Appendix A

Extended Squitter and TIS-B

Formats and Coding Definitions

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A Extended Squitter and TIS-B 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-181D. Extended Squitter messages are generated by the Mode S transponder at periodic rates as defined by RTCA/DO-181D, when data is present in Register numbers 05_{16}, 06_{16}, 08_{16}, and 09_{16}. Each time data is loaded into Register $0A_{16}$ the transponder will broadcast a single event-driven Extended Squitter. Data loaded into Registers 07_{16}, 61_{16}, 62_{16}, and 63_{16} 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 Device, 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 these MOPS.*

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A.1.2 Register Allocation Related to Extended Squitter

Table A-1: Register Allocation

Register number	Assignment	Maximum update interval
05_{16}	Extended Squitter Airborne Position	0.2 s
06_{16}	Extended Squitter Surface Position	0.2 s
07_{16}	Extended Squitter Status	1.0 s
08_{16}	Extended Squitter Identification and Category	15.0 s
09_{16}	Extended Squitter Airborne Velocity	1.3 s
$0A_{16}$	Extended Squitter Event-Driven Information	variable
10_{16}	Data Link Capability Report	≤4.0 s (see Note 2)
17_{16}	Common usage Capability Report	5.0 s
18_{16} – $1C_{16}$	Mode S Specific Services Capability Report	See Note 5
$1D_{16}$-$1F_{16}$	Mode S Specific Services Capability Report	5.0 s
20_{16}	Aircraft Identification	5.0 s
30_{16}	TCAS Active Resolution Advisory	Annex 10, Vol IV §4.3.8.4.2.2
61_{16}	Emergency/Priority Status	1.0 s
62_{16}	Target State and Status Information	0.5 s
63_{16}-64_{16}	Reserved for Extended Squitter	
65_{16}	Aircraft Operational Status	2.5 s
66_{16}-$6F_{16}$	Reserved for Extended Squitter	

Notes:

1. *The Register number is equivalent to the BDS B-Definition Subfield (BDS) value §2.2.14.4.20.b of DO-181D.*

2. *For ADS-B implementations on Mode S transponders, the data link capability report (Register 10_{16}) 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 $0A_{16}$ is not to be used for GICB or ACAS crosslink readout.*

4. *The term "minimum update rate" is used in this document. The "minimum update rate" is obtained when data is loaded in one Register field once every "maximum update interval."*

5. *A bit set in one of these Registers indicates that the service loading the Register indicated by that bit has been installed on the aircraft. In this regard, these bits are not cleared to reflect a real time loss of an application, as is done for Register 17_{16}.*

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. Any valid data will be reloaded into the relevant field as soon as it becomes available at the Mode S

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Specific Services Entity (SSE) interface regardless of the update rate. If data are not available for a time no greater than twice the specified "maximum update interval," or 2 seconds (whichever is the greater), then the status bit (if provided) will indicate that the data in that field are invalid, and the field will be ZEROed.

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_{16} to $0A_{16}$ inclusive.

   Notes:

   1. *The intent of the capability bits in Register 17_{16} is to indicate that useful data is contained in the corresponding register. For this reason, 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_{16} to $1C_{16}$ 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_{16}.*

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

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

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

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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 "Functional Test" then the status bit **shall** be set to "INVALID."

   c) If bits 30 and 31 represent "Normal Operation," "plus sign," or "minus sign," then the status bit **shall** be set to "VALID" provided that the data are being updated at the required rate.

   d) 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.

   Note: *This facilitates partial loading of the registers.*

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

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

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

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

Notes:

1. When multiple data sources are available, the one with the highest resolution should be selected.

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

3. As used in these MOPS, 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 ("ME" bits 1 – 5, Message bits 33 – 37) 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.

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Table A-2: "TYPE" Subfield Code Definitions (DF = 17 or 18)

TYPE Code	Subtype Code	NIC Supplement			Format (Message Type)	Horizontal Containment Radius Limit (R_C)	Navigation Integrity Category (NIC)	Altitude Type	Notes
		A	B	C					
0	Not Present	*Not Applicable*			No Position Information (**Airborne or Surface Position Messages**)	R_C unknown	NIC = 0	Baro Altitude or No Altitude Information	1, 2, 3
1	Not Present	*Not Applicable*			**Aircraft Identification and Category Message** (§2.2.3.2.5, §A.1.4.4)	*Not Applicable*	*Not Applicable*	*Not Applicable*	Category Set D
2									Category Set C
3									Category Set B
4									Category Set A
5	Not Present	0	--	0	**Surface Position Message** (§2.2.3.2.4, §A.1.4.3)	$R_C < 7.5$ m	NIC = 11	No Altitude Information	
6		0	--	0		$R_C < 25$ m	NIC = 10		
7		1	--	0		$R_C < 75$ m	NIC = 9		6
		0	--	0		$R_C < 0.1$ NM (185.2 m)	NIC = 8		
8		1	--	1		$R_C < 0.2$ NM (370.4 m)	NIC = 7		
		1	--	0		$R_C < 0.3$ NM (555.6 m)	NIC = 6		
		0	--	1		$R_C < 0.6$ NM (1111.2 m)	NIC = 6		
		0	--	0		$R_C \geq 0.6$ NM (1111.2 m) or unknown	NIC = 0		
9	Not Present	0	0	--	**Airborne Position Message** (§2.2.3.2.3, §A.1.4.2)	$R_C < 7.5$ m	NIC = 11	Baro Altitude	5
10		0	0	--		$R_C < 25$ m	NIC = 10		5
11		1	1	--		$R_C < 75$ m	NIC = 9		5, 6
		0	0	--		$R_C < 0.1$ NM (185.2 m)	NIC = 8		
12		0	0	--		$R_C < 0.2$ NM (370.4 m)	NIC = 7		
13		0	1	--		$R_C < 0.3$ NM (555.6 m)	NIC = 6		
		0	0	--		$R_C < 0.5$ NM (925 m)	NIC = 6		
		1	1	--		$R_C < 0.6$ NM (1111.2 m)			
14		0	0	--		$R_C < 1.0$ NM (1852 m)	NIC = 5		
15		0	0	--		$R_C < 2$ NM (3.704 km)	NIC = 4		
16		1	1	--		$R_C < 4$ NM (7.408 km)	NIC = 3		7
		0	0	--		$R_C < 8$ NM (14.816 km)	NIC = 2		
17		0	0	--		$R_C < 20$ NM (37.04 km)	NIC = 1		
18		0	0	--		$R_C \geq 20$ NM (37.04 km) or unknown	NIC = 0		
19	0	*Not Applicable*			Reserved	*Not Applicable*	*Not Applicable*	Difference between "Baro Altitude" and "GNSS Height (HAE)"	
	1 – 4				**Airborne Velocity Message** (§2.2.3.2.6, §A.1.4.5)				
	5 – 7				Reserved				
20	Not Present	0	0	--	**Airborne Position Message** (§2.2.3.2.3, §A.1.4.2)	$R_C < 7.5$ m	NIC = 11	GNSS Height (HAE)	2, 5
21		0	0	--		$R_C < 25$ m	NIC = 10		2, 5
22		0	0	--		$R_C \geq 25$ m or unknown	NIC = 0		2

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Table A-2: "TYPE" Subfield Code Definitions (DF = 17 or 18) (Continued)

TYPE Code	Subtype Code	NIC Supplement	Format (Message Type)
23	0	*Not Applicable*	**Test Message** (§2.2.3.2.7.3)
	1 – 6		Reserved
24	0		**Reserved**
	1		**Surface System Status** (§2.2.3.2.7.4) (Allocated for National Use)
	2 – 7		**Reserved**
25 – 26			**Reserved** (§2.2.3.2.7.5 and §2.2.3.2.7.6)
27			**Reserved for Trajectory Change Message** (§2.2.3.2.7.7)
28	0		**Reserved**
	1		**Extended Squitter Aircraft Status Message (Emergency/Priority Status)** (§A.1.4.8)
	2		**Extended Squitter Aircraft Status Message (TCAS RA Broadcast)** (§A.1.4.8)
	3 – 7		**Reserved**
29	0		**Target State and Status Message** (§A.1.4.9) (ADS-B Version Number=1, defined in RTCA DO-260A)
	1		**Target State and Status Message** (§A.1.4.9) (ADS-B Version Number=2, defined in these MOPS, RTCA DO-260B)
	2 - 3		Reserved
30	0 – 7		**Reserved**
31	0 – 1		**Aircraft Operational Status Message** (§A.1.4.10)
	2 – 7		Reserved

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Notes for Table A-2:

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_{16} are set to ZERO. The ZERO (binary 00000) TYPE Code field indicates that Latitude and Longitude information is not available, while the ZERO altitude field indicates that altitude information is not available.*

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

5. *This TYPE Code value implies limits for the R_C (horizontal containment limit). If this limit is not satisfied, then a different value for the TYPE Code should be selected.*

6. *The "NIC supplement" field in the Airborne Position Message (§A.1.4.2) and in the Aircraft Operational Status Message (§0~~A.1.4.10.6~~) enables the Report Assembly Function in ADS-B Receiving Subsystems to determine whether the ADS-B Transmitting Subsystem is announcing NIC=8 (R_C < 0.1 NM) or NIC=9 (R_C < 75 m).*

7. *The "NIC supplement" field in the Airborne Position Message (§A.1.4.2) and in the Aircraft Operational Status Message (§0~~A.1.4.10.6~~) enables the Report Assembly Function in ADS-B Receiving Subsystems to determine whether the ADS-B Transmitting Subsystem is announcing NIC=2 (R_C < 8 NM) or NIC=3 (R_C < 4 NM).*

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.*

9. *Future versions of these MOPS may limit transmission of Surface Position Messages at lower NIC and/or NAC_P values for Transponder-Based systems.*

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.*

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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 Code 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 Code 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 Code subfield of Airborne Position Messages to a value in the range from 20 to 22 depending on the radius of containment (R_C) 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 Code subfield in Airborne Position Messages to a value in the range from 9 to 18 depending on the radius of containment 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 (radius of containment) 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 Code subfield to ZERO (0) if valid horizontal position information is not available.

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

If valid pressure altitude is not available, but valid geometric altitude information is available, the ADS-B Transmitting Subsystem will set the TYPE Code 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 radius of containment) 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.

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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 Radius of Containment is Not Available

If R_C (horizontal radius of containment) information is not available from the navigation data source, then the ADS-B Transmitting Subsystem 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 Code subfield to ZERO (0) if valid horizontal position information is not available.

b. The ADS-B Transmitting Subsystem will set the TYPE Code subfield to 8 if valid horizontal position information is available. (This TYPE Code indicates that radius of containment, 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 Surface Position Message will be set in the range from "5" to "8."

b. If R_C (Horizontal Radius of Containment) information is available from the navigation data source, the "TYPE" Code 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" Code 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_{16} in Figure A-1.

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 (ME bit 22, Message bit 54) **shall** be used to define the CPR Format (F) type. A CPR Format equal to ZERO (0) **shall** denote an "**even**" format coding, while a CPR Format equal to ONE (1) **shall** denote an "**odd**" format coding (§A.1.7.7).

A.1.4.2.2 Time Synchronization (T)

This one-bit field (ME bit 21, Message bit 53) 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 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 CPR Encoded Latitude/Longitude

The CPR Encoded Latitude/Longitude field in the Airborne Position Message will be a 34-bit field (ME bits 23 – 56, Message bits 55 – 88) containing the Latitude and Longitude of the Aircraft's Airborne Position. The Latitude and Longitude 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.

Notes:

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

2. *Although the positional accuracy of the airborne CPR encoding is approximately 5.1 meters in most cases, implementers should be aware that the longitude position accuracy may only be approximately 10.0 meters when the latitude is either –87.0 +/- 1.0 degrees, or +87 +/- 1.0 degrees.*

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 ZERO (0) if the Time of Applicability is an even-numbered 0.2 second UTC epoch, or ONE (1) if the Time of Applicability is an odd-numbered 0.2 second epoch.

Note 1: *Here, an "even-numbered 0.2 second epoch" means an epoch that occurs 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 ADS-B Receiving Subsystem may easily recover the Time of Applicability of the data in the Airborne Position Message, as follows:

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

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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. For example, loading the register at 200 millisecond intervals would require that the time of applicability at register load time is exactly 100 milliseconds ahead of the register load time. Greater flexibility in the time of applicability at register load time is provided by increasing the update rate ~~(Shorter intervals than 200 ms are permitted, but not required.)~~*

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

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 Subsystems that the data in the Latitude and Longitude fields are invalid.

A.1.4.2.4 Altitude

This 12-bit field (ME bits 9 – 20, Message bits 41 – 52) 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 NIC Supplement-B

The first 5-bit field (ME bits 1 – 5, Message bits 33 – 37) in every Mode S Extended Squitter Message contains the format TYPE Code. The format TYPE Code differentiates the 1090ES Messages into several classes: Airborne Position, Airborne Velocity, Surface Position, Identification and Category, Aircraft Intent, Aircraft Status, etc. In addition, the format TYPE Code also encodes the Navigation Integrity Category (NIC) value of the source used for the position report.

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The NIC Supplement-B is a 1-bit (ME bit 8, Message bit 40) subfield in the Airborne Position Message that is use in conjunction with the TYPE Code and NIC value to allow surveillance applications to determine whether the reported geometric position has an acceptable level of integrity containment region for the intended use. The NIC integrity containment region is described horizontally using the radius of containment, R_C. The format TYPE Code also differentiates the Airborne Messages as to the type of their altitude measurements: barometric pressure altitude or GNSS height (HAE). The 5-bit encoding for format TYPE Code and related NIC values conforms to the definition contained in Table A-25. If an update has not been received from an on-board data source for the determination of the TYPE Code value based on the radius of containment within the past 5 seconds, then the TYPE Code value will be encoded to indicate that R_C is "Unknown."

A.1.4.3 Surface Position Format

The Surface Position squitter will be formatted as specified in the definition of Register 06_{16} in Figure A-2.

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

A.1.4.3.1 Movement

This 7-bit field (ME bits 6 – 12, Message bits 38 – 44) 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

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

A.1.4.3.2 Heading

A.1.4.3.2.1 Heading/Ground Track Status

This one bit field (ME bit 13, Message bit 45) will define the validity of the Heading value. Coding for this field will be as follows: 0=not valid and 1= valid.

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Note: *If a source of A/V Heading **is not** available to the ADS-B Transmitting Subsystem, but a source of Ground Track Angle **is** available, then Ground Track Angle may be used instead of Heading, provided that the STATUS BIT FOR HEADING subfield is set to ZERO (0) whenever the Ground Track Angle is not a reliable indication of the A/V's Heading. (The Ground Track Angle is not a reliable indication of the A/V's Heading when the A/V's Ground Speed is low.)*

A.1.4.3.2.2 Heading/Ground Track Value

This 7-bit field (ME bits 14 – 20, Message bits 46 – 52) 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 (binary 000 0000) indicating a value of ZERO degrees. 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 (ME bit 22, Message bit 54) CPR Format (F) field for the Surface Position Message will be encoded as specified for the Airborne Position 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 (ME bit 21, Message bit 53) 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 that (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 ZERO (0) and ONE (1) for successive 0.2 second time ticks, beginning with F=0 when the Time of Applicability is an exact even-numbered UTC second.

A.1.4.3.5 CPR Encoded Latitude/Longitude

The CPR Encoded Latitude/Longitude field in the Surface Position Message will be a 34-bit field (ME bits 23 – 56, Message bits 55 – 88) containing the Latitude and Longitude coding of the Aircraft's Surface Position. The Latitude (*Y*) and Longitude (*X*) 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.

Notes:

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

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

A.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_{16} in Figure A-4.

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 §2.2.19.1.13 of RTCA/DO-181D. 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, §3.1.2.9.1.2, Table 3-9) 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.

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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_{16} in Figure A-5.

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 flag (§A.1.4.5.3). After initialization, broadcast will be suppressed by loading Register 09_{16} with ALL ZEROs and then discontinuing updating the register until data input is available again.

The supersonic version of the velocity coding 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.

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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.

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

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

This Airborne Velocity Message will not be broadcast if the only valid data is the Intent Change flag (§A.1.4.5.3). After initialization, broadcast will be suppressed by loading Register 09_{16} with ALL ZEROs and then discontinuing updating the register until data input is available again.

The supersonic version of the Velocity Message coding 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_{16} to 42_{16}. 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_{16} 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 HEADING TO BE DELETED – PREVIOUSLY "IFR Capability Flag"

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A.1.4.5.5 Navigation Accuracy Category for Velocity (NAC_V)

This 3-bit (ME bits 11-13, Message bits 43-45) subfield will indicate the Navigation Accuracy Category for Velocity (NAC_V) as specified in Table A-5.

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.

If the external data source provides 95% accuracy figures of merit for horizontal and vertical 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-5.

Table A-5: Determining NAC_V Based on Position Source Declared Horizontal Velocity Error

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

A.1.4.5.6 Heading in Airborne Velocity Messages

A.1.4.5.6.1 Heading Status

This one bit (ME bit 14, Message bit 46) subfield in Airborne Velocity Messages, Subtype 3 or 4 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 (ME bits 15 – 24, Message bits 47 – 56) subfield in Airborne Velocity Messages, Subtype 3 or 4 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 ALL ZEROs (binary 00 0000 0000) indicating a value of ZERO degrees. 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).*

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A.1.4.5.7 Difference from Baro Altitude in Airborne Velocity Messages

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

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. For Format TYPE Codes 11 through 18, either GNSS HAE or altitude MSL will be used. The basis for the Baro Altitude difference (either GNSS HAE or altitude MSL) will be used consistently for the reported difference.

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.*

A.1.4.6 Aircraft Status Register Format

The Aircraft Status register will be formatted as specified in the definition of Register 07_{16} in Figure A-3.

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_{16} 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.

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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 $0A_{16}$ (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_{16} to $6F_{16}$ (see Figure A-7).

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. Two examples are: (1) the broadcast of Emergency/Priority Status at a periodic rate during a declared aircraft emergency, and (2) the broadcast of TCAS Resolution Advisory data during a declared event.*

A.1.4.7.2 TCAS Resolution Advisory (RA) Broadcast

The 1090ES TCAS RA Broadcast Message contains the same information as the RA message readout using the GICB protocol, including the aircraft ICAO 24-bit Address. A ground-based 1090ES receiver with an omni-directional receiving capability can provide TCAS RA Messages to the ground systems much sooner that with a scanning beam antenna. The TCAS RA information is defined as a Subtype=2 of the existing 1090ES Aircraft Status Message.

The airborne aircraft broadcast rates and priorities for the TCAS RA Broadcast Message are defined below and in ICAO Document 9871, §B.2.3.8.2. The format for broadcasting a 1090ES Aircraft Status Message with TCAS RA Message content (1090ES Message TYPE=28, Subtype=2) is defined here in Figure A-8b, and in ICAO Document 9871, Table B-2-97b.

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A.1.4.7.2.1 Transmission Rate

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

The ADS-B Aircraft Status (TYPE=28) TCAS RA Broadcast Message (Subtype=2) 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 TCAS Resolution Advisory.

A.1.4.7.2.2 Message Delivery

ADS-B Aircraft Status TCAS RA Broadcast Message delivery is accomplished using the Event-Driven protocol. The broadcast of the TCAS RA Broadcast Message will be terminated 24 ±1 seconds after the Resolution Advisory Termination (RAT) flag (see ICAO Annex 10, Volume IV, §4.3.8.4.2.2.1.3) transitions from ZERO (0) to ONE (1). The broadcast of the ADS-B Aircraft Status TCAS RA Broadcast Message takes priority over the Emergency/Priority Status broadcast, and all other Event-Driven Message types, as specified in §A.1.6.4.3.

A.1.4.8 Emergency/Priority Status

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

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 using the Event–Driven protocol. The rate of transmission varies depending on other conditions. If the transmission of the Mode A Code is disabled, the transmission of the "Emergency/Priority Status Message" occurs only when an emergency condition is active. When the transmission of the Mode A Code is enabled, the transmission rate of the "Emergency/Priority Status Message" depends on whether the Mode A Code is changed, or if an emergency condition is active.

When the Mode A Code is set to "3000," the 1090ES Transmitting Subsystem will disable the transmission of the Mode A Code and broadcast the "Emergency/Priority Message" in accordance with §A.1.4.8.1.1 only when an emergency is declared. Otherwise, the Mode A Code transmission is enabled and the broadcast rates of §A.1.4.8.1.2 apply.

Note: *The use of Mode A Code "3000" for this purpose is in accordance with the ICAO Doc 9871 provision to disable the transmission of the Mode A Code on 1090ES. This will occur at such time that the ATC systems no longer depend on the Mode A Code to identify aircraft.*

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A.1.4.8.1.1 "Emergency/Priority Status Message" Broadcast Rates When Transmission of Mode A Code is Disabled

When the Mode A Code transmission is disabled as per §A.1.4.8.1, the following transmit rates apply:

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

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

A.1.4.8.1.2 Emergency/Priority Status Message" Broadcast Rates When Transmission of Mode A Code is Enabled

When the Mode A Code transmission is enabled as per §A.1.4.8.1, the following transmit rates apply:

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

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

      Note: *The case where the Mode A Code is set to 7500, 7600 or 7700, the transmission of the emergency condition is covered by ii. below. Setting the Mode A Code to 7500, 7600 or 7700 is indicated by a Permanent Alert in the "Surveillance Status" field (value of 1) (see §2.2.3.2.3.2). A change in the Mode A Code, except to 7500, 7600 or 7700, is indicated by a Temporary Alert in the "Surveillance Status" subfield (value of 2) (see §2.2.3.2.3.2).*

   ii. For the duration of an emergency condition by any non-ZERO value in the "Emergency/Priority Status" subfield, if the emergency code is cleared by the pilot changing the Mode A Code to other than 7500, 7600 or 7700, the broadcast of the "Emergency/Priority Status" Message will be continued for 24 ±1 seconds as "i" above.

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

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A.1.4.8.2 Message Delivery

The Aircraft Status (TYPE=28) Emergency/Priority Status (Subtype=1) 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 broadcasts of all other message types, except for the ADS-B Aircraft Status TCAS RA Broadcast Message (TYPE=28, Subtype=2), which takes priority over the Emergency/Priority Status broadcast, and all other Event-Driven Message types, as specified in §A.1.6.4.3.

A.1.4.9 Target State and Status Information

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

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

A.1.4.9.1 Transmission Rate

This message will be broadcast 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 Source Integrity Level (SIL) Supplement

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

Table A-6: "SIL Supplement" Subfield Encoding

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

► **Per Hour:** The probability of the reported geometric position laying outside the NIC containment radius in any given hour without an alert or an alert longer than the allowable time-to-alert. The per hour representation will typically be used when the probability of exceeding the NIC is greater for the faulted versus fault-free Signal-in-Space case (When the Signal-in-Space fault rate is defined as hourly).

Note: *The probability of exceeding the integrity radius of containment for GNSS position sources are based on a per hour basis, as the NIC will be derived from the GNSS Horizontal Protection Level (HPL) which is based on a probability of $1X10^{-7}$ per hour.*

► **Per Sample:** The probability of a reported geometric position laying outside the NIC containment radius. The per sample representation will typically be used when the probability of exceeding the NIC is greater for the fault-free Signal-in-Space case, or when the position source does not depend on a Signal-in-Space.

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

A.1.4.9.3 Selected Altitude Type

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

Table A-7: “Selected Altitude Type” Subfield Encoding

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

A.1.4.9.4 MCP/FCU Selected Altitude or FMS Selected Altitude

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

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

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

d. Encoding of Selected Altitude data in “ME” bits 10 through 20 (Message bits 42 through 52) is in accordance with Table A-8. Encoding of the data is rounded so as to preserve accuracy of the source data within ±½ LSB.

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

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Table A-8: "MCP/FCU Selected Altitude or FMS Selected Altitude" Subfield Encoding

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

A.1.4.9.5 Barometric Pressure Setting (Minus 800 millibars)

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

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

c. Encoding of Barometric Pressure Setting data in "ME" bits 21 through 29 (Message bits 53 through 61) will be rounded so as to preserve a reporting accuracy within ±½ LSB.

d. Whenever there is NO valid Barometric Pressure Setting data available, then the "Barometric Pressure Setting (Minus 800 millibars) subfield ("ME" bits 21 through 29, Message bits 53 through- 1) will be set to ZERO (0) as indicated in Table A-9.

e. Whenever the Barometric Pressure Setting data is greater than 1209.5 or less than 800 millibars, then the "Barometric Pressure Setting (Minus 800 millibars) subfield ("ME" bits 21 through 29, Message bits 53 through 61) will be set to ZERO (0).

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Table A-9: "Barometric Pressure Setting (Minus 800 millibars)" Subfield Encoding

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

A.1.4.9.6 Selected Heading Status

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

Table A-10: "Selected Heading Status" Subfield Encoding

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

A.1.4.9.7 Selected Heading Sign

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

Table A-11: "Selected Heading Sign" Subfield Encoding

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

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A.1.4.9.8 Selected Heading

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

b. Encoding of Selected Heading data in "ME" bits 31 through 39 (Message bits 63 through 71) will be rounded so as to preserve accuracy of the source data within ±½ LSB.

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

Table A-12: "Selected Heading Status, Sign and Data" Subfields Encoding

"ME" Bit Coding			Meaning
30	31	32 -------- 39	
Status	**Sign**	**Data**	
0	0	0000 0000	**NO Data *or* INVALID Data**
1	0	0000 0000	0.0 degrees
1	0	0000 0001	0.703125 degrees
1	0	0000 0010	1.406250 degrees
*	*	**** ****	**** **** ****
*	*	**** ****	**** **** ****
*	*	**** ****	**** **** ****
1	0	1111 1111	179.296875 degrees
1	1	0000 0000	180.0 or -180.0 degrees
1	1	0000 0001	180.703125 or -179.296875 degrees
1	1	0000 0010	181.406250 or -178.593750 degrees
*	*	**** ****	**** **** ****
*	*	**** ****	**** **** ****
*	*	**** ****	**** **** ****
1	1	1000 0000	270.000 or -90.0000 degrees
1	1	1000 0001	270.703125 or -89.296875 degrees
1	1	1000 0010	271.406250 or -88.593750 degrees
1	1	1111 1110	358.593750 or -1.4062500 degrees
1	1	1111 1111	359.296875 or -0.7031250 degrees

A.1.4.9.9 Navigation Accuracy Category for Position (NAC_P)

This 4-bit (ME bits 40 – 43, Message bits 72 – 75) 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-15. If an update has not been received from an on-board data source for NAC_P within the past 5 seconds, then the NAC_P subfield will be encoded as a value indicating "Unknown Accuracy."

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Table A-15: Encoding of Navigation Accuracy Category for Position (NAC_P)

Coding		Meaning = 95% Horizontal Accuracy Bounds (EPU)
(Binary)	(Decimal)	
0000	0	EPU ≥ 18.52 km (10 NM) - Unknown accuracy
0001	1	EPU < 18.52 km (10 NM) - RNP-10 accuracy
0010	2	EPU < 7.408 km (4 NM) - RNP-4 accuracy
0011	3	EPU < 3.704 km (2 NM) - RNP-2 accuracy
0100	4	EPU < 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 - e.g., GPS (SA off)
1010	10	EPU < 10 m - e.g., WAAS
1011	11	EPU < 3 m - e.g., LAAS
1100 - 1111	12 - 15	Reserved

Notes:

1. *The Estimated Position Uncertainty (EPU) used in the table is a 95% 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. *RNP accuracy includes error sources other than sensor error, whereas horizontal error for NAC_P only refers to horizontal position error uncertainty.*

A.1.4.9.10 Navigation Integrity Category for Baro (NIC_{BARO})

This 1-bit (ME bit 44, Message bit 76) 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-16. If an update has not been received from an on-board data source for NIC_{BARO} within the past 5 seconds, then the NIC_{BARO} subfield will be encoded as a value of ZERO (0).

Table A-16: NIC_{BARO} Encoding

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

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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.1.4.9.11 Source Integrity Level (SIL)

This 2-bit (ME bits 45 – 46, Message bits 77 – 78) subfield will be used to define the probability of the reported horizontal position exceeding the radius of containment defined by the NIC, without alerting, assuming no avionics faults. The SIL will address the Signal-in-Space, if applicable, and will be the higher of the faulted or fault free probability of the Signal-In-Space causing the NIC radius of containment to be exceeded.

Note: *The faulted Signal-in-Space case will represent the highest probability for GNSS position sources while the fault free Signal-in-Space case will represent the highest probability for DME/DME or DME/DME/LOC position sources because the Signal-in-Space is monitored and for IRU position sources because there is no Signal-in-Space.*

The SIL probability can be defined as either "per sample" or "per hour" as defined in the SIL Supplement (SIL_{SUPP}) in §A.1.4.9.2.

The "SIL" subfield is encoded in accordance with Table A-17. For installations where the SIL value is being dynamically updated, if an update has not been received from an on-board data source for SIL within the past 5 seconds, then the SIL subfield will be encoded as a value of ZERO (0), indicating "Unknown."

Table A-17: Source Integrity Level (SIL) Encoding

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

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Note: *Implementers should not arbitrarily set the SIL to ZERO (0) just because SIL is not provided by the position source. Implementers should perform an off-line analysis of the installed position source to determine the appropriate SIL.*

A.1.4.9.12 Status of MCP/FCU Mode Bits

The "Status of MCP / FCU Mode Bits" subfield is a 1-bit ("ME" bit 47, Message bit 79) field that will be used to indicate whether the mode bits ("ME" bits 48, 49, 50 and 52, Message bits 80, 81, 82 and 84) are actively being populated (e.g., set) in the Target State and Status Message in accordance with Table A-18.

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

Table A-18: "Status of MCP/FCU Mode Bits" Subfield Encoding

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

A.1.4.9.13 Autopilot Engaged

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

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

b. The ADS-B Transmitting Subsystem will set "ME" bit 48 (Message bit 80) in accordance with Table A-19.

Table A-19: "Autopilot Engaged" Subfield Encoding

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

A.1.4.9.14 VNAV Mode Engaged

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

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

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b. The ADS-B Transmitting Subsystem will set "ME" bit 49 (Message bit 81) in accordance with Table A.1.4.9.14.

Table A.1.4.9.14: "VNAV Engaged" Subfield Encoding

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

A.1.4.9.15 Altitude Hold Mode

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

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

b. The ADS-B Transmitting Subsystem will set "ME" bit 50 (Message bit 82) in accordance with Table A.1.4.9.15.

Table A.1.4.9.15: "Altitude Hold Mode" Subfield Encoding

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

A.1.4.9.16 Reserved for ADS-R Flag

The "Reserved for ADS-R Flag" subfield is a 1-bit ("ME" bit 51, Message bit 83) field that shall be used as specified in §2.2.18.4.6.

A.1.4.9.17 Approach Mode

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

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

b. The ADS-B Transmitting Subsystem will set "ME" bit 52 (Message bit 84) in accordance with Table A.1.4.9.17.

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Table A.1.4.9.17: "Approach Mode" Subfield Encoding

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

A.1.4.9.18 TCAS/ACAS Operational

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

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

b. The ADS-B Transmitting Subsystem will set "ME" bit 53 (Message bit 85) in accordance with Table A.1.4.9.18.

Table A.1.4.9.18: "TCAS/ACAS Operational" Subfield Encoding

Coding ("ME" Bit 53)	**Meaning**
0	TCAS/ACAS System is NOT Operational
1	TCAS/ACAS System IS Operational

Note: *As a reference point, RTCA DO-181D Mode-S Transponders consider that the TCAS/ACAS System is operational when "MB" bit 16 of Register 10_{16} is set to "ONE" (1). This occurs when the transponder / TCAS/ACAS interface is operational and the transponder is receiving TCAS/ACAS RI=2, 3 or 4. (Refer to RTCA DO-181D [EUROCAE ED-73C], Appendix B, Table B-3-16.*

A.1.4.10 Aircraft Operational Status Message

Register 65_{16} contains an exact bit-for-bit duplicate of the Aircraft Operational Status Message Extended Squitter (TYPE=31 and Subtype=0). 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=31 and Subtype=0, for airborne participants) 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=1) 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

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c. NAC_P

d. SIL

Otherwise the Aircraft Operational Status (TYPE= 31 and Subtype=0, for airborne participants) 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 (ME bits 9 – 24, Message bits 41 – 56) subfield in the Airborne Aircraft Operational Status Message (Subtype=0) or 12-bit (ME bits 9 – 20, Message bits 41 – 52) subfield in the Surface Aircraft Operational Status Message (Subtype=1) will be used to report the operational capability of the aircraft. Encoding of the CC subfield will be defined as specified in Table A-21 and Table A-22.

For an ADS-B Transmitting Subsystem compliant with DO-260B, if an update has not been received from an on-board data source within the past 5 seconds for any data element of the Capability Class Codes subfield, then the data associated with that data element will be considered invalid and so reflected in the encoding of that message element to reflect "No Capability" or "Unknown" capability.

Table A-21: Airborne Capability Class (CC) Code for Version 2 Systems

Msg Bit #	41	42	43	44	45	46	47	48	49	50	51	52 -- 56
"ME" Bit #	9	10	11	12	13	14	15	16	17	18	19	20 -- 24
Content	**Reserved** = 0,0		**TCAS Operational**	**1090ES IN**	**Reserved** = 0,0		**ARV**	**TS**	**TC**		**UAT IN**	**Reserved [6]**
	0,1		Reserved									
	1,0		Reserved									
	1,1		Reserved									

Subfield Coding:

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

2. 1090ES IN (1090 MHz Extended Squitter)
   = 0: Aircraft has NO 1090ES Receive capability
   = 1: Aircraft has 1090ES Receive capability

3. ARV (Air-Referenced Velocity Report Capability)
   = 0: No capability for sending messages to support Air Referenced Velocity Reports

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= 1: Capability of sending messages to support Air-Referenced Velocity Reports.

4. TS (Target State Report Capability)
   = 0: No capability for sending messages to support Target State Reports
   = 1: Capability of sending messages to support Target State Reports

5. TC (Target Change Report Capability)
   = 0: No capability for sending messages to support Trajectory Change Reports
   = 1: Capability of sending messages to support TC+0 Report only
   = 2: Capability of sending information for multiple TC reports
   = 3: Reserved

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

Table A-22: Surface Capability Class (CC) Code for Version 2 Systems

Msg Bit #	41	42	43	44	45	46	47	48	49 --- 51	52
"ME" Bit #	9	10	11	12	13	14	15	16	17 --- 19	20
Content	**Reserved** = 0,0		**POA**	**1090ES IN**	**Reserved** = 0,0		**B2 Low**	**UAT IN**	**NAC_V [3]**	**NIC Supplement-C [1]**
	0,1		Reserved							
	1,0		Reserved							
	1,1		Reserved							

Subfield Coding:

1. 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

2. 1090ES IN (1090 MHz Extended Squitter)
   = 0: Aircraft has NO 1090ES Receive capability
   = 1: Aircraft has 1090ES Receive capability

3. B2 Low (Class B2 Transmit Power Less Than 70 Watts)
   = 0: Greater than or equal to 70 Watts Transmit Power
   = 1: Less than 70 Watts Transmit Power

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

5. NAC_V (Navigation Accuracy Category for Velocity)

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

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A.1.4.10.4 Operational Mode (OM)

This 16-bit (ME bits 25 – 40, Message bits 57 – 72) subfield will be used to indicate the Operational Modes that are active on board the aircraft. Encoding of the OM subfield for Airborne Operational Status Messages (Subtype=0) will be as shown in Table A-23A. Encoding of the OM subfield for Surface Operational Status Messages (Subtype=1) will be as shown in Table A-23B.

Table A-23A: Airborne Operational Mode (OM) Subfield Format

Msg Bit #	57	58	59	60	61	62	63 -- 64	65 --- 72
"ME" Bit #	25	26	27	28	29	30	31 -- 32	33 --- 40
OM Format	0 0		**TCAS RA Active [1]**	**IDENT Switch Active [1]**	**Reserved for Receiving ATC Services [1]**	**Single Antenna Flag [1]**	**System Design Assurance [2]**	**Reserved [8]**
	0 1		Reserved					
	1 0		Reserved					
	1 1		Reserved					

Subfield Coding:

1. TCAS Resolution Advisory (RA) Active
   = 0: TCAS II or ACAS 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. Reserved for Receiving ATC Services
   = 0: Set to ZERO for this version of these MOPS

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

5. System Design Assurance (SDA)
   (see Table A.1.4.10.14)

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Table A-23B: Surface Operational Mode (OM) Subfield Format

Msg Bit #	57	58	59	60	61	62	63 -- 64	65 --- 72
"ME" Bit #	25	26	27	28	29	30	31 -- 32	33 --- 40
OM Format	0 0		**TCAS RA Active [1]**	**IDENT Switch Active [1]**	**Reserved for Receiving ATC Services [1]**	**Single Antenna Flag [1]**	**System Design Assurance [2]**	**GPS Antenna Offset [8]**
	0 1		Reserved					
	1 0		Reserved					
	1 1		Reserved					

Subfield Coding:

1. TCAS Resolution Advisory (RA) Active
   = 0: TCAS II or ACAS 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. Reserved for Receiving ATC Services
   = 0: Set to ZERO for this version of these MOPS

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

5. System Design Assurance (SDA)
   (see Table A.1.4.10.14)

6. GPS Antenna Offset
   (see Table A.1.4.10.21A and Table A.1.4.10.21B)

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A.1.4.10.5 Version Number

This 3-bit (ME bits 41 – 43, Message bits 73 – 75) subfield 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-24.

Table A-24: Version Number Encoding

VERSION NUMBER SUBFIELD		
Coding		**Meaning**
(Binary)	**(Decimal)**	
000	0	Conformant to DO-260 and DO-242
001	1	Conformant to DO-260A and DO-242A
010	2	Conformant to DO-260B and DO-242B
011 – 111	3 – 7	Reserved

A.1.4.10.6 Navigation Integrity Category (NIC) and NIC Supplement-A

The first 5-bit field (ME bits 1 – 5, Message bits 33 – 37) in every Mode S Extended Squitter Message contains the format TYPE Code. The format TYPE Code differentiates the 1090ES Messages into several classes: Airborne Position, Airborne Velocity, Surface Position, Identification and Category, Aircraft Intent, Aircraft Status, etc. In addition, the format TYPE Code also encodes the Navigation Integrity Category (NIC) value of the source used for the position report.

The NIC Supplement-A is a 1-bit (ME bit 44, Message bit 76) subfield in the Aircraft Operational Status Message that is use in conjunction with the TYPE Code and NIC value to allow surveillance applications to determine whether the reported geometric position has an acceptable level of integrity containment region for the intended use. The NIC integrity containment region is described horizontally using the radius of containment, R_C. The format TYPE Code also differentiates the Airborne Messages as to the type of their altitude measurements: barometric pressure altitude or GNSS height (HAE). The 5-bit encoding for format TYPE Code and NIC values conforms to the definition contained in Table A-25. If an update has not been received from an on-board data source for the determination of the TYPE Code value based on the radius of containment within the past 5 seconds, then the TYPE Code value will be encoded to indicate that R_C is "Unknown."

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Table A-25: Navigation Integrity Category (NIC) Encoding.

NIC Value	Radius of Containment (R_C)	Airborne			Surface		
		Airborne Position TYPE Code	NIC Supplement Codes		Surface Position TYPE Code	NIC Supplement Codes	
			A	B		A	C
0	R_C unknown	0, 18 or 22	0	0	0, 8	0	0
1	R_C < 20 NM (37.04 km)	17	0	0	N/A	N/A	N/A
2	R_C < 8 NM (14.816 km)	16	0	0	N/A	N/A	N/A
3	R_C < 4 NM (7.408 km)	16	1	1	N/A	N/A	N/A
4	R_C < 2 NM (3.704 km)	15	0	0	N/A	N/A	N/A
5	R_C < 1 NM (1852 m)	14	0	0	N/A	N/A	N/A
6	R_C < 0.6 NM (1111.2 m)	13	1	1	8	0	1
	R_C < 0.5 NM (926 m)	13	0	0	N/A	N/A	N/A
	R_C < 0.3 NM (555.6 m)	13	0	1	8	1	0
7	R_C < 0.2 NM (370.4 m)	12	0	0	8	1	1
8	R_C < 0.1 NM (185.2 m)	11	0	0	7	0	0
9	R_C < 75m	11	1	1	7	1	0
10	R_C < 25m	10 or 21	0	0	6	0	0
11	R_C < 7.5m	9 or 20	0	0	5	0	0
12	Reserved						
13	Reserved						
14	Reserved						
15	Reserved						

Notes:

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

2. *NIC Supplement-A is broadcast in the Aircraft Operational Status Message, "ME" bit 44 (Message bit 76, see Figure A-10). NIC Supplement-B is broadcast in the Airborne Position Message, "ME" bit 8 (Message bit 40, see Figure A-1). NIC Supplement-C is broadcast in the Surface Capability Class (CC) Code Subfield of the Aircraft Operational Status Message, "ME" bit 20 (Message bit 52, see Table A-22).*

A.1.4.10.7 Navigation Accuracy Category for Position (NAC_P)

This 4-bit (ME bits 45 – 48, Message bits 77 – 80) subfield 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-15. If an update has not been received from an on-board data source for NAC_P within the past 5 seconds, then the NAC_P subfield will be encoded as a value indicating "Unknown Accuracy."

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A.1.4.10.8 Geometric Vertical Accuracy (GVA)

This 2-bit (ME bits 49 – 50, Message bits 81 – 82) subfield in the Airborne Operational Status Message (Subtype=0) will be encoded as shown in Table A.1.4.10.8, and set by using the Vertical Figure of Merit (VFOM) (95%) from the GNSS position source used to encode the geometric altitude field in the Airborne Position Message.

Table A.1.4.10.8: Encoding of the Geometric Vertical Accuracy (GVA) Subfield in Aircraft Operational Status Messages

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

Note: *For the purposes of these MOPS (RTCA DO-260B) values for 0 and 1 are encoded. Decoding values for 2 and 3 should be treated as < 45 meters until future versions of these MOPS redefine the values.*

A.1.4.10.9 Source Integrity Level (SIL)

This 2-bit (ME bits 51 – 52, Message bits 83 – 84) subfield is defined for the Target State and Status Message in §A.1.4.9.11 and Table A-17, and remains the same in the Operational Status Message.

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

This 1-bit (ME bit 53, Message bit 85) 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-16. If an update has not been received from an on-board data source for NIC_{BARO} within the past 5 seconds, then the NIC_{BARO} subfield will be encoded as a value of ZERO (0).

A.1.4.10.11 Aircraft Length and Width Codes

This 4-bit (ME bits 21 – 24, Message bits 53 – 56) subfield 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 A/V Length and Width Code will be based on the actual dimensions of the transmitting Aircraft or Surface Vehicle as specified in Table A-26. Once the actual Length and Width of the A/V has been determined, each A/V will be assigned the smallest A/V Length and Width Code from Table A-26 for which the actual length is less than or equal to the upper bound length for that Length/Width Code, and for which the actual width is less than or equal to the upper bound width for that Length/Width Code.

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Table A-26: A/V Length and Width Code

A/V - L/W Code (Decimal)	Length Code			Width Code	Upper-Bound Length and Width for Each Length/Width Code	
	ME Bit 49	ME Bit 50	ME Bit 51	ME Bit 52	Length (meters)	Width (meters)
0	0	0	0	0	No Data or Unknown	
1	0	0	0	1	15	23
2	0	0	1	0	25	28.5
3				1		34
4	0	1	0	0	35	33
5				1		38
6	0	1	1	0	45	39.5
7				1		45
8	1	0	0	0	55	45
9				1		52
10	1	0	1	0	65	59.5
11				1		67
12	1	1	0	0	75	72.5
13				1		80
14	1	1	1	0	85	80
15				1		90

If the Aircraft or Vehicle is longer than 85 meters, or wider than 90 meters, then decimal Aircraft/Vehicle Length/Width Code 15 will be used.

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

A.1.4.10.13 Horizontal Reference Direction (HRD)

This 1-bit (ME bit 54, Message bit 86) subfield will be used to indicate the reference direction (true north or magnetic north) for horizontal directions such as Heading, Track Angle. The Horizontal Reference Direction subfield will be encoded as specified in Table A-27.

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Table A-27: Horizontal Reference Direction (HRD) Encoding.

HRD Value	Meaning
0	True North
1	Magnetic North

A.1.4.10.14 System Design Assurance (SDA)

The "System Design Assurance" (SDA) subfield is a 2-bit ("ME" bits 31 – 32, Message bits 63 – 64) field that will define the failure condition that the ADS-B system is designed to support as defined in Table A.1.4.10.14.

The supported failure condition will indicate the probability of an ADS-B system fault causing false or misleading information to be transmitted. The definitions and probabilities associated with the supported failure effect are defined in AC 25.1309-1A, AC 23-1309-1C, and AC 29-2C. All relevant systems attributes should be considered including software and complex hardware in accordance with RTCA DO-178B (EUROCAE ED-12B) or RTCA DO-254 (EUROCAE ED-80).

The ADS-B system includes the ADS-B transmission equipment, ADS-B processing equipment, position source, and any other equipment that processes the position data transmitted by the ADS-B system.

Table A.1.4.10.14: "System Design Assurance" OM Subfield in Aircraft Operational Status Messages

SDA Value		Supported Failure Condition Note 2	Probability of Undetected Fault causing transmission of False or Misleading Information Note 3,4	Software & Hardware Design Assurance Level Note 1,3
(decimal)	(binary)			
0	00	Unknown/ No safety effect	> $1X10^{-3}$ per flight hour or Unknown	N/A
1	01	Minor	≤ $1X10^{-3}$ per flight hour	D
2	10	Major	≤ $1X10^{-5}$ per flight hour	C
3	11	Hazardous	≤ $1X10^{-7}$ per flight hour	B

Notes:

1. *Software Design Assurance per RTCA DO-178B (EUROCAE ED-12B). Airborne Electronic Hardware Design Assurance per RTCA DO-254 (EUROCAE ED-80).*
2. *Supported Failure Classification defined in AC-23.1309-1C, AC-25.1309-1A, and AC 29-2C.*
3. *Because the broadcast position can be used by any other ADS-B equipped aircraft or by ATC, the provisions in AC 23-1309-1C that allow reduction in failure probabilities and design assurance level for aircraft under 6,000 pounds do not apply.*
4. *Includes probability of transmitting false or misleading latitude, longitude, velocity, or associated accuracy and integrity metrics.*

A.1.4.10.15 SIL Supplement

The "SIL Supplement" (Source Integrity Level Supplement) subfield is a 1-bit ("ME" bit 8, Message bit 40) field that will define whether the reported SIL probability is based on a "per hour" probability or a "per sample" probability as defined in §A.1.4.9.2 and Table A-6.

A.1.4.10.16 TCAS/ACAS Operational

The "TCAS/ACAS Operational" subfield ("ME" bit 11, Message bit 43) of the CC Codes subfield in ADS-B Aircraft Operational Status Messages (TYPE=31, SUBTYPE=0, for airborne participants) is used to indicate whether the TCAS/ACAS System is Operational or not, and remains as defined for use in the Target State and Status Message (§A.1.4.9.18), with the encoding as specified in Table A.1.4.9.18.

A.1.4.10.17 1090ES IN

The CC Code subfield for "1090ES IN" in Aircraft Operational Status Messages (TYPE=31, Subtype=0 or 1) is a 1-bit field ("ME" bit 12, Message bit 44) that is set to ONE (1) if the transmitting aircraft has the capability to receive ADS-B 1090ES Messages. Otherwise, this CC code subfield is set to ZERO (0).

A.1.4.10.18 UAT IN

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

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

A.1.4.10.19 Navigation Accuracy Category for Velocity (NAC_V)

This 3-bit subfield (ME bits 17-19, Message bits 49-51) indicates the Navigation Accuracy Category for Velocity (NAC_V) as defined in §A.1.4.5.5, with the encoding as specified in Table A-5.

A.1.4.10.20 NIC Supplement-C

The NIC Supplement-C subfield in the Aircraft Operational Status Message is a one-bit subfield ("ME" bit 20, Message bit 52) that, together with the TYPE subfield in Surface Position Messages and the NIC Supplement-A in the Operational Status Message ("ME"

Bit 44, Message Bit 76), is used to encode the Navigation Integrity Category (NIC) of the transmitting ADS-B participant.

If an update has not been received from an on-board data source for the determination of the NIC value within the past 5 seconds, then the NIC Supplement subfield is encoded to indicate the larger Radius of Containment (R_C).

Table A-25 lists the possible NIC codes and the values of the TYPE subfield of the Airborne and Surface Position Messages, and of the NIC Supplement subfields that are used to encode those NIC codes in messages on the 1090 MHz ADS-B data link.

A.1.4.10.21 GPS Antenna Offset

The "GPS Antenna Offset" subfield is an 8-bit ("ME" bits 33 – 40, Message bits 65 – 72) field in the OM Code Subfield of surface format Aircraft Operational Status Messages that defines the position of the GPS antenna in accordance with the following, when the Position Offset Applied (see Table A-22) is set to ZERO (0).

a. Lateral Axis GPS Antenna Offset:

"ME" bits 33 through 35 (Message bits 65 through 67) are used to encode the lateral distance of the GPS Antenna from the longitudinal axis (Roll) axis of the aircraft. Encoding is established in accordance with Table A.1.4.10.21A.

Table A.1.4.10.21A: Lateral Axis GPS Antenna Offset Encoding

<table>
<tr><th colspan="3">"ME" Bit
(Message Bit)</th><th colspan="2" rowspan="3">GPS Antenna Offset
Along Lateral (Pitch) Axis
Left or Right of Longitudinal (Roll) Axis</th></tr>
<tr><th>33
(65)</th><th>34
(66)</th><th>35
(67)</th></tr>
<tr><th rowspan="2">0 = left
1 = right</th><th colspan="2">Encoding</th></tr>
<tr><th>Bit 1</th><th>Bit 0</th><th>Direction</th><th>(meters)</th></tr>
<tr><td rowspan="4">0</td><td>0</td><td>0</td><td rowspan="4">LEFT</td><td>0 or NO DATA</td></tr>
<tr><td>0</td><td>1</td><td>2</td></tr>
<tr><td>1</td><td>0</td><td>4</td></tr>
<tr><td>1</td><td>1</td><td>6</td></tr>
<tr><td rowspan="4">1</td><td>0</td><td>0</td><td rowspan="4">RIGHT</td><td>0 or NO DATA</td></tr>
<tr><td>0</td><td>1</td><td>2</td></tr>
<tr><td>1</td><td>0</td><td>4</td></tr>
<tr><td>1</td><td>1</td><td>6</td></tr>
<tr><td colspan="5">Notes:
1. Left means toward the left wing tip moving from the longitudinal center line of the aircraft.
2. Right means toward the right wing tip moving from the longitudinal center line of the aircraft.
3. Maximum distance left or right of aircraft longitudinal (roll) axis is 6 meters or 19.685 feet.</td></tr>
</table>

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b. Longitudinal Axis GPS Antenna Offset:

"ME" bits 36 through 40 (Message bits 68 through 72) are used to encode the longitudinal distance of the GPS Antenna from the NOSE of the aircraft. Encoding is established in accordance with Table A.1.4.10.21B.

Table A.1.4.10.21B: Longitudinal Axis GPS Antenna Offset Encoding

"ME" Bit (Message Bit)					**GPS Antenna Offset Along Longitudinal (Roll) Axis Aft From Aircraft Nose**
36 (68)	**37** (69)	**38** (70)	**39** (71)	**40** (72)	
Encoding					
Bit 4	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**	**(meters)**
0	0	0	0	0	0 ***or*** **NO DATA**
0	0	0	0	1	2
0	0	0	1	0	4
0	0	0	1	1	6
0	0	1	0	0	8
*	*	*	*	*	***
*	*	*	*	*	***
*	*	*	*	*	***
1	1	1	1	1	62
Note: *Maximum distance aft from aircraft nose is 62 meters or 203.412 feet.*					

When Position Offset Applied (see Table A-22) is set to ONE (1), the GPS Antenna Offset subfield is set to ALL ZEROs (0).

Note: *When Position Offset Applied (see Table A-22) is set to ONE (1), it means that the GPS antenna position has already been compensated for in the reported latitude and longitude position subfields of the Surface Position Message. Ensuring that the GPS Antenna subfield is set to ALL ZEROs in this case ensures that the offset compensation is not performed again by a receiving application.*

A.1.5 Initialization and Timeout

Note: *Initialization and timeout functions for Extended Squitter broadcast are performed by the transponder and are specified in RTCA/DO-181D. 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).*

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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, Aircraft Identification and Category, Airborne Velocity, Target State and Status and Operational Status when data are inserted into Registers 05_{16}, 06_{16}, 08_{16}, 09_{16}, 62_{16} and 65_{16} respectively. This determination will be made individually for each squitter type. The insertion of just altitude or surveillance status data into Register 05_{16} 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

Notes:

1. *These Registers are cleared to prevent the reporting of outdated position and velocity information.*

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

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

   Note: *During a timeout event the Format TYPE Code is set to ZERO (see §2.2.3.2.3.1.3.1).*

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

   Notes:

   1. *During a timeout event the Format TYPE Code is set to ZERO (see §2.2.3.2.4.1.3.1).*

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

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

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

Note: *The Intent Change information is not sufficient to consider that new data has been received (§2.2.3.2.6.1.3).*

d. The ADS-B Transmitting Subsystem will not clear the Aircraft Identification Message (see §2.2.3.2.5).

Note: *The Aircraft Identification Message, is not cleared since it contains data that rarely changes in flight and is not frequently updated.*

e. The ADS-B Transmitting Subsystem will clear each of the Selected Altitude, Selected Heading, or Barometric Pressure Setting subfields of the Target State and Status Message (see §2.2.3.2.7.1) if no new data is received within 2.0 seconds of the previous input data update for the respective subfield. Each of the subfields will be cleared independently of the other subfields. That is, each of the three specified subfields will be processed mutually exclusively of the other two specified subfields. The remaining subfields of the Target State and Status Message will not be cleared, as they contain other integrity, mode, or status information.

f. The ADS-B Transmitting Subsystem will not clear the Operational Status Messages (see §2.2.3.2.7.2) since the subfields of the Message contain various integrity, mode, or status information..

g. The ADS-B Transmitting Subsystem will not clear the Event-Driven Messages (see §2.2.3.2.7.8).

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

A.1.5.3 Termination of Extended Squitter Broadcast

If input to Register 05_{16}, or 06_{16} 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.

If input to Register 0916 stops for 2.6 seconds, broadcast of the associated Extended Squitter type will be discontinued until data insertion is resumed.

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 through §A.1.5.3.

1. A Non-Transponder Device will not broadcast acquisition squitters, and

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2. A Non-Transponder Device operating on the surface will continue to broadcast DF=18 Messages with the TYPE Code=0 at a rate specified for the Surface Position Message, even though it has lost its navigation input.

   Note: *Continued broadcast of the Surface Position Message is needed to support the operation of surface multi-lateration systems.*

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

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.*

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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. Airborne Position or Surface Position (Register 05_{16}, and 06_{16}) has not been loaded by the GFM for 2 seconds. In this case the transponder clears the entire 56 bits of the register that timed out. (In the case of the Airborne Position register, the altitude subfield is only ZEROed if no altitude data is available). Transmission of the Airborne and Surface Position Extended Squitter that broadcasts the timed out register will itself stop in 60 seconds except for the Airborne Position Message when Altitude is still available. 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 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. No other squitter types are broadcast with TYPS Code equal ZERO (0).

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.*

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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 $0A_{16}$ 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 $0A_{16}$. In this way, the GFM can provide the pseudo random timing for all applications using this protocol and maintain a maximum insertion rate that does not exceed the transponder imposed limit.*

An application that wants to use the Event-Driven protocol 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 $0A_{16}$ 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 $0A_{16}$. 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 $0A_{16}$ 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.

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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), or a TCAS RA Broadcast (TYPE=28, Subtype=2), then 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 respective Aircraft Status Message for the duration of the emergency or TCAS RA condition if the Target State and Status Message is not being broadcast. If the "Target State and Status Message" with Subtype=0 is being broadcast, then the "Emergency/Priority Status," or the TCAS RA Broadcast Message will be broadcast at random intervals that are uniformly distributed over the range of 2.4 to 2.6 seconds relative to the previous respective Aircraft Status Message for the duration of the emergency condition established in accordance with Figure A-8, Note 2, or TCAS RA (established in accordance with the notes in Figure A-8b). The broadcast of the 1090ES ADS-B Aircraft Status TCAS RA Broadcast Message takes priority over the Emergency/Priority Status broadcast, and all other Event-Driven Message types.

   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 broadcast at random intervals that are uniformly distributed over the range of 0.7 to 0.9 seconds. When enabled, the "TEST" Message with Subtype=7 **shall** be broadcast at random intervals that are uniformly distributed over the range of 11.8 to 12.2 seconds from the time of transmission of the previous "TEST" Message with Subtype=7.

   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.

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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 broadcast at random intervals uniformly distributed over the range of 2.4 to 2.6 seconds.

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-28 below:

Table A-28: Event-Driven Message Lifetime

Message TYPE	Message Subtype	Message Lifetime (seconds)
23	= 0	5.0 seconds (+/- 0.2 sec.)
	= 1, 2, 3, 4, 5, or 6	Reserved (see Note)
	= 7	24 seconds (+/- 0.2 sec.)
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, 1	5.0 seconds (+/- 0.2 sec.)
	> 1	Reserved (see Note)

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

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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 for airborne formats and 50 seconds for surface formats), the receiving system can unambiguously determine the location of the aircraft.*

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

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

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

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

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

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

<u>Note 2:</u> *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 $k \leq x$.

<u>Note 3:</u> *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

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

<u>Note 4:</u> *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.*

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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,

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

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

For lat = 0 (the equator), NL = 59

For lat = +87 degrees, NL = 2

For lat = -87 degrees, NL = 2

For lat > +87 degrees, NL = 1

For lat < -87 degrees, NL = 1

Note 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:*

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

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

A.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.

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

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

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

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

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

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

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

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

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

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

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

Note: *When performing the NL function, the encoding process must ensure that the NL value is established in accordance with Note 5 of §A.1.7.2.d.*

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

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

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

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

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

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

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

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

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

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

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 Locally Unambiguous CPR Decoding for Airborne, TIS-B and Intent Lat/Lon

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

a. $Dlat_i$ is computed from the equation:

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

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

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

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

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

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

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

Note: *When performing the NL function, the encoding process must ensure that the NL value is established in accordance with Note 5 of §A.1.7.2.d.*

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

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

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

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

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A.1.7.6 Locally Unambiguous Decoding for Surface Position

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

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:

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

Note: *When performing the NL function, the encoding process must ensure that the NL value is established in accordance with Note 5 of §A.1.7.2.d.*

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 not longer than 10 seconds for airborne formats.

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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 for airborne formats 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.

Note 3: *When performing the NL function, the encoding process must ensure that the NL value is established in accordance with Note 5 of §A.1.7.2.d. This is more important in the Global Unambiguous Decode because large longitude errors are induced if the decode function is not selecting the NL value properly as discussed in Note 5 of §A.1.7.2.d.*

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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 ($i = 1$) :

$$Dlon_i = \frac{360^\circ}{n_i},$$

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

f. Compute m, the longitude index:

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

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

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 ($i = 1$):

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

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

h. A reasonableness test **shall** be applied to the resulting decoded position in accordance with §A.1.7.10.2.

A.1.7.8 Globally Unambiguous CPR Decoding of Surface Position

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

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

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

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Note 2: *Even if the aircraft is appearing for the first time in surface format receptions, any single message could be decoded by itself into multiple locations, one being the correct location of the transmitting aircraft, and all of the others being separated by 90 NM or more from the correct location. Therefore, if it were known that the transmitting aircraft cannot be farther away than 45 NM from a known location, then the first received message could be decoded using the locally unambiguous decoding method described in §A.1.7.6. Under some circumstances it may be possible for an aircraft to be first detected when it is transmitting Surface Position Messages farther than 45 NM away from the receiving station. For this reason, even-odd decoding is required when messages are initially received from a particular aircraft. After this initial decode, as subsequent messages are received, they can be decoded individually (without using the even-odd technique), provided that the intervening time is not excessive. This subsequent decoding is based on the fact that the aircraft location has not changed by more than 45 NM between each new reception and the previously decoded location.*

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

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

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

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

$$Dlat_i = \frac{90°}{60 - i}$$

b. Compute the latitude index:

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

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

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

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

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

d. The first step in longitude decoding is to check that the ***even-odd*** pair of messages do not straddle a transition latitude. It is rare, but possible, that NL($Rlat_0$) is not equal to NL($Rlat_1$). If so, a solution for longitude cannot be calculated. In this event, abandon the decoding of this ***even-odd*** pair, and examine further receptions to identify another pair. Perform the decoding computations up to this point and check that these two NL values are equal. When that is true, proceed with the following decoding steps.

Note: *When performing the NL function, the encoding process must ensure that the NL value is established in accordance with Note 5 of §A.1.7.2.d. This is more important in the Global Unambiguous Decode because large longitude errors are induced if the decode function is not selecting the NL value properly as discussed in Note 5 of §A.1.7.2.d.*

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

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

f. Compute m, the longitude index:

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

where $NL = NL\ (Rlat_i)$

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

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

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

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

h. A reasonableness test **shall** be applied to the resulting decoded position in accordance with §A.1.7.10.2.

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

Note: *Near the equator the minimum distance between the multiple longitude solutions is more than 5000 NM, so there is no question as to the correct longitude. For locations away from the equator, the distance between solutions is less, and varies according to the cosine of latitude. For example at 87 degrees latitude, the minimum distance between solutions is 280 NM. This is sufficiently large to provide assurance that the correct aircraft location will always be obtained. Currently no airports exist within 3 degrees of either pole, so the decoding as specified here will yield the correct location of the transmitting aircraft for all existing airports.*

A.1.7.9 CPR Decoding of Received Position Reports

A.1.7.9.1 Overview

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

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A.1.7.9.2 Emitter Centered Local Decoding

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

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

A.1.7.10 Reasonableness Test for CPR Decoding of Received Position Messages

A.1.7.10.1 Overview

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

A.1.7.10.2 Reasonableness Test Applied to Position Determined from Globally Unambiguous Decoding

A reasonableness test **shall** be applied to a position computed using the Globally Unambiguous CPR decoding per §A.1.7.7 for Airborne Participants, or per §A.1.7.8 for Surface Participants. Upon receipt of the "***even***" or "***odd***" encoded Position Message that completes the Globally Unambiguous CPR decode, the receiver **shall** perform a reasonableness test on the position decode by performing the following:

If the receiver position is known, calculate the distance between the decoded position and the receiver position, and verify that the distance is less than the maximum reception range of the receiver. If the validation fails, the receiver **shall** discard the decoded position that the "***even***" and "***odd***" Position Messages used to perform the globally unambiguous CPR decode, and reinitiate the Globally Unambiguous CPR decode process.

A further validation of the Globally Unambiguous CPR decode, passing the above test, **shall** be performed by the computation of a second Globally Unambiguous CPR decode based on reception of a new "***odd***" and an "***even***" Position Message as per §A.1.7.7 for an Airborne Participant, or per §A.1.7.8 for a Surface Participant, both received subsequent to the respective "***odd***" and "***even***" Position Message used in the Globally Unambiguous CPR decode under validation. Upon accomplishing the additional Globally Unambiguous CPR decode, this decoded position and the position from the locally unambiguous CPR decode resulting from the most recently received Position Message **shall** be checked to be identical to within 5 meters for an airborne decode and 1.25 meters for a surface decode.. If the two positions are not identical to within this tolerance, the validation is failed and the initial Globally Unambiguous CPR decode under validation **shall** be discarded and the track **shall** be reinitialized.

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

A.1.7.10.3 Reasonableness Test Applied to Position Determined from Locally Unambiguous Decoding

A reasonableness test **shall** be applied to a position computed using the Locally Unambiguous CPR decoding per §A.1.7.5 for Airborne, TIS-B or Intent Participants, or per §A.1.7.6 for Surface Participants. Upon receipt of the "***even***" or "***odd***" encoded Position Message that completes the Locally Unambiguous CPR decode, the receiver **shall** perform a reasonableness test on the most recently received position decode by performing the following test:

If the difference between the TOMRs of the previously received Position Message and the most recently received Position Message is 30 seconds or less, and the reported position in the most recently received Position Message differs from the previously reported position by more than **X** NM,

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

then the most recently received position **shall not** be used to update the track.

Note: *The position threshold value is based on the assumption of a maximum aircraft velocity of **V** knots (where **V**=600 for Airborne and **V**=50 for Surface) over a maximum time period of 30 seconds. This yields a maximum positional difference of approximately 5 NM for Airborne, and 0.5 NM for Surface. An additional measure of 1 NM for Airborne, and 0.25 NM for Surface are added to account for additional ADS-B positional measurement uncertainty.*

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.*

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Figure A-1: Extended Squitter Airborne Position

Register 05_{16}

1	
2	
3	FORMAT TYPE CODE
4	(§A.1.4.1)
5	
6	
7	SURVEILLANCE STATUS
8	NIC SUPPLEMENT-B (§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 in §2.2.13.1.2 of
15	DO-181D, but with the M-bit removed (Ref ARINC 429
16	Label 203), or
17	
18	(2) GNSS Height (HAE) (Ref. ARINC 429 Label 370)
19	
20	
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	CPR ENCODED LATITUDE
31	
32	(CPR Airborne Format §A.1.7.1 to §A.1.7.7)
33	
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	
47	CPR ENCODED LONGITUDE
48	
49	(CPR Airborne Format §A.1.7.1 to §A.1.7.7)
50	
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_{16} *are ZEROed. The ZERO Format TYPE Code field indicates that Latitude and Longitude information is unavailable, while the ZERO altitude field indicates that altitude information is unavailable.*

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Figure A-2: Extended Squitter Surface Position

Register 06_{16}

Purpose: To provide accurate surface position information.

1	
2	
3	FORMAT TYPE CODE
4	(§A.1.4.1)
5	
6	
7	
8	
9	MOVEMENT
10	(§A.1.4.3.1)
11	
12	
13	STATUS for Heading (1 = valid, 0 = not valid)
14	MSB
15	
16	HEADING (7 bits)
17	(§A.1.4.3.2)
18	Resolution = 360/128 degrees
19	
20	LSB
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	CPR ENCODED LATITUDE
31	
32	(CPR Surface Format §A.1.7.1 to §A.1.7.7)
33	
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	
47	CPR ENCODED LONGITUDE
48	
49	(CPR Surface Format §A.1.7.1 to §A.1.7.7)
50	
51	
52	
53	
54	
55	
56	LSB

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Figure A-3: Extended Squitter Status

Register 07_{16}

1	TRANSMISSION RATE SUBFIELD (TRS)
2	
3	ALTITUDE TYPE SUBFIELD (ATS)
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	RESERVED
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	

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 any 30 second interval.

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

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Figure A-4: Extended Squitter Identification and Category

Register 08_{16}

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

Purpose: To provide aircraft identification and category.

TYPE Coding:
1 = Aircraft identification, Category Set D
2 = Aircraft identification, Category Set C
3 = Aircraft identification, Category Set B
4 = Aircraft identification, Category Set A

ADS-B Aircraft Emitter Category coding:

Set A

0 = No ADS-B Emitter Category Information
1 = Light (< 15500 lbs)
2 = Small (15500 to 75000 lbs)
3 = Large (75000 to 300000 lbs)
4 = High Vortex Large (aircraft such as B-757)
5 = Heavy (> 300000 lbs)
6 = High Performance (> 5g acceleration and 400 kts)
7 = Rotorcraft

Set B

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

Set C

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

Set D (Reserved)

Aircraft Identification coding:
Character coding as specified in §A.1.4.4.

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

Register 09_{16}

Bit				
1	MSB			**1**
2				**0**
3	FORMAT TYPE CODE = 19			**0**
4				**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	RESERVED-A			
11				
12	NAVIGATION ACCURACY CATEGORY FOR VELOCITY (NAC_V) (§A.1.4.5.5)			
13				
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 kts
20	2	1 kt	2	4 kts
21	3	2 kts	3	8 kts
22	---	---	---	---
23	1022	1021 kts	1022	4084 kts
24	1023	>1021.5 kts	1023	> 4086 kts
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 kts
31	2	1 kt	2	4 kts
32	3	2 kts	3	8 kts
33	---	---	---	---
34	1022	1021 kts	1022	4084 kts
35	1023	> 1021.5 kts	1023	> 4086 kts
36	SOURCE BIT FOR VERTICAL RATE (0=Geometric, 1=Baro)			
37	SIGN BIT FOR VERTICAL RATE (0=Up, 1=Down)			
38	VERTICAL RATE (9 bits)			
39	All zeros – no vertical rate info, LSB = 64 feet/min			
40	Value	Vertical Rate	Reference	
41	1	0 ft/min	ARINC 429 labels	
42	2	64 ft/min	GPS: 165	
43	---	---	INS: 365	
44	510	32576 ft/min		
45	511	> 32608 ft/min		
46				
47				
48	RESERVED-B			
49	DIFFERENCE SIGN BIT (0 = Above Baro, 1 = Below Baro Alt)			
50	GEOMETRIC HEIGHT DIFFERENCE FROM BARO ALT. (7 bits) (§A.1.4.5.7) (All zeros = no info) (LSB = 25 feet)			
51	Value	Difference		
52	1	0 feet		
53	2	25 feet		
54	---	---		
55	126	3125 feet		
56	127	> 3137.5 feet		

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

Subtype Coding:

Code	Velocity	Type
0	Reserved	
1	Ground Speed	Normal
2	Ground Speed	Supersonic
3	Airspeed, Heading	Normal
4	Airspeed, Heading	Supersonic
5	Not Assigned	
6	Not Assigned	
7	Not Assigned	

Reference ARINC Labels for Velocity:

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

Reference ARINC Labels:

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

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

Register 09_{16}

Bit				
1	MSB			**1**
2				**0**
3	FORMAT TYPE CODE = 19			**0**
4				**1**
5	LSB			**1**
6	Subtype 3	0	Subtype 4	1
7		1		0
8		1		0
9	INTENT CHANGE FLAG (§A.1.4.5.3)			
10	RESERVED-A			
11	NAVIGATION ACCURACY CATEGORY FOR VELOCITY			
12	(NAC_V) (§A.1.4.5.5)			
13				
14	STATUS BIT (1 = Heading available, 0 = Not available)			
15	MSB			
16				
17				
18	HEADING (10 bits)			
19	(§A.1.4.5.6)			
20	Resolution = 360/1024 degrees			
21				
22			Reference ARINC Label	
23			INS: 320	
24	LSB			
25	AIRSPEED TYPE (0 = IAS, 1 = TAS)			
26	AIRSPEED (10 bits)			
27	NORMAL: LSB = 1 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 kts
31	2	1 kt	2	4 kts
32	3	2 kts	3	8 kts
33	---	---	---	---
34	1022	1021 kts	1022	4084 kts
35	1023	> 1021.5 kts	1023	> 4086 kts
36	SOURCE BIT FOR VERTICAL RATE (0=Geo, 1=Baro)			
37	SIGN BIT FOR VERTICAL RATE (0=Up, 1=Down)			
38	VERTICAL RATE (9 bits)			
39	All zeros – no vertical rate information			
40	LSB = 64 feet/min			
41	Value	Vertical Rate	Reference	
42	1	0 ft/min	ARINC Labels	
43	2	64 ft/min	GPS: 165	
44	---	---	INS: 365	
45	510	32576 ft/min		
46	511	> 32608 ft/min		
47	RESERVED-B			
48				
49	DIFFERENCE SIGN BIT (0 = Above Baro, 1 = Below Baro Alt)			
50	GEOMETRIC HEIGHT DIFFERENCE FROM BARO ALT (7 bits) (§A.1.4.5.7) (All zeros = no info) (LSB = 25 feet)			
51	Value	Vertical Rate		
52	1	0 ft		
53	2	25 ft		
54	---	---		
55	126	3125 ft		
56	127	> 3137.5 ft		

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.*

Subtype Coding:

Code	Velocity	Type
0	Reserved	
1	Ground Speed	Normal
2		Supersonic
3	Airspeed, Heading	Normal
4		Supersonic
5	Not Assigned	
6	Not Assigned	
7	Not Assigned	

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

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

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Figure A-7: Extended Squitter Event-Driven Register

Register $0A_{16}$

1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
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	

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

Note: *The data in this Register is not intended for Extraction using GICB or TCAS crosslink protocols. Readout (if required) is accomplished by extracting the Contents of the appropriate Register 61_{16} to $6F_{16}$.*

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Figure A-8a: Extended Squitter Aircraft Status (Subtype 1: Emergency/Priority Status and Mode A Code)

Register 61_{16}

1	MSB
2	
3	FORMAT TYPE CODE = 28
4	
5	LSB
6	MSB
7	SUBTYPE CODE = 1
8	LSB
9	MSB
10	EMERGENCY STATE
11	LSB
12	MSB
13	
14	
15	
16	
17	MODE A (4096) CODE
18	
19	
20	
21	
22	
23	
24	LSB
25	
26	
27	
28	
29	
30	
31	
32	
33	
34	
35	
36	
37	
38	
39	
40	RESERVED
41	
42	
43	
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	

PURPOSE: To provide additional information on aircraft status.

Subtype shall be coded as follows:

0 = No information
1 = Emergency/Priority Status and Mode A Code
2 = TCAS RA Broadcast
3 to 7 = Reserved

Emergency state shall be coded as follows:

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

Notes:

1) *Message delivery is accomplished once per 0.8 seconds using the Event-Driven protocol.*

2) *Termination of emergency state is detected by coding in the surveillance status field of the Airborne Position Message.*

3) *Subtype 2 message broadcasts take priority over Subtype 1 message broadcasts.*

4) *Emergency State value 1 is set when Mode A code 7700 is provided to the transponder.*

5) *Emergency State value 4 is set when Mode A code 7600 is provided to the transponder.*

6) *Emergency State value 5 is set when Mode A code 7500 is provided to the transponder.*

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Figure A-8b: Extended Squitter Aircraft Status (Subtype 2: 1090ES TCAS RA Broadcast)

Register 61_{16}

1	MSB	
2		
3		FORMAT TYPE CODE = 28
4		
5	LSB	
6	MSB	
7		Subtype CODE = 2
8	LSB	
9	MSB	
10		
11		
12		
13		
14		
15		ACTIVE RESOLUTION ADVISORIES
16		
17		
18		
19		
20		
21		
22	LSB	
23	MSB	
24		RACs RECORD
25		
26	LSB	
27		RA TERMINATED
28		MULTIPLE THREAT ENCOUNTER
29	MSB	THREAT – TYPE INDICATOR
30	LSB	
31	MSB	
32		
33		
34		
35		
36		
37		
38		
39		
40		
41		
42		
43		THREAT IDENTITY DATA
44		
45		
46		
47		
48		
49		
50		
51		
52		
53		
54		
55		
56	LSB	

PURPOSE: To report resolution advisories (RAs) generated by TCAS equipment.

Subtype Coding:

0	=	No information
1	=	Emergency/Priority Status
2	=	TCAS RA Broadcast
3 to 7	=	Reserved

TCAS RA Broadcast Coding:

The coding of bits 9 to 56 of this Message conforms to the corresponding bits of Register 30_{16} as specified in Annex 10, Volume IV, §4.3.8.4.2.2.

Notes:

1) *Message delivery is accomplished once per 0.8 seconds using the event-driven protocol.*

2) *RA Broadcast begins within 0.5 seconds after transponder notification of the initiation of an TCAS RA.*

3) *RA Broadcast is terminated 24 ±1 seconds after the RAT flag (Annex 10, Volume IV, §4.3.8.4.2.2.1.3) transitions from ZERO (0) to ONE (1).*

4) *Subtype 2 message broadcasts take priority over subtype 1 message broadcasts.*

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Figure A-9a: Target State and Status Information
(Subtype = 0: Compatible with DO-260A, ADS-B Version Number=1)

Register 62_{16}

PURPOSE: To provide aircraft state and status information.

1		FORMAT TYPE CODE = 29
2		
3		
4		
5		
6	MSB	SUBTYPE CODE = 0
7	LSB	
8	MSB	Vertical Data Available / Source Indicator (§A.1.4.9.3)
9	LSB	
10		Target Altitude Type (§A.1.4.9.4)
11		Backward Compatibility Flag = 0
12	MSB	Target Altitude Capability (§A.1.4.9.5)
13	LSB	
14	MSB	Vertical Mode Indicator (§A.1.4.9.6)
15	LSB	
16	MSB	Target Altitude (§A.1.4.9.7)
17		
18		
19		
20		
21		
22		
23		
24		
25	LSB	
26	MSB	Horizontal Data Available / Source Indicator (§A.1.4.9.8)
27	LSB	
28	MSB	Target Heading / Track Angle (§A.1.4.9.9)
29		
30		
31		
32		
33		
34		
35		
36	LSB	
37		Target Heading / Track Indicator (§A.1.4.9.10)
38	MSB	Horizontal Mode Indicator (§A.1.4.9.11)
39	LSB	
40	MSB	Navigation Accuracy Category – Position (NAC_P) (§A.1.4.9.12)
41		
42		
43	LSB	
44		Navigation Integrity Category – Baro (NIC_{BARO}) (§A.1.4.9.13)
45	MSB	Surveillance Integrity Level (SIL) (§A.1.4.9.14)
46	LSB	
47		Reserved
48		
49		
50		
51		
52	MSB	Capability / Mode Codes (§A.1.4.9.15)
53	LSB	
54	MSB	Emergency / Priority Status (§A.1.4.9.16)
55		
56	LSB	

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Figure A-9b: Target State and Status Information (Subtype = 1: Compatible with DO-260B, ADS-B Version Number=2)

Register 62_{16}

1	
2	
3	**FORMAT TYPE CODE = 29**
4	
5	
6	MSB **SUBTYPE CODE = 1**
7	LSB
8	**SIL SUPPLEMENT** (0=Per Hour, 1=Per Sample)
9	**SELECTED ALTITUDE TYPE** (0=MCP/FCU, 1=FMS)
10	MSB = 32768 feet
11	**MCP / FCU SELECTED ALTITUDE**
12	(when Selected Altitude Type = 0)
13	**FMS SELECTED ALTITUDE**
14	(when Selected Altitude Type = 1)
15	Coding: 111 1111 1111 = 65472 feet
16	*** **** ****
17	000 0000 0010 = 32 feet
18	000 0000 0001 = 0 feet
19	000 0000 0000 = No data or Invalid
20	LSB = 32 feet
21	MSB = 204.8 millibars
22	**BAROMETRIC PRESSURE SETTING (MINUS 800 millibars)**
23	Range = [0, 408.0] Resolution = 0.8 millibars
24	Coding: 1 1111 1111 = 408.00 millibars
25	* **** ****
26	0 0000 0010 = 0.800 millibars
27	0 0000 0001 = 0.000 millibars
28	0 0000 0000 = No Data or Invalid
29	LSB = 0.8 millibars
30	STATUS (0=Invalid, 1=Valid)
31	Sign (0=Positive, 1=Negative)
32	MSB = 90.0 degrees
33	
34	**SELECTED HEADING**
35	Range = [+/- 180] degrees, Resolution = 0.703125 degrees
36	(Typical Selected Heading Label = "101")
37	
38	
39	LSB = 0.703125 degrees (180/256)
40	MSB
41	**NAVIGATION ACCURACY CATEGORY FOR POSITION (NAC_P)**
42	(§A.1.4.9.9)
43	LSB
44	**NAVIGATION INTEGRITY CATEGORY FOR BARO (NIC_{BARO})**
45	MSB **SOURCE INTEGRITY LEVEL (SIL)**
46	LSB
47	**STATUS OF MCP / FCU MODE BITS** (0 = Invalid, 1 = Valid)
48	**AUTOPILOT ENGAGED** (0 = Not Engaged, 1 = Engaged)
49	**VNAV MODE ENGAGED** (0 = Not Engaged, 1 = Engaged)
50	**ALTITUDE HOLD MODE** (0 = Not Engaged, 1 = Engaged)
51	**Reserved for ADS-R Flag** (see §2.2.18.4.6)
52	**APPROACH MODE** (0 = Not Engaged, 1 = Engaged)
53	**TCAS OPERATIONAL** (0 = Not Operational, 1 = Operational)
54	MSB
55	**RESERVED**
56	LSB

PURPOSE: To provide aircraft state and status information.

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Figure A-10: Aircraft Operational Status

Register 65_{16}

Bit		
1	MSB	
2		
3	FORMAT TYPE CODE = 31	
4		
5	LSB	
6	MSB	MSB
7	SUBTYPE CODE = 0	SUBTYPE CODE = 1
8	LSB	LSB
9	MSB	MSB
10		
11		
12		
13		
14	AIRBORNE	SURFACE
15	CAPABILITY CLASS (CC)	CAPABILITY CLASS (CC)
16	CODES	CODES
17	(§A.1.4.10.3)	(§A.1.4.10.3)
18		
19		
20		LSB
21		MSB
22		LENGTH/WIDTH CODES
23		(§A.1.4.10.11)
24	LSB	LSB
25	MSB	MSB
26		
27		
28		
29		
30	AIRBORNE	SURFACE
31	OPERATIONAL	OPERATIONAL
32	MODE (OM) CODES	MODE (OM) CODES
33	(§A.1.4.10.4)	(§A.1.4.10.4)
34		
35		
36		
37		
38		
39		
40	LSB	LSB
41	MSB	
42	VERSION NUMBER (§A.1.4.10.5)	
43	LSB	
44	NIC SUPPLEMENT-A (§A.1.4.10.6)	
45	MSB	
46	NAVIGATIONAL ACCURACY CATEGORY – POSITION	
47	(NAC_P) (§A.1.4.10.7)	
48	LSB	
49	MSB GVA	RESERVED
50	LSB (§A.1.4.10.8)	
51	MSB SOURCE INTEGRITY LEVEL (SIL)	
52	LSB (§A.1.4.10.9)	
53	NIC_{BARO} (§A.1.4.10.10)	TRK/HDG (§A.1.4.10.12)
54	HRD (§A.1.4.10.13)	
55	SIL SUPPLEMENT (§A.1.4.10.14)	
56	RESERVED	

PURPOSE: To provide the capability class and current operational mode of ATC-related applications and other operational information..

Subtype Coding:

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

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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, or is broadcasting incorrect information.*

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 A-11.

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

<u>Figure A-11:</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-29.

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Table A-29: CF Field Code Definitions in DF=18 ADS-B and TIS-B Messages

CF Value	ICAO/Mode A Flag (IMF)	Meaning
0	N/A	ADS-B Message from a non-transponder device, AA field holds 24-bit ICAO aircraft address
1	N/A	Reserved for ADS-B Message in which the AA field holds anonymous address or ground vehicle address or fixed obstruction address
2	0	Fine TIS-B Message, AA field contains the 24-bit ICAO aircraft address
	1	Fine TIS-B Message, AA field contains the 12-bit Mode A code followed by a 12-bit track file number
3	0	Coarse TIS-B Airborne Position and Velocity Message, AA field contains the 24-bit ICAO aircraft address
	1	Coarse TIS-B Airborne Position and Velocity Message, AA field contains the 12-bit Mode A code followed by a 12-bit track file number.
4	N/A	TIS-B and ADS-R Management Message AA field contains TIS-B/ADS-R management information.
5	0	Fine TIS-B Message AA field contains a non-ICAO 24-bit address
	1	Reserved
6	0	Rebroadcast of ADS-B Message from an alternate data link AA field holds 24-bit ICAO aircraft address
	1	Rebroadcast of ADS-B Message from an alternate data link AA field holds anonymous address or ground vehicle address or fixed obstruction address
7	N/A	Reserved

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-12.

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.

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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-13.

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 is 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.

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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-14. 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 Velocity Message

The TIS-B Velocity ME field will be formatted as specified in the Figure A-15 for Subtypes 1 and 2, and in Figure A-16 for Subtypes 3 and 4.

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

A.2.4.4.1 Subtype Field

Subtypes 1 through 4 will be used for the TIS-B Velocity Message. Subtype 1 will be used for velocities over ground under 1000 knots and Subtype 2 will be used for aircraft capable of supersonic flight when the velocity over ground 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.

Subtypes 3 and 4 will be used when Airspeed and Heading are substituted for velocity over ground. Subtype 3 will be used at subsonic airspeeds, while Subtype 4 will be used for aircraft capable of supersonic flight when the Airspeed might exceed 1022 knots.

The supersonic version of the Airspeed coding will be used if the Airspeed exceeds 1022 knots. A switch to the normal Airspeed coding will be made if the Airspeed drops 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 is specified in §A.2.4.1.1.

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A.2.4.5 Coarse Airborne Position Message

The TIS-B coarse airborne position ME field will be formatted as specified in Figure A-17.

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 is 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.

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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 TIS-B and ADS-R Management Messages

The TIS-B/ADS-R Management Messages use Extended Squitter format DF=18 and CF=4 to provide information related to the provision of the TIS-B and/or ADS-R Service Volume in the specific airspace being serviced by the local ground broadcast site(s).

The TIS-B/ADS-R Management Message is used to provide a specific announcement of the Service Volume and the service availability in local airspace where the TIS-B and/or ADS-R service is being supported by the ground infrastructure.

A.2.6 Formats for 1090 MHz TIS-B Messages

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Figure A-12: TIS-B Fine Airborne Position Message

1	
2	
3	FORMAT TYPE CODE
4	(See §A.1.4.1 and Note 1)
5	
6	MSB SURVEILLANCE STATUS
7	LSB
8	IMF (§A.2.4.1.1)
9	
10	
11	
12	
13	PRESURE ALTITUDE
14	
15	
16	The altitude code (AC) as specified in §2.2.13.1.2 of
17	DO-181D, but with the M-bit removed.
18	
19	
20	
21	RESERVED
22	CPR FORMAT (F) (§A.1.4.2.1)
23	MSB
24	
25	
26	
27	
28	
29	CPR ENCODED LATITUDE
30	CPR Airborne Format
31	(§A.1.7.1 to §A.1.7.7)
32	
33	
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	CPR ENCODED LONGITUDE
47	CPR Airborne Format
48	(§A.1.7.1 to §A.1.7.7)
49	
50	
51	
52	
53	
54	
55	
56	LSB

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

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

Codes 1 and 2 take precedence over code 3.

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Figure A-13: TIS-B Fine Surface Position Message

1	
2	
3	FORMAT TYPE CODE
4	(§A.1.4.1)
5	
6	
7	
8	
9	MOVEMENT
10	(§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	Resolution = 360/128 degrees
19	
20	LSB
21	IMF (§A.2.4.2.1.2)
22	CPR FORMAT (F) (§A.1.4.2.1)
23	MSB
24	
25	
26	
27	
28	
29	
30	CPR ENCODED LATITUDE
31	CPR Surface Format
32	(§A.1.7.1 to §A.1.7.7)
33	
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	
47	CPR ENCODED LONGITUDE
48	CPR Surface Format
49	(§A.1.7.1 to §A.1.7.7)
50	
51	
52	
53	
54	
55	
56	LSB

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

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Figure A-14: TIS-B Identification and Category Message

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

Purpose: To provide aircraft identification and category for aircraft that are not equipped with 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 Aircraft Emitter Category coding:

Set A
0 = No ADS-B Emitter Category Information
1 = Light (< 15500 lbs)
2 = Small (15500 to 75000 lbs)
3 = Large (75000 to 300000 lbs)
4 = High Vortex Large (aircraft such as B-757)
5 = Heavy (> 300000 lbs)
6 = High Performance (> 5g acceleration and 400 kts)
7 = Rotorcraft

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

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

Set D
(Reserved)

Aircraft Identification coding:
Character coding as specified in §A.1.4.4.

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Figure A-15: TIS-B Velocity Messages (Subtypes 1 and 2: Velocity Over Ground)

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	Normal
2	Speed	Supersonic

Note: *The "Vertical Rate" and "Geometric Height Difference From Barometric" fields for surface aircraft do not need to be processed by TIS-B receivers.*

Bit				
1	MSB			**1**
2				**0**
3	FORMAT TYPE CODE = 19			**0**
4				**1**
5	LSB			**1**
6	Subtype 1	0	Subtype 2	0
7		0		1
8		1		0
9	IMF (§A.2.4.4.2)			
10	MSB			
11	NAVIGATION ACCURACY CATEGORY FOR POSITION			
12	(NAC_P) (§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 kts
20	2	1 kt	2	4 kts
	3	2 kts	3	8 kts
22	---	---	---	---
23	1022	1021 kts	1022	4084 kts
24	1023	>1021.5 kts	1023	> 4086 kts
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 kts
31	2	1 kt	2	4 kts
32	3	2 kts	3	8 kts
33	---	---	---	---
34	1022	1021 kts	1022	4084 kts
35	1023	> 1021.5 kts	1023	> 4086 kts
36	GEO FLAG BIT (1 bit) (GEO = 0)		GEO FLAG BIT (1 bit) (GEO = 1)	
37	SIGN BIT FOR VERTICAL RATE (0=Up, 1=Down)		SIGN BIT FOR VERTICAL RATE (0=Up, 1=Down)	
38	VERTICAL RATE (9 bits)		VERTICAL RATE (9 bits)	
39	All zeros – no vertical rate info, LSB = 64 feet/min		All zeros – no vertical rate info, LSB = 64 feet/min	
40	Value	Vertical Rate	Value	Vertical Rate
41	1	0 ft/min	1	0 ft/min
42	2	64 ft/min	2	64 ft/min
43	---	---	---	---
44	510	32576 ft/min	510	32576 ft/min
45	511	> 32608 ft/min	511	> 32608 ft/min
46				
47	NIC SUPPLEMENT (§A.1.4.10.6)		NIC SUPPLEMENT (§A.1.4.10.6)	
48			RESERVED (1 bit)	
49	NAVIGATION ACCURACY CATEGORY FOR VELOCITY		DIFFERENCE SIGN BIT (0 = Above Baro, 1 = Below Baro Alt)	
50	(NAC_V) (§A.1.4.5.5)		GEOMETRIC HEIGHT DIFFERENCE FROM BARO ALT. (7 bits) (§A.1.4.5.7) (All zeros = no info) (LSB = 25 feet)	
51	SURVEILLANCE INTEGRITY LEVEL (SIL)		Value	Difference
52	(§A.1.4.10.9)		1	0 feet
53			2	25 feet
54	RESERVED (4 bits)		---	---
55			126	3125 feet
56			127	> 3137.5 feet

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Figure A-16: TIS-B Velocity Messages (Subtypes 3 and 4: Air Referenced Velocity)

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
3	Airspeed, Heading	Normal
4		Supersonic

Note: *The "Vertical Rate" and "Geometric Height Difference From Barometric" fields for surface aircraft do not need to be processed by TIS-B receivers*

Bit				
1	MSB			**1**
2				**0**
3	FORMAT TYPE CODE = 19			**0**
4				**1**
5	LSB			**1**
6	Subtype 3	0	Subtype 4	1
7		1		0
8		1		0
9	IMF (§A.2.4.4.2)			
10				
11				
12	NAVIGATION ACCURACY CATEGORY FOR POSITION (NAC_P) (§A.1.4.10.7)			
13				
14	HEADING STATUS BIT (1 = Available, 0 = Not Available)			
15	MSB			
16				
17				
18	HEADING (10 bits)			
19	(§A.1.4.5.6)			
20	Resolution = 360/1024 degrees			
21				
22				
23				
24	LSB			
25	AIRSPEED TYPE (0 = IAS, 1 = TAS)			
26	AIRSPEED (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 kts
31	2	1 kt	2	4 kts
32	3	2 kts	3	8 kts
33	---	---	---	---
34	1022	1021 kts	1022	4084 kts
35	1023	> 1021.5 kts	1023	> 4086 kts

Bit				
36	GEO FLAG Bit (GEO = 0)		GEO FLAG Bit (GEO =1)	
37	SIGN BIT FOR VERTICAL RATE (0=Up, 1=Down)		SIGN BIT FOR VERTICAL RATE (0=Up, 1=Down)	
38	VERTICAL RATE (9 bits)		VERTICAL RATE (9 bits)	
39	All zeros – no vertical rate information		All zeros – no vertical rate information	
40	LSB = 64 feet/min		LSB = 64 feet/min	
41	Value	Vertical Rate	Value	Vertical Rate
42	1	0 ft/min	1	0 ft/min
43	2	64 ft/min	2	64 ft/min
44	---	---	---	---
45	510	32576 ft/min	510	32576 ft/min
46	511	> 32608 ft/min	511	> 32608 ft/min
47	NIC SUPPLEMENT (§A.1.4.10.6)		NIC SUPPLEMENT (§A.1.4.10.6)	
48			RESERVED (1 bit)	
49	NAVIGATION ACCURACY CATEGORY FOR VELOCITY		DIFFERENCE SIGN BIT (0 = Above Baro, 1 = Below Baro Alt)	
50	(NAC_V) (§A.1.4.5.5)		GEOMETRIC HEIGHT DIFFERENCE FROM BARO ALT (7 bits) (§A.1.4.5.7) (All zeros = no info) (LSB = 25 feet)	
51	SURVEILLANCE INTEGRITY LEVEL		Value	Vertical Rate
52	(§A.1.4.10.9)		1	0 ft
53	RESERVED		2	25 ft
54	RESERVED		---	---
55	TRUE / MAGNETIC HEADING (0 = True, 1 = Magnetic)		126	3125 ft
56	RESERVED		127	> 3137.5 ft

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Figure A-17: TIS-B Coarse Airborne Position Message

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

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

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A.3 ADS-B Rebroadcast Service – Formats and Coding

A.3.1 Introduction

The TIS-B MASPS, RTCA/DO-286B defines an "ADS-B Rebroadcast Service", as a "Fundamental TIS-B Service," that may be provided. The Messages of the ADS-B Rebroadcast Service are not transmitted by aircraft, but by ADS-B ground stations.

Notes:

1. *This section of Appendix A defines the formats and coding for an ADS-B Rebroadcast Service (see the TIS-B MASPS, RTCA/DO-286B, §1.4.1) based on the same 112-bit 1090 MHz Extended Squitter signal transmission that is used for DF=17 ADS-B Messages on 1090 MHz.*
2. *The ADS-B Rebroadcast Service complements the operation of ADS-B and the Fundamental TIS-B Service (see the TIS-B MASPS, RTCA/DO-286B, §1.4.1) by providing ground-to-air rebroadcast of ADS-B data about aircraft that are not equipped for 1090 MHz Extended Squitter ADS-B, but are equipped with an alternate form of ADS-B (e.g., Universal Access Transceiver (UAT)). The basis for the ADS-B Rebroadcast transmission is the ADS-B Report received at the ground station using a receiver compatible with the alternate ADS-B data link.*
3. *The ADS-B Rebroadcast ground-to-air transmissions use the same signal formats as the DF=17 1090 MHz Extended Squitter ADS-B and can therefore be accepted by a 1090 MHz ADS-B Receiving Subsystem, with the exceptions identified in the following sections.*

A.3.2 ADS-B Rebroadcast Format Definition

ADS-B Rebroadcast information is transmitted using the 112-bit Mode S DF=18 format specified in Figure A-11.

A.3.3 Control Field Allocation

The content of the DF=18 transmission is defined by the value of the Control Field (CF). As specified in Table A-29, ADS-B Rebroadcasts (i.e., ADS-R) transmissions **shall** use CF=6 and ADS-R Management information transmissions (i.e., defining ADS-R Service Volume and service availability) **shall** use CF=4.

A.3.4 ADS-B Rebroadcast Surveillance Message Definitions

The Rebroadcast of ADS-B information on the 1090 MHz Extended Squitter data link is accomplished by utilizing the same ADS-B Message formats defined in Figure A-1 through Figure A-10, with the exception of the need to transmit an indication to the 1090 MHz Receiving Subsystem as to the type of identity associated with the aircraft data being reported in the ADS-B Rebroadcast Message. This identification is performed using the ICAO/Mode A Flag (IMF), which was previously discussed in §A.2.4.1.1 for the TIS-B transmissions.

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The insertion of this one bit into the ADS-B Messages identified below allows the ADS-B Receiving Subsystem to interpret the Address Field (AF) in the following manner:

IMF = 0 indicates that the ADS-B Rebroadcast data is identified by an ICAO 24-bit Address

IMF = 1 indicates that the ADS-B Rebroadcast data is identified by an anonymous 24-bit Address

A.3.4.1 Rebroadcast Airborne Position Message

The ME Field of the Rebroadcast Airborne Position Message will be formatted as specified in section §A.1.4.2 and Figure A-1, except that ME bit 8 is redefined to be the ICAO/Mode A Flag (IMF).

A.3.4.2 Rebroadcast Surface Position Message

The ME Field of the Rebroadcast Surface Position Message will be formatted as specified in section §A.1.4.3 and Figure A-2, except that ME bit 21 is redefined to be the ICAO/Mode A Flag (IMF).

A.3.4.3 Rebroadcast Aircraft Identification and Category Message

The ME Field of the Rebroadcast Aircraft Identification and Category Message will be formatted exactly as specified in section §A.1.4.4 and Figure A-4.

Note: *Any Rebroadcast Aircraft Identification and Category Message does not contain the IMF bit since aircraft using an anonymous 24-bit address will not provide identity and category information.*

A.3.4.4 Rebroadcast Airborne Velocity Message

The ME Field of the Rebroadcast Airborne Velocity Messages will be formatted as specified in section §A.1.4.5.1 and Figure A-5 for Subtype 1 & 2 Messages, and in section §A.1.4.5.2 and Figure A-6 for Subtype 3 & 4 Messages, except that ME bit 9 is redefined to be the ICAO/Mode A Flag (IMF).

A.3.4.5 Rebroadcast Extended Squitter Aircraft Status Message

The ME Field of the Rebroadcast Extended Squitter Aircraft Status Message will be formatted as specified in section §A.1.4.8 and Figure A-8, except that ME bit 56 is redefined to be the ICAO/Mode A Flag (IMF).

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A.3.4.6 Rebroadcast Target State and Status Message

The ME Field of the Rebroadcast Target State and Status Message will be formatted as specified in section §A.1.4.9 and Figure A-9, except that ME bit 51 is redefined to be the ICAO/Mode A Flag (IMF).

A.3.4.7 Rebroadcast Aircraft Operational Status Message

The ME Field of the Rebroadcast Aircraft Operational Status Message will be formatted as specified in section §A.1.4.10 and Figure A-10, except that ME bit 56 is redefined to be the ICAO/Mode A Flag (IMF).

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