder should default to the input data priority as listed in the table to obtain the missing data.

   ATSU Active determination:
   label 377 is received with a value of 167Hex,
   AND
   label 270 is received with bit 16=0 (ATSU in Normal operation) AND bit 20=1
   (ATSU is active)

2. The Type field encoding for this transponder register requires information specific to horizontal and/or vertical position accuracy. Information given herein is intended to provide such data.

3. Surveillance Status is a function of the Mode S transponder and Automatic Dependent Surveillance – Broadcast (ADS-B) transmitters. Appropriate definition for setting of the Surveillance Status is provided in the applicable Minimum Operational Performance Standards (MOPS) for these systems, as well as in Annex 10 Volume III, Appendix to Chapter 5 in regards to definitions of transponder register number 05_{16}.

4. The Single Antenna Flag is a function of the Mode S transponder and ADS-B transmitters. Appropriate definition for setting the Single Antenna Flag is provided in the applicable MOPS for these systems, as well as in Annex 10 Volume III in regards to definitions of transponder register number 05_{16}.

5. The Compact Position Reporting (CPR) algorithm requires positional information and velocity information. Information given here is in the form of polar velocity (e.g. label 103 GNSS Track Angle and label 112 GNSS Ground Speed can be used to derive polar velocity).

6. The CPR algorithm requires positional information and velocity information. Information given here is in the form of rectangular velocity (e.g. label 166 GNSS N/S Velocity and label 174 GNSS E/W Velocity can be used to derive rectangular velocity).

7. Utilized for encoding Movement information.

8. Utilized for encoding Ground Track information.

9. The Transmission Rate Subfield is a function of the Mode S transponder and ADS-B transmitters. Appropriate definition for setting the Transmission Rate Subfield is provided in the applicable MOPS for these systems, as well as in Annex 10 Volume III, Appendix to Chapter 5 in regards to definitions of transponder register number 07_{16}.

10. Data received from a Radio Altimeter data source.

11. Data received from a VHF Comm. data source.

12. Transponder register numbers 08_{16} and 20_{16} allow for encoding only 8 characters. On certain airframe configurations this information may be provided within ARINC 429 labels 233-237 or label 360. In all cases, encoding of these transponder register subfields should conform to Annex 10 Volume IV, 3.1.2.9 where:

- All characters will be left justified prior to encoding the character fields.
- Characters will be coded consecutively without intervening SPACE codes.
- Any unused character spaces at the end of the subfield should contain a SPACE character code.
- Any extra characters will be truncated.

The sign status matrix of labels 233 through 237 should be treated by the transponder as follows:

SSM 233 - 236		
BIT		MEANING
31	30	
0	0	Normal Operation
0	1	No Computed Data
1	0	Functional Test
1	1	Normal Operation

It is recommended that control panels and other devices supplying these labels do so by setting the sign status matrix of labels 233 through 237 to 1,1 for normal operation in accordance with ARINC 429P1.

Note.— The following information is provided in order to clarify the confusion that has existed in the industry in regards to definition of the status matrix for labels 233 through 236. This document now establishes the status matrix to be consistent with ARINC 429P1 as given below. Implementers should take note that this reflects a change from what was previously defined in ARINC 718 and EUROCAE ED-86.

ARINC 429 P1 Attachment 1 identifies labels 233 through 236 as ACMS data having binary (BNR) format. Word structure for labels 233 through 236 is provided in ARINC 429P1, Attachment 6. ARINC 429P1 Section 2.1.5.2 defines the status matrix for binary words as follows:

BNR SSM		
BIT		MEANING
31	30	
0	0	Failure Warning
0	1	No Computed Data
1	0	Functional Test
1	1	Normal Operation

Previous definitions of labels 233 through 236 provided in ARINC 718 and subsequent documents identified the status matrix for BCD or discrete data. The status matrix in these words was then given by either of the two following tables:

BCD SSM (Old)		
BIT		MEANING
30	31	
0	0	VALID
0	1	No Computed Data
1	0	Functional Test
1	1	Not Defined

DISCRETE SSM		
BIT		MEANING
31	30	
0	0	Normal Operation
0	1	No Computed Data
1	0	Functional Test
1	1	Failure Warning

13. Flight identification or aircraft registration data usage should adhere to the following guidelines:
    a. In accordance with the intent of Annex 10 Volume IV, 3.1.2.9, if flight identification data (labels 233 – 237, respectively, or label 360) are available (i.e. proper labels received and SSM is not set to No Computed Data (NCD)) at any time during unit operation, then flight identification data should be inserted into the character subfields of transponder registers 08_{16} and 20_{16}.
    b. If flight identification data are NOT available (i.e. no labels received or SSM set to NCD) then aircraft registration should be inserted into the character subfields of transponder register numbers 08_{16} and 20_{16}. On certain airframe configurations aircraft registration data may be provided within ARINC-429 labels 301 – 303.
    c. If flight identification data have been entered into transponder register numbers 08_{16} and 20_{16} and then become NOT available, then the character subfields of the transponder registers should be set to all ZEROs.
    Note that Aircraft Registration data must NOT be used to fill the character subfields of the transponder registers once flight identification data have been used during the transponder power-on cycle.
    d. In all of the above cases, encoding of the character subfields in registers 08_{16} and 20_{16} should conform to Annex 10 Volume IV, 3.1.2.9 where:
        - All characters will be left justified prior to encoding the character fields.
        - Characters will be coded consecutively without intervening SPACE codes.
        - Any unused character spaces at the end of the subfield will contain a SPACE character code.
        - Any extra characters will be truncated.

14. Aircraft identification labels 301-303 can be obtained from the Centralized Fault Display System via the CFDIU (Centralized Fault Display Interface Unit) on the aircraft's maintenance bus. This is typically an ARINC 429 low speed bus.

15. Although data are shown to be available from the MCP, it is more probable that they will be available from the FCC Control Panel (ARINC 701). In this case, the FCC Control Panel and the MCP are treated as one and the same.

16. There is at present no clear availability of coding of target altitude source, but with knowledge of the aircraft type on which the transponder is installed, the VNAV, Approach and Alt Hold mode bits can possibly be identified and used in transponder register 40_{16}. It is expected that standardized mode coding labels will be available from the FMC, Autopilot or Data Concentrator on the aircraft. Note that the referenced MCP has an equipment code of $01D_{HEX}$.
Availability and coding of autopilot mode status information varies from aircraft type to aircraft type. Note that the designer should take into account the specific aircraft's flight systems when encoding these fields. The following logic is an example of how to set transponder register 40_{16} mode fields:
For the VNAV mode encoding, the following logic applies:
IF label 272 bit 13 = "1" (indicating VNAV is engaged)
THEN set transponder register 40_{16} VNAV mode field to "Active" (indicating that the A/C is in the VNAV state).
For the ALT HOLD mode encoding, the following logic applies:
IF label 273 bit 19 = "0" (indicating that Approach Mode is not engaged) AND
label 272 bit 9 = "1" (indicating that Altitude Hold Mode is engaged)
THEN set transponder register 40_{16} ALT HOLD mode field to "Active" (indicating that the A/C is in the Alt Hold state).
For the APPROACH mode encoding, the following logic applies:
IF label 272 bit 9 = "0" (indicating that Altitude Hold is not engaged) AND
label 273 bit 19 = "1" (indicating that Approach Mode is engaged)
THEN set transponder register 40_{16} APPROACH mode field to "Active" (indicating that the A/C is in the Approach state).

17. To achieve the most satisfactory source of flight identification data, the source is more important than the label that carries the data. Therefore flight identification should be captured using the following priority configuration:

Priority	Label	Source
1	233-237	Control Panel
2	360	Control Panel
3	233-237	FMC Gen
4	360	FMC Gen
5	233-237	FMC/GNSS
6	360	FMC/GNSS
7	233-237	IRS/FMS/Data Conc.
8	360	IRS/FMS/Data Conc.
9	233-237	Maintenance Data In
10	360	Maintenance Data In
11	301-303	Maintenance Data In (see Note 13)

18. The contents and source for transponder register number 10_{16} are strictly defined in Annex 10 Volume III , Chapter 5 and Appendix to Chapter 5.

19. In the definition of transponder register number 40_{16} in Annex 10, mode bits 55 and 56 DO NOT indicate the content of any other fields in the register, they DO give to the recipient of the data contained in transponder register 40_{16}, the information as to which altitude source the aircraft is actually using to determine its short term altitude intent. When the target altitude source for aircraft short term altitude intent is unknown, these bits should be set to 00 and the status bit for target altitude source (bit 54) should be set to 1.

The Fields in transponder register 40_{16} should contain the following data:

Bits 1 to 13 of transponder register 40_{16} should only ever contain the 'MCP/FCU Selected Altitude' or all zeros.
Bits 14 to 26 of transponder register 40_{16} should only ever contain the 'FMS Selected Altitude' or all zeros.
Bits 27 to 39 of transponder register 40_{16} should only ever contain the 'Barometric pressure setting minus 800mb' or all zeros.
Bits 48 to 56 of transponder register 40_{16} should only ever contain the information as specified in paragraph 5 of the text alongside Table 2.64 in the Appendix to Chapter 5 of Annex 10 Volume III.

Target altitude is 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 will be indicated in the altitude source bits (54 to 56). *Note.— This information which represents the real "aircraft intent", when available, is represented by the altitude control panel selected altitude, the flight management system selected altitude, or the current aircraft altitude according to the aircraft's mode of flight (the intent may not be available at all when the pilot is flying the aircraft).* The current barometric pressure setting shall be calculated from the value inserted in the field (bits 28 to 39) plus 800 mb. When the barometric pressure setting is less than 800 mb or greater than 1 209.5 mb, the status bit for this field (bit 27) shall be set to indicate invalid data.

20. The best resolution currently available is 0.05 degrees. Coding space in this field is available for a resolution of 0.01 degrees.

Table 2-3. 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

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*
	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

Table 2-4. 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

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*
	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

Table 2-5. 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	**	90.0000000
45	41.3865183	30	59.9545928	15	75.4205626		
** Δlon = 360 nautical miles							

— END —

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