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RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #14

Proposed Revisions to Appendix A for 1090 TIS-B and ADS-B MASPS Changes

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SUMMARY
This working paper presents a revised draft of Appendix A that contains all of the new material for ADS-B and TIS-B formats and protocols. This draft is not complete. Missing items include (1) the broadcast rates for Target State and Status Information Message and the Aircraft Operational Status Message, and (2) the revised priority structure to be used if the broadcast rate exceeds 6.2 per second. Material for the above two items is available in the draft of Section 2.2 and will be included in the next revision to Appendix A

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Appendix A

Extended Squitter and TIS-B Formats And Coding Definitions

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A Extended Squitter Formats and Coding Definitions

A.1 ADS-B 1090 MHz Formats and Coding

A.1.1 Introduction

This Appendix is intended to be consistent with Section 2 of these MOPS. However, in the event of conflict between this Appendix and Section 2, the requirements in Section 2 **shall** take precedence.

Notes:

1. *This section of Appendix A defines the formats and coding for Extended Squitter ADS-B messages. When Extended Squitter capability is incorporated into a Mode S transponder, the registers used to contain the Extended Squitter messages are part of the transponder's Ground-Initiated Comm-B service. This service consists of defined data available on board the aircraft being put into one of the 255 registers (each with a length of 56 bits) in the Mode S transponder by a serving process, e.g. ADS-B, at specified intervals. The Mode S ground interrogator can extract the information from any of these registers at any time and pass it to the ground-based application. In the case of Extended Squitter, the information in the registers defined for ADS-B are spontaneously broadcast as specified in RTCA/DO-181C. Extended Squitter messages are generated by the Mode S transponder at periodic rates as defined by DO-181C, when data is present in Register numbers 05 {HEX}, 06 {HEX}, 08 {HEX}, and 09 {HEX}. Each time data is loaded into Register 0A {HEX} the transponder will broadcast a single event-driven Extended Squitter. Data loaded into Registers 07 {HEX}, 61 {HEX}, 62 {HEX}, and 63 {HEX} while related to the Extended Squitter services is not used directly by the transponder for any Extended Squitter broadcast. However the contents of these registers is available as part of the transponder's Ground-Initiated Comm-B service.*

2. *If the Extended Squitter capability is implemented as a non-transponder function, the convention for register numbering does not apply. However, the data content is the same as specified for the transponder case, and the transmit times are as specified in the body of this MOPS.*

A.1.2 Register Allocation Related to Extended Squitter

Table A-1: Register Allocation

Register number	Assignment	Minimum update rate
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	5.0 s
09_{16}	Extended Squitter Airborne Velocity	0.2 s
$0A_{16}$	Extended Squitter Event-Driven Information	variable
10_{16}	Data Link Capability Report	4.0 s (see Note 2)
17_{16}	Common usage Capability Report	5.0 s
18_{16}-$1F_{16}$	Mode S Specific Services Capability Report	5.0 s
20_{16}	Aircraft Identification	5.0 s
61_{16}	Emergency/Priority Status	1.0 s
62_{16}	Target State and Status Information	0.5 s
63_{16}	Aircraft Operational Status	0.5 s
64_{16}-$6F_{16}$	Reserved for Extended Squitter	

Notes:

1. *The register number is equivalent to the BDS B-Definition Subfield (BDS) value §2.2.14.4.14.b of DO-181C.*

2. *For ADS-B implementations on Mode S transponders, the data link capability report (BDS1,0) is used to indicate Extended Squitter capability (bit 34) and the contents of this register are updated within one second of the data changing and at least every four seconds thereafter.*

3. *Register 0A {HEX} is not to be used for GICB or ACAS crosslink readout.*

The details of the data to be entered into the registers assigned for Extended Squitter will be as defined in this Appendix. Table A-1 specifies the minimum update rates at which the appropriate transponder register(s) will be reloaded with valid data. If the defined update rate is not maintained, the status bit (if provided) will indicate that the data in that field are invalid.

A.1.3 General Conventions On Data Formats

A.1.3.1 Validity of Data

The bit patterns contained in the 56-bit transponder registers **shall** be considered to be valid application data only if:

1. The Mode S specific services capability is present. This is indicated by bit 25 of the data link capability report contained in BDS 1,0 being set to “ONE;”

2. The service corresponding to the application is shown as “supported” by the corresponding bit in the Common Usage Capability Report (BDS 1,7) being set to “ONE” for the Extended Squitter Registers 05 {HEX} to 0A {HEX} inclusive.

   Notes:

   1. *The intent of the capability bits in Register 17 {HEX} is to indicate that useful data is contained in the corresponding register. For this reason, the bit for a register is cleared if data becomes unavailable (§A.1.6.2) and set again when data insertion into the register resumes.*

   2. *A bit set in Register 18 {HEX} to 1C {HEX} indicates that the application using this register has been installed on the aircraft. These bits are not cleared to reflect a real time loss of an application, as is done for Register 17 {HEX}.*

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

A.1.3.2 Representation of Numerical Data

Numerical data **shall** be represented as follows:

1. Numerical data are represented as binary numerals. When the value is signed, 2’s complement representation is used, and the bit following the status bit is the sign bit.

2. Whenever applicable, the resolution has been either tailored to the corresponding ARINC 429 label or aligned with ICAO documents.

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

4. Where ARINC 429 data are used, the ARINC 429 status bits 30 and 31 are 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.

5. In all cases where a status bit is used, it must be set to “ONE” to indicate VALID and to “ZERO” to indicate INVALID.

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

7. Bits are numbered in the Message, Comm-B Field in order of their transmission, beginning with bit 1. If numerical values are encoded by groups of bits (fields), then the first bit transmitted is the most significant bit (MSB) unless otherwise stated.

Note: *BDS A,B is equivalent to Register Number AB_{16}.*

A.1.4 Extended Squitter Formats

A.1.4.1 Format Type Codes

The first 5-bit field in every Mode S Extended Squitter message will contain the format type. The format type will differentiate the messages into several classes: airborne position, airborne velocity, surface position, identification, aircraft intent, aircraft state, etc. In addition, the format type will also encode the Navigation Integrity Category (NIC) of the source used for the position report. The format type will also differentiate the airborne messages as to the type of their altitude measurements: barometric pressure altitude or GNSS height (HAE). The 5-bit encoding for format type will conform to the definition contained in Table A-2.

Table A-2: Format Type Codes

Type Code	Format (Message Type)	Horizontal Containment Limit (R_C) and Navigation Integrity Category (NIC)		Altitude Type	Notes
0	No Position Information (**Airborne Position Message** or **Surface Position Message**)	R_C unknown	NIC = 0	Baro Altitude *or* No Altitude Information	1, 2, 3
1	**Aircraft Identification and Type Message** (§2.2.3.2.5)	*Not Applicable*		*Not Applicable*	Category Set D
2		*Not Applicable*		*Not Applicable*	Category Set C
3		*Not Applicable*		*Not Applicable*	Category Set B
4		*Not Applicable*		*Not Applicable*	Category Set A
5	**Surface Position Message** (§2.2.3.2.4)	R_C < 7.5 m	NIC = 11	No Altitude Information	
6		R_C < 75 m	NIC = 9 or 10		6
7		R_C < 0.1 NM (185.2 m)	NIC = 8		
8		R_C = 0.1 NM (185.2 m) or unknown	NIC = 0		
9	**Airborne Position Message** (§2.2.3.2.3)	R_C < 7.5 m *and* VPL < 11 m	NIC = 11	Baro Altitude	5
10		R_C < 75 m *and* VPL < 112 m	NIC = 9 or 10		5, 6
11		R_C < 0.1 NM (185.2 m)	NIC = 8		
12		R_C < 0.2 NM (370.4 m)	NIC = 7		
13		R_C < 0.6 NM (1111.2 m)	NIC = 6		
14		R_C < 1.0 NM (1852 m)	NIC = 5		
15		R_C < 2 NM (3.704 km)	NIC = 4		
16		R_C < 8 NM (14.816 km)	NIC = 2 or 3		7
17		R_C < 20 NM (37.04 km)	NIC = 1		
18		R_C = 20 NM (37.04 km) or unknown	NIC = 0		
19	**Airborne Velocity Message** (§2.2.3.2.6)	*Not Applicable*		*Difference between "Baro Altitude" and "GNSS Height (HAE)"*	
20	**Airborne Position Message** (§2.2.3.2.3)	R_C < 7.5 m *and* VPL < 11 m	NIC = 11	GNSS Height (HAE)	2, 5
21		R_C < 25 m *and* VPL < 37.5 m	NIC = 10		2, 5
22		R_C = 25 m *or* VPL = 37.5 m *or* R_C or VPL unknown	NIC = 0		2
23	**Reserved for Test Purposes (§2.2.3.2.7.3)**				
24	**Reserved for Surface System Status (§2.2.3.2.7.4)**				
25 - 27	**Reserved (§2.2.3.2.7.5 to §2.2.3.2.7.7)**				
28	**Aircraft Status Message (§2.2.3.2.7.8)**				
29	**Target State and Status Message (§2.2.3.2.7.1)**				
30	**Reserved**				
31	**Aircraft Operational Status Message (§2.2.3.2.7.2)**				

Notes:

1. *"Baro-Altitude" refers to barometric pressure altitude, relative to a standard pressure of 1013.25 millibars (29.92 in Hg). It does not refer to baro corrected altitude.*

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

3. *After initialization, when horizontal position information is not available but altitude information is available, the Airborne Position Message is transmitted with a type code of zero in bits 1-5, the barometric pressure altitude in bits 9 to 20, and bits 22 to 56 set to zero. If neither horizontal position nor barometric altitude information is available, then all 56 bits of Register 05 {HEX} are set to zero. The ZERO Type Code field indicates that latitude and longitude information is not available, while the ZERO altitude field indicates that altitude information is not available.*

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

5. *This TYPE code value implies limits for both R_C (horizontal containment limit) and VPL (Vertical Protection Limit). If* <u>*either*</u> *of these limits is not satisfied, then a different value for the TYPE code should be selected.*

6 *The "NIC supplement" field in the Aircraft Operational Status Message (§2.2.3.2.7.3.6) enables the report assembly function in ADS-B receiving equipment to determine whether the transmitting ADS-B subsystem is announcing NIC = 9 (R_C < 75 m and VPL < 112 m) or NIC = 10 (R_C < 25 m and VPL < 37.5 m).*

7 *The "NIC supplement" field in the Aircraft Operational Status Message (§2.2.3.2.7.3.6) enables the report assembly function in ADS-B receiving equipment to determine whether the transmitting ADS-B subsystem is announcing NIC = 2 (R_C < 8 NM) or NIC = 3 (R_C < 4 NM).*

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

A.1.4.1.1 Airborne Position Message Type Code

A.1.4.1.1.1 Airborne Position Message Type Code if Containment Radius is Available

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

If R_C (containment radius) information is available from the navigation data source, then the transmitting ADS-B subsystem will determine the Type Code (the value of the TYPE subfield) of Airborne Position Messages as follows.

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

b. If valid horizontal position and barometric pressure altitude information are both available to the ADS-B transmitting subsystem, then the ADS-B transmitting subsystem will set the TYPE subfield of Airborne Position Messages to a value in the range from 9 to 18 in accordance with Table A-2.

c. If valid horizontal position information is available to the ADS-B transmitting subsystem, but valid barometric pressure altitude information is *not* available, and valid geometric altitude information *is* available, the ADS-B transmitting subsystem will set the TYPE subfield of Airborne Position Messages to a value in the range from 20 to 22 depending on the containment radius R_C and vertical protection limit VPL in accordance with Table A-2.

d. If valid horizontal position information is available to the ADS-B transmitting subsystem, but neither valid barometric altitude information nor valid geometric altitude information is available, the ADS-B transmitting subsystem will set the TYPE subfield in Airborne Position Messages to a value in the range from 9 to 18 depending on the containment radius R_C in accordance with Table A-2. (In that case, the ALTITUDE subfield of the Airborne Position Messages would be set to all ZEROs in order to indicate that valid altitude information is not available.)

A.1.4.1.1.2 Airborne Position Message Type Code if Containment Radius is Not Available

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

a. The ADS-B transmitting subsystem will set the TYPE subfield to ZERO (0) if valid horizontal position information is not available.

b. The ADS-B transmitting subsystem will set the TYPE subfield to 18 if valid pressure altitude information is available, or if neither valid pressure altitude nor valid geometric altitude information is available.

If valid pressure altitude is not available, but valid geometric altitude information is available, the ADS-B transmitting subsystem will set the TYPE subfield to 22.

A.1.4.1.2 Surface Position Message Type Code

A.1.4.1.2.1 Surface Position Message Type Code if Containment Radius is Available

If R_C (horizontal containment radius) information is available from the navigation data source, then the ADS-B transmitting subsystem will use R_C to determine the Type Code used in the Surface Position Message in accordance with Table A-2.

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

A.1.4.1.2.2 Surface Position Message Type Code if Containment Radius is Not Available

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

a. The ADS-B transmitting subsystem will set the TYPE subfield to ZERO if valid horizontal position information is not available.

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

A.1.4.1.2.3 Type Code based on Horizontal Protection Level or Estimated Horizontal Position Accuracy

a. If valid horizontal position information is available, then the “TYPE” code in the Airborne Position Message will be set in the range from “5” to “8.”

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

c. If R_C is not available from the navigation data source, then the “TYPE” coding will be set to 8.

A.1.4.2 Airborne Position Format

The airborne position squitter will be formatted as specified in the definition of Register 05 {HEX}.

Note: *Additional details are specified in the following paragraphs.*

A.1.4.2.1 Compact Position Reporting (CPR) Format (F)

In order to achieve coding that is unambiguous world wide, CPR will use two format types, known as “even” and “odd.” This one-bit field (bit 22) **shall** be used to define the CPR format type. A CPR Format equal to ZERO (0) **shall** denote an “even” format coding, while a CPR Format equal to ONE (1) **shall** denote an “odd” format coding (A.1.7.7).

A.1.4.2.2 Time Synchronization (T)

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

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

A.1.4.2.3 Latitude/Longitude

The latitude/longitude field in the airborne position message will be a 34-bit field containing the latitude and longitude of the aircraft airborne position. The latitude and longitude will each occupy 17 bits. The airborne latitude and longitude encoding will contain airborne CPR-encoded values in accordance with §A.1.7. The unambiguous range for the local decoding of airborne messages will be 666 km (360 NM). The positional accuracy maintained by the airborne CPR encoding will be approximately 5.1 meters.

Note: *The latitude/longitude encoding is also a function of the CPR format value (the “F” bit) described above.*

A.1.4.2.3.1 Extrapolating Position (When T=1)

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

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

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

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

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

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

Note 2: *If the airborne position register is loaded every 200 ms, the ideal time to load that register would be 100 ms before the time of applicability of the data being loaded. The register would then be re-loaded, with data applicable at the next subsequent 0.2 second UTC epoch, 100 ms before that next subsequent 0.2 second epoch. That way, the time of transmission of an airborne position message would never differ by more than 100 ms from the time of applicability of the data in that message. By specifying "100 ms ± 50 ms" rather than 100 ms exactly, some tolerance is allowed for variations in implementation.*

The position data that is loaded into the airborne position register will be an estimate of the A/V position at the time of applicability.

Note 3: *The position may be estimated by extrapolating the position from the time of validity of the fix (included in the position fix) to the time of applicability of the data in the register (which, if T=1, is an exact 0.2 UTC time tick). This may be done by a simple linear extrapolation using the velocity provided with the position fix and the time difference between the position fix validity time and the time of applicability of the transmitted data. Alternatively, other methods of estimating the position, such as alpha-beta trackers or Kalman filters, may be used.*

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

A.1.4.2.3.2 Extrapolating Position (When T=0)

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

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

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

A.1.4.2.3.3 Time-Out When New Position Data is Unavailable

In the event that the navigation input ceases, the extrapolation described in §A.1.4.2.3.1 and §A.1.4.2.3.2 will be limited to no more than two seconds. At the end of this timeout of two seconds, all fields of the airborne position register, except the altitude field, will be cleared (set to zero).

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

With the appropriate register fields cleared, the zero type code field will serve to notify ADS-B receiving equipment that the data in the latitude and longitude fields are invalid.

A.1.4.2.4 Altitude

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

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

2. GNSS height above ellipsoid (HAE).

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

A.1.4.2.5 Single Antenna Flag (SAF)

This one-bit field will indicate the type of antenna system that is being used to transmit Extended Squitters. SAF equal to ONE will signify a single transmit antenna. SAF equal to ZERO will signify a dual transmit antenna system. At any time that the diversity configuration cannot guarantee that both antenna channels are functional, then the SAF Subfield will be set to ONE.

A.1.4.3 Surface Position Format

The surface position squitter will be formatted as specified in the definition of Register 06 {HEX}.

Note: *Additional details are specified in the following paragraphs.*

A.1.4.3.1 Movement

This 7-bit field will provide information on the ground speed of the aircraft. A non-linear scale will be used as defined in the Table A-3, where speeds are given in km/h (kt).

Table A-3: Coding of the Movement Field

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

A.1.4.3.2 Heading

A.1.4.3.2.1 Heading/Ground Track Status

This one bit field will define the validity of the heading value. Coding for this field will be as follows: 0=not valid and 1= valid.

Note: *If a source of A/V heading* ***is not*** *available to the ADS-B transmitting subsystem, but a source of ground track angle* ***is*** *available, ground track angle may be used instead of heading,, provided that the STATUS BIT FOR HEADING subfield is set to ZERO whenever the ground track angle is not a reliable indication of the A/V's heading. (The ground* *track angle is not a reliable indication of the A/V's heading when the A/V's ground speed is close to ZERO.)*

A.1.4.3.2.2 Heading/Ground Track Value

This 7-bit (14-20) field will define the direction (in degrees clockwise from true or magnetic north) of aircraft motion on the surface. The ground track will be encoded as an unsigned angular weighted binary numeral, with an MSB of 180 degrees and an LSB of 360/128 degrees, with ZERO (0) indicating true or magnetic north. The data in the field will be rounded to the nearest multiple of 360/128 degrees.

Note: The reference direction for Heading (whether True North or Magnetic North) is indicated in the Horizontal Reference Direction (HRD) field of the Aircraft Operational Status Message (A.1.4.10.13).

A.1.4.3.3 Compact Position Reporting (CPR) Format (F)

The one-bit (22) CPR format field for the surface position message will be encoded as specified for the airborne message. That is, F = 0 will denote an "even" format coding, while F = 1 will denote an "odd" format coding (§A.1.7.7).

A.1.4.3.4 Time Synchronization (T)

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

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

A.1.4.3.5 Latitude/longitude

The latitude/longitude field in the surface message will be a 34-bit field containing the latitude and longitude coding of the aircraft's surface position. The latitude (*Y*) and longitude (*X*) will each occupy 17 bits. The surface latitude and longitude encoding will contain surface CPR-encoded values in accordance with §A.1.7. The unambiguous range for local decoding of surface messages will be 166.5 km (90 NM). The positional accuracy maintained by the surface CPR encoding will be approximately 1.25 meters.

<u>Note</u>: *The latitude/longitude encoding is also a function of the CPR format value (the "F" bit).*

A.1.4.3.5.1 Extrapolating Position (When T=1)

This extrapolation will conform to §A.1.4.2.3.1 (Substitute "surface" for "airborne" where appropriate).

A.1.4.3.5.2 Extrapolating Position (When T=0)

This extrapolation will conform to §A.1.4.2.3.2 (Substitute "surface" for "airborne" where appropriate).

A.1.4.3.5.3 Time-Out When New Position Data is Unavailable

This time-out will conform to §A.1.4.2.3.3 (Substitute "surface" for "airborne" where appropriate).

A.1.4.4 Identification and Category Format

The identification and category squitter will be formatted as specified in the definition of Register 08 {HEX}.

Note: *Additional details are specified in the following paragraphs.*

A.1.4.4.1 Aircraft Identification Coding

Note: *The coding of aircraft identification is defined in §2.2.17.1.13 of RTCA/DO-181C. It is reproduced here for convenience.*

Each character will be coded as a six-bit subset of the ICAO 7-unit coded character set (ICAO Annex 10, Vol. IV, §3.1.2.10, Table 3-6) as specified in the Table A-4. The character set will be transmitted with the most significant bit (MSB) first. The reported aircraft code will begin with character 1. Characters will be coded consecutively without an intervening SPACE code. Any unused character spaces at the end of the subfield will contain a SPACE character code.

Table A-4: Aircraft Identification Character Coding

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

[1]SP = SPACE code

A.1.4.5 Airborne Velocity Format

The airborne velocity squitter will be formatted as specified in the definition of Register 09 {HEX}.

Note: *Additional details are specified in the following paragraphs.*

A.1.4.5.1 Subtypes 1 and 2

Subtypes 1 and 2 of the airborne velocity format will be used when the transmitting aircraft's velocity over ground is known. Subtype 1 will be used for velocities under 1000 knots and subtype 2 will be used for aircraft capable of supersonic flight when the velocity might exceed 1022 knots.

This message will not be broadcast if the only valid data is the Intent Change and the IFR Capability flags (§A.1.4.5.3, §A.1.4.5.4). After initialization, broadcast will be suppressed by loading Register 09 {HEX} with all zeros and then discontinuing updating the register until data input is available again.

The supersonic version of the velocity coding will be used if either the east-west OR north-south velocities exceed 1022 knots. A switch to the normal velocity coding will be made if both the east-west AND north-south velocities drop below 1000 knots.

A.1.4.5.2 Subtypes 3 and 4

Subtypes 3 and 4 of the airborne velocity format will be used when the transmitting aircraft's velocity over ground is not known. These subtypes will substitute airspeed and heading for the velocity over ground. Subtype 3 will be used at subsonic velocities, while subtype 4 will be reserved for airspeeds in excess of 1000 knots.

This message will not be broadcast if the only valid data is the Intent Change and the IFR Capability flags (§A.1.4.5.3, §A.1.4.5.4). After initialization, broadcast will be suppressed by loading Register 09 {HEX} with all zeros and then discontinuing updating the register until data input is available again.

The supersonic version of the velocity coding will be used if the airspeed exceeds 1022 knots. A switch to the normal velocity coding will be made if the airspeed drops below 1000 knots.

A.1.4.5.3 Intent change Flag in Airborne Velocity Messages

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

Intent Change Flag coding:

0 = no change in intent
1 = intent change

Notes:

1. *Register 43 {HEX} is not included since it contains dynamic data that will be continuously changing.*

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

A.1.4.5.4 IFR Capability Flag (IFR) in Airborne Velocity Messages

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

A.1.4.5.5 Navigation Accuracy Category for Velocity (NAC_V)

This 3-bit (11-13) subfield will indicate the Navigation Accuracy Category for Velocity as specified in Tables A.1.4.5.5-1 to A.1.4.5.5-3.

The ADS-B Transmitting Subsystem will accept, via an appropriate data interface, data from which the own-vehicle Navigation Accuracy Category for Velocity (NAC_V) may be determined, and it will use such data to establish the NAC_V subfields in transmitted ADS-B airborne velocity messages as follows:

a. If the external data source provides 95% accuracy figures of merit for horizontal and vertical velocity [$HFOM_R$ (Horizontal Figure of Merit for Velocity) and $VFOM_R$ (Vertical Figure of Merit for Velocity)], then the ADS-B Transmitting Subsystem will determine the value of the NAC_V field in the Airborne Velocity Messages, Subtypes 1, 2, 3 and 4 according to Table A.1.4.5.5-1:

Table A.1.4.5.5-1: Determining NAC_V If $HFOM_R$ and $VFOM_R$ Are Provided

NAC_V value (Decimal)	$HFOM_R$ value		$VFOM_R$ value
4	$HFOM_R$ < 0.3 m/s (0.984 fps)	AND	$VFOM_R$ < 0.46 m/s (1.5 fps)
3	$HFOM_R$ < 1 m/s (3.28 fps)	AND	$VFOM_R$ < 1.52 m/s (5.0 fps)
2	$HFOM_R$ < 3 m/s (9.84 fps)	AND	$VFOM_R$ < 4.57 m/s (15.0 fps)
1	$HFOM_R$ < 10 m/s (32.8 fps)	AND	$VFOM_R$ < 15.24 m/s (50 fps)
0	$HFOM_R$ unknown or $HFOM_R$ ≥ 10 m/s (32.8 fps)	OR	$VFOM_R$ unknown or $VFOM_R$ ≥ 15.24 m/s (50 fps)

Note:

The tests in the table are to be applied in the order shown, from the most stringent test (for NAC_V = 4) to the least stringent (for NAC_V = 0). That is, if $HFOM_R$ and $VFOM_R$ do not satisfy the conditions for NAC_V = 4, then they are tested against the conditions for NAC_V = 3. If they do not satisfy the conditions for NAC_V = 3, they are tested against the conditions for NAC_V = 2, and so on.

b. If the external data source does not provide $HFOM_R$ and $VFOM_R$, the 95% accuracy figures of merit for horizontal and vertical velocity, but it does provide 95% accuracy figures of merit for the horizontal and vertical positions [HFOM, Horizontal Figure of Merit for position, and VFOM, Vertical Figure of Merit for position], then the following tables may be used to determine the NAC_V value to be inserted in the Airborne Velocity message. Table A.1.4.5.5-2 will be used if the position and velocity are obtained from a GNSS/LAAS or GNSS/WAAS receiver (Global Navigation Satellite System with Local Area Augmentation System or with Wide Area Augmentation System) when that receiver is operating in LAAS or WAAS mode. Table A.1.4.5.5-3 will be used if the position and velocity are obtained from a GNSS receiver operating in autonomous mode (that is, without LAAS or WAAS differential corrections).

Table A.1.4.5.5-2: Determining NAC_V From a GNSS Receiver Operating in LAAS or WAAS Mode.

NAC_V value (Decimal)	HFOM and VFOM values
4	HFOM ≤ 1 m and VFOM ≤ 5.85 ft
3	(HFOM > 1 m or VFOM > 5.85 ft) and HFOM ≤ 4.5 m, and VFOM ≤ 23.3 ft
2	(HFOM > 4.5 m or VFOM >23.3 ft) and HFOM ≤ 14.5 m, and VFOM ≤ 73.3 ft
1	(HFOM > 14.5 m or VFOM >73.3 ft) and HFOM ≤ 49.5 m, and VFOM ≤ 248 ft
0	HFOM > 49.5 m or VFOM > 248 ft

Table A.1.4.5.5-3: Determining NAC_V When Differential GNSS Corrections Are Not Available

NAC_V value (Decimal)	HFOM and VFOM values
2	HFOM ≤ 125 m, and VFOM ≤ 585 ft
0	HFOM > 475 m or VFOM > 2335 ft
1	(HFOM > 125 m or VFOM >585 ft) and HFOM ≤ 475 m, and VFOM ≤ 2335 ft

c. If the external source of position and velocity data provides neither 95% bounds on the accuracy of the velocity data ($HFOM_R$ and $VFOM_R$) nor 95% bounds on the accuracy of the position data (HFOM and VFOM), then the transmitting ADS-B device will set the value of the NAC_V field in the Airborne Velocity Messages to ZERO.

A.1.4.5.6 Heading in Airborne Velocity Messages

A.1.4.5.6.1 Heading Status

This one bit subfield will define the availability of the heading value. Coding for this field will be: 0 = not available and 1 = available.

A.1.4.5.6.2 Heading Value

This 10-bit field will give the aircraft heading (in degrees clockwise from true or magnetic north) when velocity over ground is not available. The heading will be encoded as an unsigned angular weighted binary numeral with an MSB of 180 degrees and an LSB of 360/1024 degrees, with ZERO (0) indicating true or magnetic north. The data in the field will be rounded to the nearest multiple of 360/1024 degrees.

Note: The reference direction for Heading (whether True North or Magnetic North) is indicated in the Horizontal Reference Direction (HRD) field of the Aircraft Operational Status Message (§A.1.4.10.13).

A.1.4.5.7 Difference from Baro Altitude in Airborne Velocity Messages

This 8-bit field will give the signed difference between barometric and GNSS altitude. (Coding for this field will be as indicated in Figure A-6 and Figure A-7).

Note: *The difference between baro altitude and GNSS height above ellipsoid (HAE) is preferred. However, GNSS altitude (MSL) may be used when airborne position is being reported using Format Type Codes 11 through 18.*

If airborne position is being reported using Format Type Codes 9 or 10, only GNSS HAE will be used. For Format Type Codes 9 or 10, if GNSS HAE is not available, the field will be coded with all zeros. The basis for the baro altitude difference (either GNSS HAE or altitude MSL) will be used consistently for the reported difference.

A.1.4.6 Status Register Format

The status register will be formatted as specified in the definition of Register 07 {HEX}.

Note: *Additional details are specified in the following paragraphs.*

A.1.4.6.1 Purpose

Note: *Unlike the other Extended Squitter registers, the contents of this register are not broadcast. The purpose of this register is to serve as an interface between the transponder function and the General Formatter/Manager function (GFM, A.1.6). The two fields defined for this format are the Transmission Rate Subfield and the Altitude Type Subfield.*

A.1.4.6.2 Transmission Rate Subfield (TRS)

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

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

The algorithm specified in the definition of Register 07 {HEX} will be used by the GFM (§A.1.6) to determine motion status and the appropriate code will be set in the TRS subfield. The transponder will examine the TRS subfield to determine which rate to use when it is broadcasting surface squitters.

A.1.4.6.3 Altitude Type Subfield (ATS)

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

Note: *The transponder normally loads the altitude field of the airborne position squitter from the same digital source as used for addressed replies. This is done to minimize the possibility that the altitude in the squitter is different from the altitude that would be obtained by direct interrogation.*

If the GFM (§A.1.6) inserts GNSS height (HAE) into the airborne position squitter, it will instruct the transponder not to insert the baro altitude into the altitude field. The ATS subfield will be used for this purpose.

A.1.4.7 Event Driven Protocol

A message inserted in Register 0A {HEX} (or an equivalent transmit register) will be broadcast once by the transponder at the earliest opportunity. Formats for messages using this protocol will be identical to those defined for Registers 61 {HEX} to 6F {HEX} (see Figure A-8).

Note: *The GFM (§A.1.6) is responsible for ensuring pseudo-random timing, priority and for observing the maximum transmission rate for this register of 2 per second. Additional details are specified in §A.1.6.4 and in the following paragraphs.*

A.1.4.7.1 Purpose

Note: *The event driven protocol is intended as a flexible means to support the broadcast of messages beyond those defined for position, velocity, and identification. These typically will be messages that are broadcast regularly for a period of time based on the occurrence of an event and/or having a variable broadcast rate as determined by processes external to the transponder. An example is the broadcast of emergency/priority status at a periodic rate during a declared aircraft emergency.*

A.1.4.8 Emergency/Priority Status

Register 61 {HEX} contains an exact bit-for-bit duplicate of the emergency/priority status information that is broadcast using an Event-Driven Aircraft Status Extended Squitter (TYPE = 28 and SUBTYPE = 1). The contents of Register 61 {HEX} will be formatted as specified in Figure A-8.

Note: *Additional details are specified in the following paragraphs.*

A.1.4.8.1 Transmission Rate

The Aircraft Status (Type=28) Emergency/Priority Status ADS-B Message (SUBTYPE = 1) will be broadcast at random intervals that are uniformly distributed over the range of 2.4 to 2.6 seconds for the duration of the emergency when the Target State and Status Message (TYPE = 29 and SUBTYPE = 0) is also being broadcast. Otherwise the Aircraft Status (Type=28) Emergency/Priority Status ADS-B Message (SUBTYPE = 1) will be broadcast at random intervals that are uniformly distributed over the range of 0.7 to 0.9 seconds for the duration of the emergency.

A.1.4.8.2 Message Delivery

Extended Squitter Message delivery will be accomplished using the event driven protocol (§A.1.4.7). The broadcast of this message takes priority over the event driven protocol broadcast of all other message types, as specified in §A.1.6.4.3.

A.1.4.9 Target State and Status Information

Register 62 {HEX} contains an exact bit-for-bit duplicate of the Target State and Status Extended Squitter Message (TYPE = 29 and SUBTYPE = 0) and will be formatted as specified in Figure A-9.

Note: *Additional details are specified in the following paragraphs.*

A.1.4.9.1 Transmission Rate

This message will be broadcast once per at random intervals uniformly distributed over the range of 1.2 to 1.3 seconds for the duration of the operation.

A.1.4.9.2 Message Delivery

Extended Squitter Message delivery will be accomplished using the event driven protocol (§A.1.4.7).

A.1.4.9.3 Vertical Data Available/Source Indicator

This 2-bit (8-9) subfield will be used to identify if aircraft vertical state information is available and present as well as the data source for the vertical data when present in the subsequent subfields. Encoding will be defined as shown in Table A.1.4.9.3.

Table A.1.4.9.3: Vertical Data Available/Source Indicator Encoding

Encoding		Meaning
(binary)	(decimal)	
00	0	No valid Vertical Target State data is available
01	1	Autopilot control panel selected value, such as Mode Control Panel (MCP) or Flight Control Unit (FCU)
10	2	Holding Altitude
11	3	FMS/RNAV System

A.1.4.9.4 Target Altitude Type

This one bit (10) subfield will be used to identify whether the altitude reported in the "Target Altitude" subfield is referenced to mean sea level (MSL) or to a flight level (FL). A value of ZERO will indicate target altitude referenced to pressure altitude (flight level). A value of ONE will indicate a target altitude referenced to baro-corrected altitude (mean sea level).

A.1.4.9.5 Target Altitude Capability

This 2-bit subfield (12-13) will be used describe the aircraft's capabilities for providing the data reported in the target altitude subfield. The target altitude capability subfield will be encoded as shown in Table A.1.4.9.5.

Table A.1.4.9.5: Target Altitude Capability Encoding

Encoding		Meaning
(binary)	(decimal)	
00	0	Capability for reporting holding altitude only
01	1	Capability for reporting either holding altitude or autopilot control panel selected altitude
10	2	Capability for reporting either holding altitude, autopilot control panel selected altitude, or any FMS/RNAV level-off altitude
11	3	Reserved

A.1.4.9.6 Vertical Mode Indicator

This 2-bit (14-15) subfield will be used to indicate whether the target altitude is in the process of being acquired (i.e., aircraft is climbing or descending toward the target altitude) or whether the target altitude has been acquired/being held. The vertical mode indicator subfield will be encoded as shown in Table A.1.4.9.6

Table A.1.4.9.6: Target Altitude Capability Encoding

Encoding		Meaning
(binary)	(decimal)	
00	0	Unknown Mode or Information Unavailable
01	1	"Acquiring" Mode
10	2	"Capturing" or "Maintaining" Mode
11	3	Reserved

A.1.4.9.7 Target Altitude

This 10-bit (16-25) subfield will be used to provide aircraft's next intended level-off altitude if in a climb or descent, or the aircraft current intended altitude if it is intending to hold its current altitude. It is intended that the reported "Target Altitude" be the operational altitude recognized by the aircraft's guidance system. The target altitude subfield will be encoded as shown in Table A.1.4.9.7.

Table A.1.4.9.7: Target Altitude Encoding

Coding (binary)	Coding (decimal)	Meaning
00 0000 0000	0	Target Altitude = -1000 feet
00 0000 0001	1	Target Altitude = -900 feet
00 0000 0010	2	Target Altitude = -800 feet
***	***	***
00 0000 1011	11	Target Altitude = zero (0) feet
00 0000 1100	12	Target Altitude = 100 feet
***	***	***
11 1111 0010	1010	Target Altitude = 100,000 feet
11 1111 0011 - 11 1111 1111	1011 - 1023	Invalid (out of range)

A.1.4.9.8 Horizontal Data Available/Source Indicator

This 2-bit (26-27) subfield will be used to identify if aircraft horizontal state information is available and present as well as the data source for the horizontal target data when present in the subsequent subfields. The horizontal data available/source indicator subfield will be encoded as shown in Table A.1.4.9.8.

Table A.1.4.9.8: Horizontal Data Available/Source Indicator Encoding

Encoding		Meaning
(binary)	(decimal)	
00	0	No valid horizontal Target State data is available
01	1	Autopilot control panel selected value, such as Mode Control Panel (MCP) or Flight Control Unit (FCU)
10	2	Maintaining current heading or track angle (e.g., autopilot mode select)
11	3	FMS/RNAV System (indicates track angle specified by leg type)

A.1.4.9.9 Target Heading/Track Angle

This 9-bit (28-36) subfield will be used to provide aircraft's intended (i.e., target or selected) heading or track. The target heading/track angle subfield will be encoded as shown in Table A.1.4.9.9.

Table A.1.4.9.9: Target Heading/Track Angle Encoding

Coding (binary)	Coding (decimal)	Meaning
0 0000 0000	0	Target Heading/Track = Zero degrees
0 0000 0001	1	Target Heading/Track = 1 degrees
0 0000 0010	2	Target Heading/Track = 2 degrees
***	***	***
1 0110 0111	359	Target Heading/Track = 359 degrees
1 0110 1000 through 1 1111 1111	360 through 511	Invalid

A.1.4.9.10 Target Heading/Track Indicator

This 1-bit (37) subfield will be used to indicate whether a heading angle or a track angle is being reported in the target heading/track angle subfield. A value of ZERO will indicate the target heading angle is being reported. A value of ONE will indicate that track angle is being reported.

A.1.4.9.11 Horizontal Mode Indicator

This 2-bit (38-39) subfield will be used to indicate whether the target heading/track is being acquired (i.e., lateral transition toward the target direction is in progress) or whether the target heading/track has been acquired and is currently being maintained. The horizontal mode indicator subfield will be encoded as shown in Table A.1.4.9.11.

Table A.1.4.9.11: Horizontal Mode Indicator Encoding

Encoding		Meaning
(binary)	(decimal)	
00	0	Unknown Mode or Information Unavailable
01	1	“Acquiring” Mode
10	2	“Capturing” or “Maintaining” Mode
11	3	Reserved

A.1.4.9.12 Navigation Accuracy Category for position (NAC_P)

This 4-bit (40-43) subfield will be used to indicate the navigational accuracy category of the navigation information used as the basis for the aircraft reported position. The NAC_P subfield will be encoded as shown in Table A.1.4.9.12.

Table A.1.4.9.12: Encoding of Navigation Accuracy Category for Position (NAC_P)

Encoding (binary)	Encoding (decimal)	Meaning = 95% Horizontal and Vertical Accuracy Bounds (EPU and VEPU)
0000	0	EPU ≥ 18.52 km (10 NM) - Unknown accuracy
0001	1	EPU < 18.52 km (10 NM) - RNP-10 accuracy
0010	2	EPU < 7.408 km (4 NM) - RNP-4 accuracy
0011	3	EPU < 3.704 km (2 NM) - RNP-2 accuracy
0100	4	EPU < 1852 m (1NM) - RNP-1 accuracy
0101	5	EPU < 926 m (0.5 NM) - RNP-0.5 accuracy
0110	6	EPU < 555.6 m (0.3 NM) - RNP-0.3 accuracy
0111	7	EPU < 185.2 m (0.1 NM) - RNP-0.1 accuracy
1000	8	EPU < 92.6 m (0.05 NM) - e.g., GPS (with SA)
1001	9	EPU < 30 m and VEPU < 45 m - e.g., GPS (SA off)
1010	10	EPU < 10 m and VEPU < 15 m - e.g., WAAS
1011	11	EPU < 3 m and VEPU < 4 m - e.g., LAAS
1100 - 1111	12 - 15	Reserved

Notes:

1. *The Estimated Position Uncertainty (EPU) used in the table is a 95% accuracy bound on horizontal position. EPU is defined as the radius of a circle, centered on the reported position, such that the probability of the actual position lying outside the circle is 0.05. When reported by a GPS or GNSS system, EPU is commonly called HFOM (Horizontal Figure of Merit).*

2. *Vertical Estimated Position Uncertainty (VEPU) is a 95% accuracy limit on the vertical position (geometric altitude). VEPU is defined as a vertical position limit, such that the probability of the actual geometric altitude differing from the reported geometric altitude by more than that limit is 0.05. When reported by a GPS or GNSS system, VEPU is commonly called VFOM (Vertical Figure of Merit).*

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

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

A.1.4.9.13 Navigation Integrity Category for Baro (NIC_{BARO})

This 1-bit (44) subfield will be used to indicate whether or not the barometric pressure altitude being reported in the airborne position message (§A.1.TBD) has been cross-checked against another source of pressure altitude. The NIC_{BARO} subfield will be encoded as shown in Table A.1.4.9.13.

Table A.1.4.9.13: NIC_{BARO} Encoding

Encoding	Meaning
0	The barometric altitude that is being reported in the Airborne Position Message is based on a Gilham coded input that has not been cross-checked against another source of pressure altitude
1	The barometric altitude that is being reported in the Airborne Position Message is either based on a Gilham code input that has been cross-checked against another source of pressure altitude and verified as being consistent, or is based on a non-Gilham coded source

Notes:

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

2. *The NIC_{BARO} subfield provides a method of indicating a level of data integrity for aircraft installed with Gilham encoding barometric altitude sources. Because of the potential of an undetected error when using a Gilham encoded altitude source, a comparison will be performed with a second source and only if the two sources agree will the NIC_{BARO} subfield be set to a value of "1". For other barometric altitude sources (Synchro or DADS) the integrity of the data is indicated with a validity flag or SSM. No additional checks or comparisons are necessary. For these sources the NIC_{BARO} subfield will be set to a value of "1" whenever the barometric altitude is valid.*

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

A.1.4.9.14 Surveillance Integrity Level (SIL)

This 2-bit (45-46) subfield will be used to define the probability of the integrity containment radius used in the NIC subfield being exceeded, without alerting, including the effects of the airborne equipment condition, which airborne equipment is in use, and which external signals are used by the navigation source. The SIL subfield will be encoded as shown in Table A.1.4.9.14.

Table A.1.4.9.14: Surveillance Integrity Level Encoding

SIL Encoding		Probability of Exceeding the R_C Containment Radius Without Detection
(Binary)	(Decimal)	
00	0	Unknown
01	1	1×10^{-3} per flight hour or per operation
10	2	1×10^{-5} per flight hour or per operation
11	3	1×10^{-7} per flight hour or per operation

Notes:

1. *The NIC parameter is broadcast partly in the TYPE subfield of Airborne Position and Surface Position Messages, and partly in the NIC Supplement subfield of the Aircraft Operational Status Message.*

2. *The Surveillance Integrity Level (SIL) defines the probability of exceeding the integrity containment radius, R_C, used in the NIC parameter without being detected at the transmitting ADS-B participant.*

A.1.4.9.15 Capability/Mode Codes

This 2-bit (52-53) subfield will be used to indicate the current operational status of TCAS/ACAS systems/functions. This subfield will be encoded as shown in Table A.1.4.9.15.

Table A.1.4.9.15: Capability/Mode Codes Encoding

Encoding	Meaning
ME bit 52 = 0	TCAS/ACAS operational or unknown
ME bit 52 = 1	TCAS/ACAS not operational
ME bit 53 = 0	No TCAS/ACAS Resolution Advisory active
ME bit 53 = 1	TCAS/ACAS Resolution Advisory active

A.1.4.9.16 Emergency/Priority Status

This 3-bit (53-56) subfield will be used to provide additional information regarding aircraft status. The emergency/priority status subfield will be encoded as shown in Table A.1.4.9.16.

Table A.1.4.9.16: Emergency/Priority Status Encoding

Encoding (binary)	Encoding (decimal)	Meaning
000	0	No emergency
001	1	General emergency
010	2	Lifeguard/medical emergency
011	3	Minimum fuel
100	4	No communications
101	5	Unlawful interference
110	6	Downed Aircraft
111	7	Reserved

A.1.4.10 Aircraft Operational Status Message

Register 63 {HEX} contains an exact bit-for-bit duplicate of the aircraft operational status message extended squitter (TYPE = 31 and SUBTYPE = 0). The contents of the aircraft operational status message will be formatted as specified Figure A-10.

Note: *Additional details are specified in the following paragraphs.*

A.1.4.10.1 Transmission Rate

The Aircraft Operational Status (Type=30 and SUBTYPE = 0) ADS-B Message will be broadcast at random intervals that are uniformly distributed over the range of 0.7 to 0.9 seconds when the Target State and Status Message (TYPE = 29 and SUBTYPE = 0) is not being broadcast and there has been a change within the past 24 +/- 1 seconds for value of any of the following message parameters:

a. TCAS/ACAS Operational

b. ACAS/TCAS resolution advisory active

c. NACp

d. SIL

Otherwise the Aircraft Operational Status (Type = 30 and SUBTYPE = 0) ADS-B Message will be broadcast at random intervals that are uniformly distributed over the range of 2.4 to 2.6 seconds.

A.1.4.10.2 Message Delivery

Message delivery will be accomplished using the event driven protocol (§A.1.4.7).

A.1.4.10.3 Capability Class (CC) Codes

This 16-bit (9-24) subfield in the airborne Aircraft Operational Status Message (Subtype=0) or 12-bit (9-24) subfield in the surface Aircraft Operational Status Message (Subtype=1) will be used to report the operational capability of the aircraft. Encoding of the CC subfield will be defined as specified in Tables A.1.4.10.3-1 to A.1.4.10.3-3.

Table A.1.4.10.3-1 : Capability Class (CC) Code for Version 0 Systems

Msg Bit #	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
"ME" Bit #	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Content	0	0	TCAS	CDTI	Reserved											

Subfield Coding:

1. TCAS (Traffic Alert and Collision Avoidance System Status)
   = 0: TCAS not installed or not operational
   =1: TCAS operational or unknown
2. CDTI = CDTI Traffic Display Capability

Table A.1.4.10.3-2: Airborne Capability Class (CC) Code for Version 1 Systems

Msg Bit #	41	42	43	44	45	46	47	48	49	50	51 -- 56
"ME" Bit #	9	10	11	12	13	14	15	16	17	18	19 -- 24
Content	**Service Level** MSBs = 0 0		**~TCAS**	**CDTI**	**Service Level** LSBs = 0 0		**ARV**	**TS**	**TC**		**Reserved**

Subfield Coding:

1. ~TCAS (Not Traffic Alert and Collision Avoidance System Status)
   = 0: TCAS operational or unknown
   =1: TCAS not installed or not operational

2. CDTI (Cockpit Display of Traffic Information Status)
   = 0: Traffic display not operational
   =1: Traffic display operational

3. ARV (Air-Referenced Velocity Report Capability)
   =0: No capability for air referenced velocity reports
   =1: Capability of sending messages to support Air-Referenced Velocity Reports.

4. TS (Target State Report Capability)
   =0 No capability for Target State Reports

=1: Capability of sending messages to support Target State Reports

5. TC (Target Change Report Capability)
=0: No capability for Trajectory Change Reports
=1: Capability of sending messages to support TC+0 Report only
=2: Capability of sending information for multiple TC reports
=4: Reserved

Table A.1.4.10.3-3: Surface Capability Class (CC) Code for Version 1 Systems

Msg Bit #	41	42	43	44	45	46	47	48	49	50	51	52
"ME" Bit #	9	10	11	12	13	14	15	16	17	18	19	20
Content	**Service Level** MSBs = 0 0		**POA**	**CDTI**	**Service Level** LSBs = 0 0		**Reserved**					

Subfield Coding:

1. CDTI (Cockpit Display of Traffic Information)
= 0 Traffic display not operational
=1: Traffic display operational

2. POA (Position Offset Applied)
=0: Position transmitted is not the ADS-B position reference point
=1: Position transmitted is the ADS-B position reference point

A.1.4.10.4 Operational Mode (OM)

This 516-bit subfield (25-40) will be used to indicate operational modes that are active on board the aircraft. Encoding of the subfield will be as shown in Table A.1.4.10.4.

Table A.1.4.10.4: Operational Mode (OM) Subfield Format

Msg Bit #	57	58	59	60	61	62 -- 72
"ME" Bit #	25	26	27	28	29	30 -- 40
OM Format	0 0		TCAS RA Active	IDENT Switch Active	Receiving ATC Services	Reserved
	0 1		Reserved			
	1 0		Reserved			
	1 1		Reserved			

Subfield Coding:

1. TCAS Resolution Advisory (RA) Active
   = 0: TCAS RA not active
   =1: TCAS RA is active

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

3. Receiving ATC Services
   =0: Aircraft not receiving ATC services
   =1: Aircraft receiving ATC services

A.1.4.10.5 Version Number

This 3-bit subfield (41-43) will be used indicate the Version Number of the formats and protocols in use on the aircraft installation. Encoding of the subfield will be as shown in Table A-21.

Table A-21: Version Number Encoding

VERSION NUMBER SUBFIELD		
Coding		**Meaning**
(Binary)	**(Decimal)**	
000	0	Conformant to DO-260
001	1	Conformant to DO-260A
010 – 111	2 – 7	Reserved

A.1.4.10.6 NIC Supplement

This 1-bit subfield (44) will be used with the Type Code to encode the Navigation Integrity Category (NIC) of the transmitting ADS-B participant. Encoding of the subfield will be as specified in Table A.1.4.10.6.

Table A.1.4.10.6: Navigation Integrity Category (NIC) Encoding.

NIC Value	Containment Radius (R_C) and Vertical Protection Limit (VPL)	Airborne		Surface	
		Airborne Position Type Code	NIC Supplement Code	Surface Position Type Code	NIC Supplement Code
0	R_C unknown	0, 18, 22	0	0, 8	0
1	R_C < 20 NM (37.04 km)	17	0	N/A	N/A
2	R_C < 8 NM (14.816 km)	16	0	N/A	N/A
3	R_C < 4 NM (7.408 km)	16	1	N/A	N/A
4	R_C < 2 NM (3.704 km)	15	0	N/A	N/A
5	R_C < 1 NM (1852 m)	14	0	N/A	N/A
6	R_C < 0.6 NM (1111.2 m)	13	0	N/A	N/A
7	R_C < 0.2 NM (370.4 m)	12	0	N/A	N/A
8	R_C < 0.1 NM (185.2 m)	11	0	7	0
9	R_C < 75m *and* VPL < 112 m	10	0	6	0
10	R_C < 25m *and* VPL < 37.5 m	10	1	6	1
		21	0		
11	R_C < 7.5m *and* VPL < 11 m	9, 20	0	5	0

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

A.1.4.10.7 Navigation Accuracy Category for Position (NAC_P)

This 4-bit subfield (45-48) will be used to announce 95% accuracy limits for the horizontal position (and for some NAC_P values, the vertical position) that is being currently broadcast in airborne position and surface position messages. Encoding of the subfield will be as shown in Table A.1.4.9.12.

A.1.4.10.8 Reserved for Barometric Altitude Quality (BAQ)

This 2-bit subfield (49-50) in the airborne Operational Status Message (subtype=0) will be set to ZERO by ADS-B Transmitting Subsystems that conform to RTCA DO-260A

Note: *Non-zero versions of the BAQ subfield will be specified in future version of this MOPS..*

A.1.4.10.9 Surveillance Integrity Level (SIL)

This 2-bit subfield (51-52) will be used to announce the integrity level associated with the containment radius (R_C) being broadcast in the NIC parameter. Encoding of the subfield will be as shown in Table A.4.9.14.

A.1.4.10.10 Barometric Altitude Integrity Code (NIC_{BARO})

This 1-bit (53) subfield will be used to indicate whether or not the barometric pressure altitude being reported in the airborne position message (§A.1.4.2) has been cross-checked against another source of pressure altitude. The NIC_{BARO} subfield will be encoded as shown in Table A.4.1.9.13.

A.1.4.10.11 Aircraft Length and Width Codes

This 4-bit subfield (21-24) will be used in the surface Aircraft Operational Status Message (subtype=1) to describe the amount of space that an aircraft or ground vehicle occupies. The length and width codes will be based on the actual dimensions of the transmitting aircraft or surface vehicle as specified in Table A.1.4.10.11. Each aircraft or vehicle will be assigned the smallest length and width codes consistent with its actual dimensions.

Table A.1.4.10.11: Aircraft Length and Width Encoding

A/V - L/W Code (Decimal)	Length Code			Width Code	Length Category (meters)	Width Category (meters)
	ME Bit 49	ME Bit 50	ME Bit 51	ME Bit 52		
0	0	0	0	0	0 < L < 15	0 < W < 11.5
1				1		11.5 ≤ W < 23
2	0	0	1	0	15 ≤ L < 25	23 ≤ W < 28.5
3				1		28.5 ≤ W < 34
4	0	1	0	0	25 ≤ L < 35	28 ≤ W < 33
5				1		33 ≤ W < 38
6	0	1	1	0	35 ≤ L < 45	34 ≤ W < 39.5
7				1		39.5 ≤ W < 45
8	1	0	0	0	45 ≤ L < 55	38 ≤ W < 45
9				1		45 ≤ W < 52
10	1	0	1	0	55 ≤ L < 65	52 ≤ W < 59.5
11				1		59.5 ≤ W < 67
12	1	1	0	0	65 ≤ L < 75	65 ≤ W < 72.5
13				1		72.5 ≤ W < 80
14	1	1	1	0	L ≥ 75	W < 80
15				1		W ≥ 80

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

A.1.4.10.12 Track Angle/Heading

The Track Angle/Heading subfield is a 1-bit field ("ME" bit 53, Message bit 85) of the ADS-B Aircraft Operational Status Message (Subtype = 1, for Surface Participants) that allows correct interpretation of the data contained in the Heading/Ground Track subfield of the ADS-B Surface Position Message when the Air/Ground status is determined to be in the "On-Ground" state as defined in §2.2.3.2.1.2.

A.1.4.10.13 Horizontal Reference Direction (HRD)

This 1-bit subfield (33-37) will be used to indicate the reference direction (true north or magnetic north) for horizontal directions such as heading, track angle, selected heading, selected track angle, etc. The Horizontal Reference Direction subfield will be encoded as specified in Table A.1.4.10.13.

Table A.1.4.10.13: Horizontal Reference Direction (HRD) Encoding.

HRD Value	Meaning
0	True North
1	Magnetic North

.

A.1.5 Initialization and Timeout

Note: *Initialization and timeout functions for Extended Squitter broadcast are performed by the transponder and are specified in DO-181C. A description of these functions is presented in the following paragraphs to serve as reference material for the section on the GFM (A.1.6).*

A.1.5.1 Initiation of Extended Squitter Broadcast

At power up initialization, the transponder will commence operation in a mode in which it broadcasts only acquisition squitters. The transponder will initiate the broadcast of Extended Squitters for Airborne Position, Surface Position, Airborne Velocity and Aircraft Identification and Type when data are inserted into Registers 05 {HEX}, 06 {HEX}, 09 {HEX} and 08 {HEX} respectively. This determination will be made individually for each squitter type. The insertion of just altitude or surveillance status data into Register 05 {HEX} by the transponder will not satisfy the minimum requirement for broadcast of the airborne position squitter.

Note: *This suppresses the transmission of Extended Squitters from aircraft that are unable to report position, velocity or identity information.*

A.1.5.2 Register Timeout

The transponder will clear all but the altitude and surveillance status subfields in the airborne position register (Register 05 {HEX}) and all 56-bits of the surface position, squitter status and airborne velocity registers (Registers 06 {HEX}, 07 {HEX} and 09 {HEX}), if these registers are not updated within two seconds of the previous update. This timeout will be determined separately for each of these registers. The insertion of altitude or surveillance status data by the transponder into these registers will not qualify as a register update for the purposes of this timeout condition. Transponder data insertion will not be affected by a register timeout condition.

Notes:

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

2. *The identification Register, 08 {HEX}, is not cleared since it contains data that rarely changes in flight and is less frequently updated. The event-driven Register, 0A {HEX} or equivalent transmit register does not need to be cleared since its contents are only broadcast once each time that the register is loaded (A.1.6.4).*

3. *During a register timeout event, the ME field of the Extended Squitter may contain all ZEROs, except for any data inserted by the transponder.*

A.1.5.3 Termination of Extended Squitter Broadcast

If input to Register 05 {HEX}, 06 {HEX}, 07 {HEX}, or 09 {HEX} stops for 60 seconds, broadcast of the associated Extended Squitter type will be discontinued until data insertion is resumed. The insertion of altitude by the transponder will satisfy the minimum requirement for continuing to broadcast the airborne position squitter.

Notes:

1. *Until timeout, an Extended Squitter type may contain an ME field of all ZEROs.*

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

A.1.5.4 Requirements for Non-Transponder Devices

Non-transponder devices will provide the same functionality for initialization, register timeout and broadcast termination as specified for the transponder case in A.1.5.1 to A.1.5.3.

A.1.6 General Formatter/Manager (GFM)

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

A.1.6.1 Navigation Source Selection

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

A.1.6.2 Loss of Input Data

The GFM will be responsible for loading the registers for which it is programmed at the required update rate. If for any reason data is unavailable for a time equal to twice the update interval or 2 seconds (whichever is greater), the GFM will ZERO old data (on a per field basis) and insert the resulting message into the appropriate register.

Note: *For Register 05 {HEX} and 06 {HEX} a loss of position data would cause the GFM to set the Format Type Code to ZERO as the means of indicating "no position data" since all ZEROs in the Lat/Lon fields is a legal value.*

A.1.6.3 Special Processing for Format Type Code Zero

A.1.6.3.1 Significance of Format Type Code Equal to Zero

Notes:

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

2. Special handling is required for the airborne and surface position messages because a CPR encoded value of all ZEROs in the lat/lon field is a valid value.

A.1.6.3.2 Broadcast of Format Type Code Equal to Zero

Format Type Code 0 will only be set by the following events:

1. An Extended Squitter Register monitored by the transponder (Register 05 {HEX}, 06 {HEX}, 07 {HEX} and 09 {HEX}) has not been loaded by the GFM for 2 seconds. In this case the transponder clears the entire 56 bits of the register that timed out. (In the case of the airborne position register, the altitude subfield is only ZEROed if no altitude data is available).

Transmission of the Extended Squitter that broadcasts the timed out register will itself stop in 60 seconds. Broadcast of this Extended Squitter will resume when the GFM begins to insert data into the register.

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

Note that in all of the above cases, a Format Type Code of ZERO contains a message of all ZEROs. The only exception is the airborne position format that may contain barometric altitude and surveillance status data as set by the transponder. There is no analogous case for the other Extended Squitter format types, since a zero value in any of the fields indicates no information.

A.1.6.3.3 Reception of Format Type Code Equal to Zero

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

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

A.1.6.4 Handling of Event Driven Protocol

The Event-Driven interface protocol will provide a general-purpose interface into the transponder function for either those messages beyond those that are regularly transmitted all the time (provided input data is available), or those that are transmitted at a fixed periodic rate. This protocol will operate by having the transponder broadcast a message once each time the event driven register is loaded by the GFM.

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

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

A.1.6.4.1 Transponder Support for the Event Driven Protocol

A message will be transmitted once by the transponder, each time that Register 0A {HEX} is loaded. Transmission will be delayed if the transponder is busy at the time of insertion.

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

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

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

A.1.6.4.2 GFM Use of the Event Driven Protocol

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

An application that wants to use the event driven protocol will notify the GFM of the format type and required update rate. The GFM will then locate the necessary input data for this format type and begin inserting data into Register 0A{HEX} at the required rate. The GFM will also insert this message into the register for this format type. This register image will be maintained to allow readout of this information by air-ground or air-air register readout. When broadcast of a format type ceases, the GFM will clear the corresponding register assigned to this message.

The maximum rate that can be supported by the event driven protocol will be twice per second from one or a collection of applications. For each event-driven format type being broadcast, the GFM will retain the time of the last insertion into Register 0A {HEX}. The next insertion will be scheduled at a random interval that is uniformly distributed over the range of the update interval ± 0.1 second relative to the previous insertion into Register 0A{HEX} for this format type.

The GFM will monitor the number of insertions scheduled in any one second interval. If more than two would occur, the GFM will schedule the pending messages based on message priorities and queue management rules defined in §A.1.4.6.3 in order to ensure that the limit of two messages per second is observed while ensuring that high priority Extended Squitter Message as broadcast at the required rates.

A.1.6.4.3 Event-Driven Message Transmission Scheduling Function

The Event-Driven Message Scheduling Function will ensure that the total Event-Driven message rate does not exceed 2 transmitted messages per second.

The Event-Driven Message Scheduling Function will apply the following rules as a means of prioritizing the Event-Driven Message transmissions and limited the transmission rates:

a. The Event-Driven Message scheduling function will reorder, as necessary, pending Event-Driven Messages according to the following message priorities, listed below in descending order from highest to lowest priority:

    i. When an Extended Squitter Status Message is active for the broadcast of an Emergency/Priority Condition (TYPE = 28 and SUBTYPE = 1), that message will continue to be transmitted at random intervals that are uniformly distributed over the range of 0.7 to 0.9 seconds, relative to the previous Emergency/Priority Status Message for the duration of the emergency/priority condition if the Target State and Status Message is not being broadcast. If the "Target State and Status Message" with SUBTYPE = ZERO (0) is being broadcast, then the "Emergency/Priority Status" will be broadcast at random intervals that are uniformly distributed over the range of 2.4 to 2.6 seconds relative to the previous Emergency/Priority Status Message for the duration of the emergency condition established in accordance with Figure A-9, Note 2.

    ii. Reserved for future use.

    iii. Reserved for future use.

    iv. When an Aircraft Operational Status Message is active (TYPE = 31 and SUBTYPE = 0) and there has been a change in one or more of the message parameters within the past 24 seconds that results in a higher update rate reporting requirement, the Aircraft Operational Status Message will be transmitted at the rate specified in §2.2.3.3.1.4.2.

    v. When a Target State and Status Message is active for the broadcast of Target State information (message TYPE = 29 and SUBTYPE = 0) the Target State and Status Message will be transmitted at random intervals that are uniformly distributed over the range of 1.2 to 1.3 seconds relative to the previous Target State and Status Message for as long as target state information is available and valid.

    vi. Reserved for future use.

    vii. When an Aircraft Operational Status Message is active (TYPE = 31 and SUBTYPE = 0) and there has been no change in the message parameters that would require an increased broadcast rate, the Aircraft Operational Status Message will be transmitted at the rate specified in §2.2.3.3.1.4.2.

viii. This priority level applies as a default to any Event-Driven Message TYPE and SUBTYPE combination not specifically identified at a higher priority level above. Event-Driven Messages of this default priority level will be delivered to the transponder on a first-in-first-out basis at equal priority.

b. The Event-Driven Message scheduling function will limit the number of Event-Driven Messages provided to the transponder to two (2) messages per second.

c. If (b) results in a queue of messages awaiting delivery to the transponder, the higher priority pending messages, according to (a) above will be delivered to the transponder for transmission before lower priority messages.

d. If (b) results in a queue of messages awaiting delivery to the transponder, new Event-Driven messages will directly replace older messages of the same exact Type and Subtype (where a Subtype is defined) that are already in the pending message queue. The updated message will maintain the same position in the message queue as the pending message that is being replaced.

e. If (b) above results in a queue of messages awaiting delivery to the transponder, then pending message(s), will be deleted from the message transmission queue if not delivered to the transponder for transmission, or not replaced with a newer message of the same message Type and Subtype, within the Message Lifetime value specified in the Table A.1.6.4.3 below:

Table A.1.6.4.3: Event-Drive Message Lifetime

Message TYPE	Message SUBTYPE	Message Lifetime (seconds)
23		Reserved (see Note)
24		Reserved (see Note)
25		Reserved (see Note)
26		Reserved (see Note)
27		Reserved (see Note)
28	=1	5.0 seconds (+/- 0.2 sec.)
	0, >1	Reserved (see Note)
29	=0	2.5 seconds (+/- 0.2 sec.)
	>0	Reserved (see Note)
30		Reserved (see Note)
31	=0	5.0 seconds (+/- 0.2 sec.)
	>0	Reserved (see Note)

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

A.1.7 Latitude/Longitude Coding Using Compact Position Reporting (CPR)

A.1.7.1 Principle of the CPR algorithm

Notes:

1. *The Mode S Extended Squitters use Compact Position Reporting (CPR) to encode latitude and longitude efficiently into messages. The resulting messages are compact in the sense that several higher-order bits, which are normally constant for long periods of time, are not transmitted in every message. For example, in a direct binary representation of latitude, one bit would designate whether the aircraft is in the northern or southern hemisphere. This bit would remain constant for a long time, possibly the entire life of the aircraft. To repeatedly transmit this bit in every position message would be inefficient.*

2. *Because the higher-order bits are not transmitted, it follows that multiple locations on the earth will produce the same encoded position. If only a single position message were received, the decoding would involve ambiguity as to which of the multiple solutions is the correct location of the aircraft. The CPR technique includes a provision to enable a receiving system to unambiguously determine the location of the aircraft. This is done by encoding in two ways that differ slightly. The two formats, called even-format and odd-format, are each transmitted fifty percent of the time. Upon reception of both types within a short period (approximately 10 seconds), the receiving system can unambiguously determine the location of the aircraft.*

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

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

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

A.1.7.2 CPR Algorithm Parameters and Internal Functions

The CPR algorithm **shall** utilize the following parameters whose values are set as follows for the Mode S Extended Squitter application:

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

   For airborne encoding: *Nb* = 17

   For surface encoding: *Nb* = 19

   For intent encoding: *Nb* = 14

   For TIS-B encoding: *Nb* = 12.

   Note 1: *The* Nb *parameter determines the encoded position precision (approximately 5 m for the airborne encoding, 1.25 m for the surface encoding,, 41 m for theintent1 encoding and TBD for the TIS-B encoding).*

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

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

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

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

   Note 3: *For example,* ***floor****(3.8) = 3, while* ***floor****(-3.8) = -4.*

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

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

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

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

   For example, $\mathrm{MOD}(-40°,6°) = \mathrm{MOD}(320°,6°) = 2°$.

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

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

where *lat* denotes the latitude argument in degrees. For latitudes at or near the N or S pole, where the above formula would either be undefined or yield **NL**(*lat*) = 0, the value returned by the NL( ) function **shall** be 1. Likewise, at the equator, where the above formula might otherwise yield NL(*lat*) = 60, the value returned by the NL( ) function **shall** be 59.

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

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

and a table search procedure used to obtain the return value for NL( ). *The table value for NL = 1 is 90 degrees.*

A.1.7.3 CPR Encoding Process

The CPR encoding process **shall** calculate the encoded position values XZ_i and YZ_i for either airborne, surface, intent, or TIS-B latitude and longitude fields from the global position *lat* (latitude in degrees), *lon* (longitude in degrees), and the CPR encoding type *i* (0 for even format and 1 for odd format), by performing the following sequence of computations. The CPR encoding for intent always uses the even format (*i* = 0), whereas the airborne, surface, and TIS-B encoding use both even (*i* = 0) and odd (*i* = 1) formats.

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

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

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

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

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

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

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

Where k=1 for airborne TIS-B and k=4 for surface TIS-B modes.

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

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

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

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

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

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

---

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

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

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

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

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

Where k=1 for airborne TIS-B and k=4 for surface TIS-B modes.

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

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

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

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

For TIS-B encoding: $$YZ_i = \text{MOD}(YZ_i, 2^{12}),$$ $$XZ_i = \text{MOD}(XZ_i, 2^{12})$$

A.1.7.4 Locally Unambiguous CPR Decoding

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

Note: *This reference point may be a previously tracked position that has been confirmed by global decoding (§A.1.7.7) or it may be the own aircraft position, which would be used for decoding a new tentative position report.*

The encoded position coordinates XZ_i and YZ_i and the CPR encoding type i (0 for the even encoding and 1 for the odd encoding) contained in a Mode S Extended Squitter message **shall** be decoded by performing the sequence of computations given in §A.1.7.5 for the airborne and intent format types and in §A.1.7.6 for the surface format type.

A.1.7.5 Computations for Airborne, TIS-B and Intent Lat/Lon

The following computations **shall** be performed to obtain the decoded lat/lon for the airborne, intent, and TIS-B messages. For intent lat/lon, *i* is always 0 (even encoding), whereas airborne and TIS-B lat/lon use both even (i = 0) and odd (i = 1) encodings. For airborne lat/lon, Nb = 17, for intent, Nb = 14, and for TIS-B Nb =12

a. $Dlat_i$ is computed from the equation:

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

where $k=1$ for all modes except TIS-B surface mode when $k=4$.

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

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

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

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

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

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

where $k=1$ for all modes except TIS-B surface mode when $k=4$.

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

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

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

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

A.1.7.6 Computations for the Surface Message

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

1. $Dlat_i$ is computed from the equation:

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

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

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

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

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

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

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

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

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

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

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

A.1.7.7 Globally Unambiguous Airborne Position Decoding

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

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

Note 2: *The time difference limit of 10 seconds between the even- and odd-format position reports is determined by the maximum permitted separation of 3 NM. Positions greater than 3 NM apart cannot be used* *to solve for a unique global position. An aircraft capable of a speed of 1,850 km/h (1,000 kt) will fly about 5.1 km (2.8 NM) in 10 seconds. Therefore, the CPR algorithm will be able to unambiguously decode its position over a 10-second delay between position reports.*

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

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

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

b. Compute the latitude index:

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

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

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

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

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

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

$$Dlon_i = \frac{360°}{n_i},$$

where n_i = greater of $[\text{NL}(Rlat_i) - i]$ and 1.

f. Compute m, the longitude index:

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

where $NL = \text{NL}(Rlat_i)$.

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

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

where n_i = greater of $[\text{NL}(Rlat_i) - i]$ and 1.

A.1.7.8 CPR Decoding of Received Position Reports

A.1.7.8.1 Overview

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

A.1.7.8.2 Emitter Centered Local Decoding

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

Note: *This produces an unambiguous decoding at each update, since the transmitting aircraft cannot move more than 360 NM between position updates.*

A.1.8 Formats for Extended Squitter

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

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

Figure A-1: Extended Squitter Airborne Position

BDS 0,5

1	
2	
3	FORMAT TYPE CODE
4	(§A.1.4.1)
5	
6	SURVEILLANCE STATUS
7	
8	SINGLE ANTENNA FLAG (SAF) (§A.1.4.2.5)
9	
10	
11	ALTITUDE
12	Specified by the Format Type Code
13	
14	(1) the altitude code (AC) as specified
15	in §2.2.13.1.2 of DO-181C but
16	with the M-bit removed
17	(Ref ARINC 429 Label 203), or
18	
19	(2) GNSS height (HAE)
20	(Ref. ARINC 429 Label 370)
21	TIME (T) (§A.1.4.2.2)
22	CPR FORMAT (F) (§A.1.4.2.1)
23	MSB
24	
25	
26	
27	
28	
29	
30	ENCODED LATITUDE
31	
32	(CPR Airborne Format
33	§A.1.7.1 to §A.1.7.7)
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	
47	ENCODED LONGITUDE
48	
49	(CPR Airborne Format
50	§A.1.7.1 to §A.1.7.7)
51	
52	
53	
54	
55	
56	LSB

Purpose: To provide accurate airborne position information

Surveillance Status coding
0 = no condition information
1 = permanent alert (emergency condition)
2 = temporary alert (change in Mode A identity code other than emergency condition)
3 = SPI condition

Codes 1 and 2 take precedence over code 3.

Note: *When horizontal position information is unavailable, but altitude information is available, the airborne position message is transmitted with a Format Type Code of ZERO in bits 1-5 and the barometric pressure altitude in bits 9 to 20. If neither horizontal position nor barometric altitude information is available, then all 56 bits of Register 05 {HEX} are ZEROed. The ZERO Format Type Code field indicates that latitude and longitude information is unavailable, while the ZERO altitude field indicates that altitude information is unavailable.*

Figure A-2: Extended Squitter Surface Position

BDS 0,6

1–5	FORMAT TYPE CODE (§A.1.4.1)
6–12	MOVEMENT (§A.1.4.3.1)
13	STATUS for Heading (1 =valid, 0 = not valid)
14–20	MSB (14) HEADING (7 bits) (§A.1.4.3.2) **Resolution = 360/128 deg** LSB (20)
21	TIME (T) (§A.1.4.2.2)
22	CPR FORMAT (F) (§A.1.4.2.1)
23–39	MSB (23) ENCODED LATITUDE (CPR Surface Format §A.1.7.1 to §A.1.7.7) LSB (39)
40–56	MSB (40) ENCODED LONGITUDE (CPR Surface Format §A.1.7.1 to §A.1.7.7) LSB (56)

Purpose: To provide accurate surface position information.

Figure A-3: Extended Squitter Status

BDS 0,7

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

PURPOSE : To provide information on the capability and status of the Extended Squitter rate of the transponder.

Transmission Rate Subfield (TRS) coding:

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

Altitude type subfield (ATS) coding:

0 = barometric altitude.
1 = GNSS height (HAE), ARINC 429 Label 370

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

a) Switching from high to low rate: Aircraft must switch from high to low rate when the onboard navigation unit reports that the aircraft's position has not changed more than 10 meters in a 30 second sampling interval.

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

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

Figure A-4: Extended Squitter Identification and Category

BDS 0,8

1–5	FORMAT TYPE CODE (§A.1.4.1)
6–8	AIRCRAFT CATEGORY
9 (MSB) – 14 (LSB)	CHARACTER 1
15 (MSB) – 20 (LSB)	CHARACTER 2
21 (MSB) – 26 (LSB)	CHARACTER 3
27 (MSB) – 32 (LSB)	CHARACTER 4
33 (MSB) – 38 (LSB)	CHARACTER 5
39 (MSB) – 44 (LSB)	CHARACTER 6
45 (MSB) – 50 (LSB)	CHARACTER 7
51 (MSB) – 56 (LSB)	CHARACTER 8

Purpose: To provide aircraft identification and category.

Type coding:

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

ADS-B Emitter Category coding:

Set A

0 = No ADS-B Emitter Category Information
1 = Light (< *15 500* lbs.)
2 = Small (*15 500* to 75 000 lbs.)
3 = Large (75 000 to 300 000 lbs.)
4 = High Vortex Large(aircraft such as B-757)
5 = Heavy (> 300 000 lbs.)
6 = High Performance (> 5 g acceleration and > 400kts)
7 = Rotorcraft

Set B

0 = No ADS-B Emitter Category Information
1 = Glider/sailplane
2 = Lighter-than-Air
3 = Parachutist/Skydiver
4 = Ultralight/hang-glider/paraglider
5 = Reserved
6 = Unmanned Aerial Vehicle
7 = Space/Trans-atmospheric vehicle

Set C

0 = No ADS-B Emitter Category Information
1 = Surface Vehicle – Emergency Vehicle
2 = Surface Vehicle – Service Vehicle
3 = Point Obstacle (includes tethered balloons)
4 = Cluster Obstacle
5 = Line Obstacle
6-7 = Reserved

Set D : Reserved

Aircraft identification coding:

Character coding as specified for A.1.4.4

Figure A-6 : Extended Squitter Airborne Velocity (Subtypes 1 and 2: Velocity Over Ground)

BDS 0,9

Bit				
1	MSB		**1**	
2			**0**	
3	FORMAT TYPE CODE = 19		**0**	
4			**1**	
5	LSB		**1**	
6	SUBTYPE 1	0	SUBTYPE 2	0
7		0		1
8		1		0
9	INTENT CHANGE FLAG (A.1.4.5.3)			
10	IFR CAPABILITY FLAG (A.1.4.5.4))			
11	NAVIGATION ACCURACY			
12	CATEGORY FOR VELOCITY (NAC_V)			
13	(A1.4.5.5)			
14	DIRECTION BIT for E-W velocity **(0=East, 1=West)**			
15	EAST-WEST VELOCITY (10 bits)			
16	NORMAL : LSB = 1 knot		SUPERSONIC : LSB =4 knots	
17	All zeros = no velocity info		All zeros = no velocity info	
18	Value	Velocity	Value	Velocity
19	1	0 kts	1	0 kt
20	2	1 kt	2	4 kt
21	3	2 kt	3	8 kt
22	-	-	-	-
23	1022	1021 kt	1022	4084 kt
24	1023	>1021.5 kt	1023	> 4086kt
25	DIRECTION BIT for N-S velocity **(0=North, 1=South)**			
26	NORTH-SOUTH VELOCITY (10 bits)			
27	NORMAL : LSB = 1 knot		SUPERSONIC : LSB =4 knots	
28	All zeros = no velocity info		All zeros = no velocity info	
29	Value	Velocity	Value	Velocity
30	1	0 kts	1	0 kt
31	2	1 kt	2	4 kt
32	3	2 kt	3	8 kt
33	-	-	-	-
34	1022	1021 kt	1022	4084 kt
35	1023	>1021.5 kt	1023	> 4086kt
36	SOURCE BIT FOR VERTICAL RATE: 0 = Geometric, 1 = baro (1 bit)			
37	SIGN BIT FOR VERTICAL RATE: 0 = up, 1 = down			
38	VERTICAL RATE (9 bits)			
39	All zeros – no vertical rate information, LSB = 64 ft/min			
40	Value	Vertical rate	Ref. ARINC 429 labels	
41	1	0 ft/min	GPS: 165	
42	2	64 ft/min	INS: 365	
43	-	-		
44	510	32576 ft/min		
45	511	> 32608 ft/min		
46				
47	RESERVED			
48				
49	DIFFERENCE SIGN BIT (0 = above baro, 1 = below baro alt)			
50	GEOMETRIC HEIGHT DIFFERENCE FROM BARO. ALT. (7 bits) (A.1.4.5.6)			
51	All zeros = no info; LSB = 25 ft			
52	Value	Difference		
53	1	0 ft		
54	2	25 ft		
55	-	-		
56	126	3125 ft		
	127	> 3137.5 ft		

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

Subtype Coding

Code	Velocity	Type
	As in first edition of the ICAO Manual on Mode S Specific Services	
1	Ground speed	normal
2		supersonic
3	Airspeed, heading	normal
4		supersonic
5	Not assigned	
6	Not assigned	
7	Not assigned	

IFR Capability Flag coding:

0 = Transmitting aircraft has no capability for applications requiring ADS-B equipage class A1 or above

1 = Transmitting aircraft has capability for applications requiring ADS-B equipage class A1 or above.

Ref. ARINC Labels for Velocity:

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

Ref. ARINC Labels
GNSS Height (HAE): GPS: 370
GNSS Altitude (MSL): GPS: 076

Figure A-7: Extended Squitter Airborne Velocity (Subtypes 3 and 4: Airspeed and Heading)

BDS 0,9

1 2 3 4 5	MSB FORMAT TYPE CODE = 19 LSB		**1** **0** **0** **1** **1**
6 7 8	SUBTYPE 3	0 1 1	SUBTYPE 4 1 0 0
9	INTENT CHANGE FLAG (§A.4.5.3)		
10	IFR CAPABILITY FLAG (A.1.4.5.4)		
11 12 13	NAVIGATION ACCURACY CATEGORY FOR VELOCITY (NAC_V) (A.1.4.5.5)		
14	STATUS BIT – 1 = Heading available, 0 = not available		
15 16 17 18 19 20 21 22 23 24	MSB HEADING (10 bits) (A.1.4.5.6) Resolution = 360/1024 deg LSB		Ref. ARINC 429 Label: INS: 320
25	AIRSPEED TYPE: 0 = IAS, 1 = TAS		
26	AIRSPEED (10 bits)		
27 28 29 30 31 32 33 34 35	NORMAL : LSB = 1 knot All zeros = no velocity info Value — Velocity 1 — 0 kts 2 — 1 kt 3 — 2 kt - — - 1022 — 1021 kt 1023 — >1021.5 kt		SUPERSONIC : LSB =4 knots All zeros = no velocity info Value — Velocity 1 — 0 kt 2 — 4 kt 3 — 8 kt - — - 1022 — 4084 kt 1023 — > 4086 kt
36	SOURCE BIT FOR VERTICAL RATE: 0 = Geometric, 1 = baro (1 bit)		
37	SIGN BIT FOR VERTICAL RATE: 0 = up, 1 = down		
38 39 40 41 42 43 44 45 46	VERTICAL RATE (9 bits) All zeros – no vertical rate information LSB = 64 ft/min Value — Vertical rate 1 — 0 ft/min 2 — 64 ft/min - — - 510 — 32576 ft/min 511 — > 32608 ft/min		 Ref. ARINC labels GPS: 165 INS: 365
47 48	RESERVED		
49	DIFFERENCE SIGN BIT (0 = above baro, 1 = below baro alt))		
50 51 52 53 54 55 56	GEOMETRIC HEIGHT DIFFERENCE FROM BARO. ALT. (7 bits) (§A.1.4.5.6) All zeros = no info; LSB = 25 ft Value — Vertical rate 1 — 0 ft 2 — 25 ft - — - 126 — 3125 ft 127 — > 3137.5 ft		 Ref. ARINC 429 labels

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

Note: *This format is only used if velocity over ground is not available*

NAC_V is specified in §2.2.3.2.6.1.5.

Subtype Coding

Code	Velocity	Type
0	As in first edition of the ICAO Manual on Mode S Specific Services	
1	Ground speed	normal
2		supersonic
3	Airspeed, heading	normal
4		supersonic
5	Not assigned	
6	Not assigned	
7	Not assigned	

IFR Capability Flag coding:

0 = Transmitting aircraft has no capability for applications requiring ADS-B equipage class A1 or above

1 = Transmitting aircraft has capability for applications requiring ADS-B equipage class A1 or above.

Ref. ARINC 429 Labels for Air Data Source:
IAS: 206
TAS: 210

Figure A-8: Extended Squitter Event Driven Register

BDS 0,A

1	
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3	
4	
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56	

Purpose. To provide a flexible means to squitter messages other than position, velocity and identification.

Note:

The data in this register is not intended for extraction using the GICB or TCAS crosslink protocols. Readout (if required) is accomplished by extracting the contents of the appropriate Register 61 {HEX} to 6F {HEX}.

Figure A-9: Aircraft Status
(Subtype 1: Emergency/Priority Status)

BDS 6,1

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

Purpose. To provide additional information on aircraft status.

Subtype Coding:

0	=	No Information
1	=	Emergency/Priority Status
2-7	=	Reserved

Emergency/Priority Status Coding

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

Notes:

1. *Message delivery is accomplished once per second using the event driven protocol.*

2. *Termination of emergency state is detected by coding in the surveillance status field of the airborne position message.*

Figure A.1.4.9: Target State and Status Information

BDS 6,2:

1	
2	
3	FORMAT TYPE CODE = 29
4	
5	
6	Subtype Code = 0
7	LSB
8	Vertical Data Available /Source Indicator
9	LSB (A.1.4.9.3)
10	Target Altitude Type (A.1.4.9.4)
11	Backward Compatibility Flag = 0
12	Target Altitude Capability
13	LSB (A.1.4.9.5)
14	Vertical Mode indicator
15	LSB (A.1.4.9.6)
16	MSB
17	
18	
19	
20	Target Altitude
21	(A.1.4.9.7)
22	
23	
24	
25	LSB
26	Horizontal Data Available/Source Indicator
27	LSB (A.1.4.9.8)
28	MSB
29	
30	
31	
32	Target Heading/Track Angle
33	(A.1.9.9)
34	
35	
36	LSB
37	Target Heading/ Track Indicator (A1.4.9.10)
38	Horizontal Mode Indicator
39	LSB (A.1.4.9.11)
40	MSB
41	Navigation Accuracy Category – Position (NAC_P)
42	(A.1.4.9.12)
43	LSB
44	Navigation Integrity Category – Baro (NIC_{BARO}) – Baro (A.1.9.13)
45	System Integrity Level (SIL)
46	LSB (A.1.4.9.14)
47	
48	
49	Reserved
50	
51	
52	Capability/Mode Codes
53	LSB (A.1.4.9.15)
54	MSB
55	Emergency/ Priority
56	LSB (A.1.4.9.16)

Purpose. To provide aircraft state and status information..

Figure A-12: Aircraft Operational Status

BDS 6,3

1	MSB	
2		
3	FORMAT TYPE CODE = 31	
4		
5	LSB	
6	MSB	MSB
7	Subtype Code = 0	Subtype Code = 1
8	LSB	LSB
9	MSB	MSB
10		
11		
12		
13	Airborne	Surface
14	Capability Class	Capability Class
15	(CC) Codes	(CC) Codes
16	(A.1.4.10.3)	(A.1.4.10.3)
17		
18		
19		
20		LSB
21		MSB
22		Length/Width Codes
23		(A.1.4.10.11)
24	LSB	LSB
25	MSB	
26		
27		
28		
29		
30		
31	Operational Mode (OM) Codes	
32	(A.1.4.10.4)	
33		
34		
35		
36		
37		
38		
39		
40	LSB	
41	MSB	
42	Version Number (A.1.4.10.5)	
43	LSB	
44	NIC Supplement (A.1.4.10.6)	
45	MSB	
46	Navigational Accuracy Category – Position (NAC_P)	
47	(A.1.4.10.7)	
48	LSB	
49	BAQ=0	Reserved
50	LSB (A.1.4.10.8)	
51	System Integrity Level (SIL)	
52	LSB (A.1.4.10.9)	
53	NIC_{BARO} LSB (A.1.4.10.10)	TRK/HDG LSB (A.1.4.10.12)
54	HRD (A.1.4.10.13)	
55	Reserved	
56		

Purpose. To provide the aircraft capability class, current operational mode of ATC related applications and other operational information

Subtype Coding:

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

A.2 Traffic Information Services – Broadcast (TIS-B) Formats and Coding

A.2.1 Introduction

Notes:

1. *This section of Appendix A defines the formats and coding for a Traffic Information Service Broadcast (TIS-B) based on the same 112-bit 1090 MHz signal transmission that is used for ADS-B on 1090 MHz.*

2. *TIS-B complements the operation of ADS-B by providing ground-to-air broadcast of surveillance data on aircraft that are not equipped for 1090 MHz ADS-B. The basis for this ground surveillance data may be an ATC Mode S radar, a surface or approach multi-lateration system or a multi-sensor data processing system. The TIS-B ground-to-air transmissions use the same signal formats as 1090 MHz ADS-B and can therefore be accepted by a 1090 MHz ADS-B receiver.*

3. *TIS-B service is the means for providing a complete surveillance picture to 1090 MHz ADS-B users during a transition period. After transition, it also provides a means to cope with a user that has lost its 1090 MHz ADS-B capability.*

A.2.2 TIS-B Format Definition

TIS-B information is broadcast using the 112-bit Mode S DF=18 format as shown below in Figure 13.

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

<u>Figure A-13:</u> TIS-B Format Definition

A.2.3 Control Field Allocation

The content of the DF=18 transmission is defined by the value of the control field, as specified in Table A-22.

Table A-22: CF Field Code Definitions in DF=18 ADS-B and TIS-B Messages

CF Value	ICAO/Mode A Flag (IMF)	Meaning
0	N/A	ADS-B message from a non-transponder device, AA field holds 24-bit ICAO aircraft address
1	N/A	Reserved for ADS-B message in which the AA field holds anonymous address or ground vehicle address or fixed obstruction address
2	0	Fine TIS-B message, AA field contains the 24-bit ICAO aircraft address
	1	Fine TIS-B message, AA field contains the 12-bit Mode A code followed by a 12-bit track file number
3	0	Coarse TIS-B airborne position and velocity message, AA field contains the 24-bit ICAO aircraft address
	1	Coarse TIS-B airborne position and velocity message, AA field contains the 12-bit Mode A code followed by a 12-bit track file number.
4	N/A	Reserved for TIS-B management message AA field holds TIS-B service volume ID + other information (e.g., MSB of reference position for the service volume)
5	0	Reserved for TIS-B messages that relay ADS-B messages using anonymous 24-bit addresses
	1	Reserved
6 – 7	N/A	Reserved

A.2.4 TIS-B Surveillance Message Definition

A.2.4.1 TIS-B Fine Airborne Position Message

The TIS-B fine airborne position ME field will be formatted as specified in Figure A-14.

Note: *Additional details are specified in the following paragraphs.*

A.2.4.1.1 ICAO/Mode A Flag (IMF)

This one-bit field (bit 8) will indicate the type of identity associated with the aircraft data reported in the TIS-B message. IMF equal to ZERO (0) will indicate that the TIS-B data is identified by an ICAO 24-bit address. IMF equal to ONE (1) will indicate that the TIS-B data is identified by a “Mode A” code. A TIS-B report on a primary radar target will indicate a “Mode A” code of all ZEROs.

Notes:

1. *The AA field is coded differently for 24-bit addresses and Mode A codes as specified in Table A-22.*

2. *A target with a ZERO "Mode A" code and a reported altitude, is an SSR target.*

A.2.4.1.2 Pressure Altitude

This 12-bit field will provide the aircraft pressure altitude. This field will contain barometric altitude encoded in 25 or 100-foot increments (as indicated by the Q Bit). All zeroes in this field will indicate that there is no altitude data.

A.2.4.1.3 Compact Position Reporting (CPR) Format (F)

This field will be set as specified in §A.1.4.2.1.

A.2.4.1.4 Latitude/Longitude

The latitude/longitude fields in the TIS-B fine airborne position message will be set as specified in §A.1.4.2.3.

A.2.4.2 TIS-B Surface Position Message

The TIS-B surface position ME field will be formatted as specified in Figure A-15.

Note: *Additional details are specified in the following paragraphs.*

A.2.4.2.1 Movement

This field will be set as specified in §A.1.4.3.1.

A.2.4.2.1.1 Ground Track (True)

A.2.4.2.1.1.1 Ground Track Status

This field will be set as specified in §A.1.4.3.2.1.

A.2.4.2.1.1.2 Ground Track Angle

This field will be set as specified in §A.1.4.3.2.2.

A.2.4.2.1.2 ICAO/Mode A Flag (IMF)

This one-bit field (bit 21) will indicate the type of identity associated with the aircraft data reported in the TIS-B message. Coding will be as specified in §A.2.4.1.1.

A.2.4.2.1.3 Compact Position Reporting (CPR) Format (F)

This field will be set as specified in §A.1.4.3.3.

A.2.4.2.1.4 Latitude/Longitude

The latitude/longitude fields in the TIS-B fine surface position message will be set as specified in §A.1.4.3.5.

A.2.4.3 Identification and Category Message

The TIS-B identification and category ME field will be formatted as specified in Figure A-16. This message will only be used for aircraft identified with an ICAO 24-bit address.

Note: *Additional details are specified in the following paragraphs.*

A.2.4.3.1 Aircraft Identification Coding

This field will be set as specified in §A.1.4.4.1.

A.2.4.4 Airborne Velocity Message

The TIS-B airborne velocity ME field will be formatted as specified in the 7A-14.

Note: *Additional details are specified in the following paragraphs.*

A.2.4.4.1 Subtype Field

Only Subtypes 1 and 2 will be used for the TIS-B Airborne Velocity Message. Subtype 1 will be used for velocities under 1000 knots and Subtype 2 will be used for aircraft capable of supersonic flight when the velocity might exceed 1022 knots.

The supersonic version of the velocity coding will be used if either the east-west OR north-south velocities exceed 1022 knots. A switch to the normal velocity coding will be made if both the east-west AND north-south velocities drop below 1000 knots.

A.2.4.4.2 ICAO/Mode A Flag (IMF)

This one-bit field (bit 9) will indicate the type of identity associated with the aircraft data reported in the TIS-B message. Coding will be as specified in §A.2.4.1.1.

A.2.4.5 Coarse Airborne Position Message

The TIS-B coarse airborne position ME field will be formatted as specified in Figure A-18.

Notes:

1. *This message is used if the surveillance source for TIS-B is not of high enough quality to justify the use of the fine formats. An example of such a source is a scanning beam Mode S interrogator.*

2. *Additional details are specified in the following paragraphs.*

A.2.4.5.1 ICAO/Mode A Flag (IMF)

This one-bit field (bit 1) will indicate the type of identity associated with the aircraft data reported in the TIS-B message. Coding will be as specified in §A.2.4.1.1.

A.2.4.5.2 Service Volume ID (SVID)

The 4-bit SVID field will identify the TIS-B site that delivered the surveillance data.

Note: *In the case where TIS-B messages are being received from more than one TIS-B ground stations, the SVID can be used to select coarse messages from a single source. This will prevent the TIS-B track from wandering due to the different error biases associated with different sources.*

A.2.4.5.3 Pressure Altitude

This 12-bit field will provide the aircraft pressure altitude. This field will contain barometric altitude encoded in 25 or 100-foot increments (as indicated by the Q Bit).

A.2.4.5.4 Ground Track Status

This one bit (ME bit 20) field will define the validity of the ground track value. Coding for this field will be as follows: 0=not valid and 1= valid.

A.2.4.5.5 Ground Track Angle

This 5-bit (ME bits 21-25) field will define the direction (in degrees clockwise from true north) of aircraft motion. The ground track will be encoded as an unsigned angular weighted binary numeral, with an MSB of 180 degrees and an LSB of 360/32 degrees, with ZERO (0) indicating true north. The data in the field will be rounded to the nearest multiple of 360/32 degrees.

A.2.4.5.6 Ground Speed

This 6-bit (ME bits 26-31) field will define the aircraft speed over the ground. Coding of this field will be as specified in §2.2.17.3.5.6.

A.2.4.5.7 Latitude/Longitude

The latitude/longitude fields in the TIS-B coarse airborne position message will be set as specified in §A.1.4.2.3, except that the 12-bit form of CPR coding will be used.

A.2.5 Reserved for TIS-B Management Messages

Note: *TIS-B management messages could announce information such as location and the service volume of the TIS-B ground station. There is no requirement in the TIS-B MASPS (RTCA DO-TBD) for management messages. Format DF=18 with CF=4 has been reserved for management messages should they be required in the future.*

Figure A-14: TIS-B Fine Airborne Position Message

1–5	FORMAT TYPE CODE (See §A.1.4.1 and Note 1)
6–7	SURVEILLANCE STATUS LSB (bit 7)
8	IMF (See §A.2.4.1.1)
9–20	PRESSURE ALTITUDE The altitude code (AC) as specified in section 2.2.13.1.2 of DO-181C but with the M-bit removed
21	Reserved
22	CPR FORMAT (F) (See §A.1.4.2.1)
23–39	MSB (bit 23) CPR ENCODED LATITUDE (CPR Airborne Format See §A.1.7.1 to §A.1.7.7) LSB (bit 39)
40–56	MSB (bit 40) CPR ENCODED LONGITUDE (CPR Airborne Format See §A.1.7.1 to §A.1.7.4) LSB (bit 56)

Purpose: To provide airborne position information for aircraft that are not equipped with 1090 MHz ADS-B when the TIS-B service is based on high quality surveillance data.

Surveillance Status coding
0 = no condition information
1 = permanent alert (emergency condition)
2 = temporary alert (change in Mode A identity code other than emergency condition)
3 = SPI condition

Codes 1 and 2 take precedence over code 3.

Figure A-15: TIS-B Fine Surface Position Message

1	
2	
3	FORMAT TYPE CODE
4	(See §A.1.4.1)
5	
6	
7	
8	
9	MOVEMENT
10	(See §A.1.4.3.1)
11	
12	
13	STATUS for Heading/Ground Track (1 =valid, 0 = not valid)
14	MSB
15	
16	HEADING/GROUND TRACK (7 bits)
17	(Referenced to true north)
18	
19	Resolution = 360/128 deg
20	LSB
21	IMF (See §A.2.4.2.12)
22	CPR FORMAT (F) (See §A.1.4.2.1)
23	MSB
24	
25	
26	
27	
28	
29	
30	CPR ENCODED LATITUDE
31	
32	(CPR Surface Format
33	See §A.1.7.1 to §A.1.7.7)
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	
47	CPR ENCODED LONGITUDE
48	
49	(CPR Surface Format
50	See §A.1.7.1 to §A.1.7.7)
51	
52	
53	
54	
55	
56	LSB

Purpose: To provide surface position information for aircraft that are not equipped with 1090 MHz ADS-B.

Figure A-16: TIS-B Identification and Category Message

1	FORMAT TYPE CODE (See §A.1.4.1)
2	
3	
4	
5	
6	EMITTER CATEGORY
7	
8	
9	CHARACTER 1 (MSB)
10	
11	
12	
13	
14	(LSB)
15	CHARACTER 2 (MSB)
16	
17	
18	
19	
20	(LSB)
21	CHARACTER 3 (MSB)
22	
23	
24	
25	
26	(LSB)
27	CHARACTER 4 (MSB)
28	
29	
30	
31	
32	(LSB)
33	CHARACTER 5 (MSB)
34	
35	
36	
37	
38	(LSB)
39	CHARACTER 6 (MSB)
40	
41	
42	
43	
44	(LSB)
45	CHARACTER 7 (MSB)
46	
47	
48	
49	
50	(LSB)
51	CHARACTER 8 (MSB)
52	
53	
54	
55	
56	(LSB)

Purpose: To provide aircraft identification and category for aircraft that are not equipped with 1090 MHz ADS-B.

Type coding:

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

ADS-B Emitter Category coding:

Set A

0 = No ADS-B Emitter Category Information
1 = Light (< *15 500* lbs.)
2 = Small (*15 500* to 75 000 lbs.)
3 = Large (75 000 to 300 000 lbs.)
4 = High Vortex Large (aircraft such as B-757)
5 = Heavy (> 300 000 lbs.)
6 = High Performance (> 5 g acceleration and > 400kts)
7 = Rotorcraft

Set B

0 = No ADS-B Emitter Category Information
1 = Glider/sailplane
2 = Lighter-than-Air
3 = Parachutist/Skydiver
4 = Ultralight/hang-glider/paraglider
5 = Reserved
6 = Unmanned Aerial Vehicle
7 = Space/Trans-atmospheric Vehicle

Set C

0 = No ADS-B Emitter Category Information
1 = Surface Vehicle – Emergency Vehicle
2 = Surface Vehicle – Service Vehicle
3 = Fixed Ground or Tethered Obstruction
4-7 = Reserved

Set D : Reserved

Aircraft identification coding:

Coding as specified for A.1.4.4

Figure A-17: TIS-B Airborne Velocity Messages (Subtypes 1 and 2: Velocity Over Ground)

BDS 0,9

Bit		
1	MSB **1**	
2	**0**	
3	FORMAT TYPE CODE = 19 **0**	
4	**1**	
5	LSB **1**	
6	SUBTYPE 1 0	SUBTYPE 2 0
7	0	1
8	1	0
9	IMF (See §A.2.4.4.2)	
10	MSB	
11	Navigation Accuracy Category for Position (NAC_P)	
12	(A.1.4.10.7)	
13	LSB	
14	DIRECTION BIT for E-W velocity **(0=East, 1=West)**	
15	EAST-WEST VELOCITY (10 bits)	
16	NORMAL : LSB = 1 knot	SUPERSONIC : LSB =4 knots
17	All zeros = no velocity info	All zeros = no velocity info
18	Value / Velocity	Value / Velocity
19	1 / 0 kts	1 / 0 kt
20	2 / 1 kt	2 / 4 kt
21	3 / 2 kt	3 / 8 kt
22	- / -	- / -
23	1022 / 1021 kt	1022 / 4084 kt
24	1023 / >1021.5 kt	1023 / > 4086kt
25	DIRECTION BIT for N-S velocity **(0=North, 1=South)**	
26	NORTH-SOUTH VELOCITY (10 bits)	
27	NORMAL : LSB = 1 knot	SUPERSONIC : LSB =4 knots
28	All zeros = no velocity info	All zeros = no velocity info
29	Value / Velocity	Value / Velocity
30	1 / 0 kts	1 / 0 kt
31	2 / 1 kt	2 / 4 kt
32	3 / 2 kt	3 / 8 kt
33	- / -	- / -
34	1022 / 1021 kt	1022 / 4084 kt
35	1023 / >1021.5 kt	1023 / > 4086kt
36	Reserved (1 bit)	
37	SIGN BIT FOR VERTICAL RATE: 0 = up, 1 = down	
38	VERTICAL RATE (9 bits)	
39	All zeros – no vertical rate information, LSB = 64 ft/min	
40	Value / Vertical rate	
41	1 / 0 ft/min	
42	2 / 64 ft/min	
43	- / -	
44	510 / 32576 ft/min	
45	511 / > 32608 ft/min	
46		
47	NIC Supplement (See §A.1.4.10.6)	
48	Navigation Accuracy Category for Velocity (NAC_V)	
49	(See §A.1.4.5.5)	
50		
51	Surveillance Integrity Level (SIL)	
52	LSB (See §A.1.4.10.9)	
53		
54	Reserved	
55		
56		

Purpose: To provide velocity information for aircraft that are not equipped with 1090 MHz ADS-B when the TIS-B service is based on high quality surveillance data.

Subtype Coding

Code	Velocity	Type
1	Ground speed	normal
2		supersonic

Figure A-18: TIS-B Coarse Airborne Position Message

1	**IMF** (See §A.2.4.5.1)
2	**SURVEILLANCE STATUS**
3	
4	MSB
5	**SERVICE VOLUME ID (SVID)**
6	
7	LSB
8	MSB
9	
10	
11	
12	
13	**PRESSURE ALTITUDE**
14	
15	
16	
17	
18	
19	LSB
20	**GRND TRACK STATUS** (1=valid, 0=invalid)
21	**GROUND TRACK ANGLE**
22	
23	(See §A.2.4.5.5)
24	
25	
26	**GROUND SPEED**
27	
28	(See §A.2.4.5.6)
29	
30	
31	
32	**CPR FORMAT (F)** (0 = even, 1 = odd)
33	
34	
35	
36	
37	
38	**CPR-ENCODED LATITUDE**
39	
40	(See §A.2.4.5.7)
41	
42	
43	
44	LSB
45	MSB
46	
47	
48	
49	
50	**CPR-ENCODED LONGITUDE**
51	
52	(See §A.2.4.5.7)
53	
54	
55	
56	LSB

Purpose: To provide airborne position information for aircraft that are not equipped with 1090 MHz ADS-B when the TIS-B service is based on moderate quality surveillance data..