RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #10

Proposed Enhancements to the 1090 MHz Extended Squitter MOPS

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Summary

The proposed changes to the ADS-B MASPS for the broadcast of intent information will need to be finalized for the ballot version of DO-242A in March 2002. DO-260A is expected to include the specific provisions to accommodate TSRs. This paper includes specific proposals, in Attachment A, for how 1090 MHz ADS-B MOPS could support the revised requirements for intent reporting. Also the attachment to this paper includes proposed changes for version number reporting, message broadcast rates and event-driven message scheduling.

References: Proposed ADS-B MASPS DO-242A, March 2, 2002 ballot draft

Attachment A: Proposed DO-260A revisions for intent reporting, version number reporting, message broadcast rates and event-driven message scheduling

1. Background

The referenced draft DO-242A, that was produced by WG-6 is an update to the current ADS-B MASPS. For a given ADS-B link, the associated MOPS will need to define the transmission rates for each of the various ADS-B messages necessary to allow the generation of the ADS-B Reports defined by the ADS-B MASPS. The ADS-B MASPS must remain independent of the ADS-B link technologies. Therefore, the MASPS requirements are expressed in terms of the effective update rate requirements for report updates as viewed by the receiving system. This is the same approach that was taken for expressing the update rate requirements in the current DO-242. The following material discusses needed changes to DO-260A that are aligned with the draft MASPS DO-242A requirements associated with intent report requirements and associated update rates. The previous MASPS requirements for TCP and TCP+1 for intent reporting have been replaced with requirements for TSR and TCR. The ADS-B link MOPS are not expected to include explicit technical provisions for supporting TCRs until the associated MASPS requirements have been validated. However, support for TSRs are expected to be included in both the UAT MOPS and the update to the 1090 ADS-B MOPS (i.e., DO-260A).

2. Discussion

The update rate requirements for TSRs that have been included in the draft DO-242A are a nominal rate of 12 seconds at 95% probability at an air-to-air range of 20 NM and at ranges beyond 20 NM the nominal update rate would be no faster than 12 seconds but would decrease to 18 seconds at 40 NM according to the formula 0.45 x Range. In effect requiring a 12 second update rate out to 27 NM then linearly decreasing to 18 seconds at 40 NM. The draft DO-242A defines only <u>desired</u> update rates for TSR beyond 40 NM. As a further condition the update rate following a significant change in the information being conveyed in a TSR would need to be received within 12 seconds even at the 40 NM air-to-air range.

The message contents and the update rates for the initial TC Reports are also defined by DO-242A, however neither DO-260A nor the UAT MOPS are expected to specify the requirements for supporting TCRs as this will incorporated into a later update to the MOPS. However, TCR+0 should be addressed in an appendix to DO-260A indicating the overall longer-term requirement for Class A2 and Class A3 avionics to support TCR+0 reporting and providing a discussion of the approach that will be taken to incorporate provisions for TCR+0 into a future edition of the MOPS as well as the expected performance of the link to support TCR+0. DO-242A will include only appendix material, not specific requirements for TCR+1.

2.1 Currently for 1090 MHz ADS-B avionics (transponder based on stand-alone ADS-B avionics) limit the overall maximum extended squitter transmission rate to 6.2 squitters per second. For transponder based avionics, it is the responsibility of the transponder to enforce this rate limit on the extended squitter transmissions. Further the Mode S transponder is responsible, as per DO-181B, for the broadcast of the following squitter types (while airborne) at the indicated nominal transmission rates:

- position squitter 2 per second
- velocity squitter 2 per second
- aircraft identity and type squitter 0.2 per second

All other squitters types are defined as event driven. The contents of these event driver squitters are defined by DO-260 while the maximum total transmission rate for the event driven squitters is limited by the Mode S transponder MOPS (DO-181C) to 2 per second.

Currently the following types of ADS-B messages are defined by DO-260 or have been proposed for DO-260A that would use event driven squitters:

- additional aircraft identity and type messages has been considered by WG-3 for DO-260A with a nominal rate of 0.2 per second (this has been discussed but no specific proposed MOPS change has been put forward to WG3)
- intent information (current nominal update is 0.588/sec for TCP and 0.588/sec for TCP+1 - see below for proposal to replace with messages to support TSR at a revised update rate)
- operational coordination message (nominal rate 0.2/sec. increasing to 0.5/sec. when there is a change in the information – most aircraft would be broadcasting this message continuously at the nominal rate of 0.2 per second)
- operational status message (nominal rate 0.588/sec. currently only defined to report status of TCAS and CDTI – TCAS and/or CDTI equipped aircraft would normally be broadcasting this message at the specified rate)
- extended squitter aircraft status (nominal rate 1/sec. and used to report emergency conditions and is only broadcast for the duration of the emergency.

Thus under 'normal' conditions many air carrier class aircraft could routinely be broadcasting event-driven messages at a rate of (0.2 + + 0.588 = 0.788 squitters per second) even without any intent information, without an extra aircraft ID message, without an emergency and without any change in the contents of the Operational Coordination Message. Given these requirements it is clear that the total limit of 2 squitters per second for event driven messages cannot simultaneously satisfy all of the reporting requirements associated with all of the even driven messages all of the time. The current DO-260 MOPS offers some recognition for the need to further define the requirements for event driven messages in Note number 2 under para. 2.2.3.3.1.3

This MOPS contains a limited capability to adjust event-driven message rates to stay within the Event-Driven budget of 2 transmissions per second (2.2.3.3.2.10). If additional Event-Driven message types are defined, a later version of this document may define a more fully featured scheduling function that assigns rates based upon the relative priority of the Event-Driven messages.

It would appear appropriate, to address this limitation of the current MOPS in the revisions for DO-260A.

2.2 The current DO-260 broadcast rate requirements for intent (i.e., TCP and TCP+1) information are shown below in Table 1.

TABLE 1

DO-260 TCP requirements	TCP rate	TCP+1 rate	**Total Rate (squitters/sec)**
broadcast interval	1.700	1.700	
broadcast squitters/sec.	0.588	0.588	**1.176**

The draft DO-242A includes three types of intent reports (TSR, TCR+0 and future TCR+x), although only TSR and TCR+0 will be included as requirements for this update to the ADS-B MASPS. The information necessary to allow generation of a TSR could be broadcast within a single squitter, but TCR+0 and TCR+1 (at least certain variations of these reports) may require more data elements than could be supported in a single squitter. Consistent with the directions for the SC-186 plenary in December 2001, TSR requirements will need to be addressed in DO-260A. WG6 is defining the minimum required elements for TCR and these will need to be accommodated in a future update (beyond DO-260A) to the 1090 MHz ADS-B MOPS. A preliminary review of the proposed TSR and TCR report contents, from the recent draft DO-242A on the report contents and reporting rate indicates that the long-term intent requirements for TSR, TCR+0 and TCR+1 could result in a 400% to 500% increase in the intent information that needs to be conveyed per unit of time as compared to the current DO-242 requirement for TCP plus TCP+1. This represents a substantial new requirement for the ADS-B links and could have a significant impact on the link MOPS. However, in the short term it is expected that SC-186 will agree to only include specific requirements in the link MOPS for TSR with the requirements for TCRs to be addressed in future updates.

One significant consideration of accommodating TCR+0 and TCR+x within a future update to the 1090 MHz Extended Squitter MOPS will need to be to either keep the total allowed peak squitter rate at approximately the same as currently defined (i.e., 6.2 squitters per second) or to seek approval from ICAO and RTCA for allowing a higher peak total squitter rate and to revise the requirements of the Mode S transponder MOPS/SARPS related to extended squitter transmission rates accordingly. Since for the moment we need to only consider just the near-term requirement for DO-260A to support

TSRs in the 1090 extended squitter MOPS then no increase to the total authorized peak squitter rate are proposed nor are changes to DO-181C necessary.

2.3 The proposed changes to DO-260A in the attachment to this working paper include support for TSRs and include specific proposals for the update rates associated with the event-driven extended squitter messages. A new message type for an "Aircraft Trajectory Intent and System Status Message" is proposed (replacing the DO-260 Aircraft Trajectory Intent message). This new message type would be used to support both TSR and TCRs. Also the message bits not needed to convey trajectory status information would be used to convey other dynamic status information that would allow a reduced broadcast rate for "Aircraft Operational Status" messages.

2.4 The proposed message reporting rates in attachment 1 would use a nominal squitter transmission rate of once per 1.25 seconds for when the trajectory intent or system status information has not changed and an increased rate of once per 0.75 seconds for when the message contents have changed. This would directly address the proposed MASPS requirements and make for efficient use of the fixed limit of 1090ES for transmission of event driven squitters. Table 3 below shows the required squitter reception probabilities for the case where the messages necessary to generate a TSR update has a nominal transmission rate of 0.8 message per second with a maximum rate of 1.33 messages per second for a 24 second interval following any significant change in TSR message contents.

Table 2 Required Squitter Reception Probability

a-a range	Required per Squitter Reception Probability	
	Nominal (0.667/sec)	Max (1.33/sec)
20 NM	0.268	0.171
40 NM	0.188	0.171

The probabilities shown in Table 2 above are for 95% probability of being able to generate a TSR update are based on the formula: $P_{squitter} = 1 – (0.05)^{1/N}$. Where $P_{squitter}$ is the probability of individual squitter reception and N is the number of squitter transmissions within the required update interval. Thus at the maximum required range of 40 NM for TSR updates, as per the draft DO-242A, the probability of squitter reception would need to be 18.8% under nominal conditions and 17.1% following a change in the trajectory state information. Based on data from 1090ES flight measurements in both LA and Frankfurt these level of performance could be achieved in today's highest traffic density environments by a Class A2 receiver with enhanced reception techniques. Preliminary modeling results would suggest that such a level of performance may be possible in a postulated future LA scenario for 2020, but additional simulation work will be needed to confirm this.

2.5 Future accommodation of TCR requirements may require a change to the Mode S transponder MOPS/SARPs as well as the 1090 MHz ADS-B MOPS/SARPs. Two possible alternatives available to accommodate TCR+0 would be:

a) to reduce the rate at which state vector information is transmitted; and/or

b) to seek approval to allow the use of a higher total peak rate for squitter transmission for those aircraft capable of reporting TCR+0 (only applicable to Class A2 and A3 avionics).

The first approach would require a change to the Mode S transponder MOPS and SARPs and although it might be possible to accommodate the TCR+0 requirement without exceeding the total rates currently specified for the transponder, but it is unlikely that TCR+1 could be accommodated with this approach. The second approach would require also approval from ICAO, RTCA and the FAA spectrum office for changes to the Mode S transponder MOPS and SARPs. The timescale for the first approach would probably be shorter than for the second but in either case the needed timeframe for the accommodation of TCR+0 and especially TCR+x are relatively long term. Once the MASPS requirements for TCR+0 and TCR+x are validated and we have a more mature operational concept of what aircraft are expected to be capable of broadcasting TCR information, under what conditions and how the information may be used, then a decision will need to be made as the preferred approach to accommodate these new requirements in the 1090 MHz ADS-B system design.

3. Proposal

It is proposed that WG3 progress the development of DO-260A to:

1. define the provisions for an event-driven trajectory intent messages including a specification of the message formats and transmission rates, based attachment A to this paper, and to develop the associated test requirements as a replacement for or modification to the existing TCP related tests.

2. review and modify, as appropriate, the message contents and/or reporting rates for the event-driven messages as per attachment A to this paper in order to better utilize the 2 squitters per second allowed for the transmission of event-driven squitters

3. include requirements for a scheduling function that assigns rates based upon the relative priority of the Event-Driven messages as per attachment A to this paper including the definition of the relative priorities of all of the event-driven messages

4. develop an appendix describing the longer term need to support TCR+0 based on the provisions being introduced in DO-242A. Also include a discussion of the possible approach to supporting TCR+0 and TCR+x in the future 1090 MHz ADS-B design and the expected performance.

ATTACHMENT A

This attachment has 3 Parts:

1. DO-260A changes to support new intent reporting requirements
2. DO-260A changes to version number
3. DO-260A changes for event-driven message rates and message scheduling

PART 1

The following draft DO-260A material proposes to replace "Aircraft Trajectory Intent" Messages (Section 2.2.3.2.7.1) with "Aircraft Trajectory Intent and System Status" Messages. This new message type would provide support for TSRs and future TCRs as well as providing other status information, including NAC, SIL, TCAS status, etc. within a single message type.

2.2.3.2.7 ADS-B Intent, Operational Coordination, and Operational Status Messages

Type codes 29, 30 and 31 have been identified for Aircraft Intent, Aircraft Operational Coordination, and Aircraft Operational Status. Structure of these messages is provided in detail in the subsequent paragraphs.

2.2.3.2.7.1 "Aircraft Trajectory Intent and System Status" Messages

The "Aircraft Trajectory Intent and System Status" Message are used to provide the current state of an airborne aircraft in navigating to its intended trajectory and the status of the aircraft's navigation data source, CDTI and TCAS/ACAS systems. For this version of these MOPS the Aircraft Trajectory Intent and System Status message is defined to convey information on the aircraft's target heading and altitude (i.e. Target State information) as well as information on the status of the navigation data being used by ADS-B and the status of the aircraft CDTI and TCAS systems. The format of the Aircraft Trajectory Intent and System Status message is provided in Figure 2-8, while further definition of each of the subfields is provided in the subsequent paragraphs.

Notes:

1. *Future editions of these MOPS may include provisions for additional sub-types of aircraft trajectory intent and status messages supporting broadcast of trajectory change information. An overview of such messages is provided in Appendix tbd.*

2. *At the time of the adoption of RTCA DO-260, it was decided by RTCA SC-186 Plenary that insufficient information was known about Trajectory Change Points and their usage to broadcast a TCP Valid Flag ("ME" bit 11) set equal to one (1), indicating that the following TCP Data was "Valid," without a clear understanding of what that data represented. It was agreed that the TCP Valid Flag be set to zero (0), until the issue of TCP was resolved by changes to the ADS-B MASPS, RTCA DO-242. This would result in the TCP/TCP+1 messages not being broadcast from a RTCA DO-260 compliant airborne implementation.*

   It was further agreed by the RTCA SC-186 Plenary, which approved DO-260 that all remaining text in DO-260 regarding TCP and TCP+1 was to remain as written, without modification, except for the test procedure in subparagraph 2.4.3.2.7.1.4, which deals specifically with the TCP Valid Flag in subparagraph 2.2.3.2.7.1.4.

   In these revised MOPS (RTCA DO-260A) the provisions of RTCA DO-260 related to TCP/TCP+1 have been removed and provisions for a Aircraft Trajectory Intent and System Status message has been defined using the same message Type value (i.e, Type = 29) as previously defined by RTCA DO-260 for the Aircraft Trajectory Intent messages that conveyed TCP/TCP+1 information. It is not expected that any implementation based on RTCA DO-260 would have implemented the messages for TCP and TCP+1. However, for purposes of backward compatibility these MOPS require for a Type=29 message that "ME" bit 11 always be set to zero (0) which would result in a RTCA DO-260 conformant ADS-B receiver not attempting to make use of the remaining contents of the message. Likewise any Type = 29 message transmitted by an implementation based on DO-260 that has incorrectly set "ME" bit 11 set to one(1) (i.e., indicating a valid TCP/TCP+1 message is being transmitted) should be discarded.

MSG BIT #	33--37	38---39	40---88
ME BIT #	1----5	6---7	8---56
FIELD NAME	TYPE=29 [5]	SUBTYPE [2]	Intent/Status Information (see 2.2.3.2.7.1.2) [49]
	MSB---LSB	MSB---LSB	MSB---LSB

Figure 2-8 "Aircraft Trajectory Intent and System Status" Message Overall Format

2.2.3.2.7.1.1 "TYPE" Subfield in Aircraft Trajectory Intent and System Status Message

The "TYPE" subfield was previously defined for the Airborne Position Message in subparagraph 2.2.3.2.3.1 and remains the same for the Aircraft Trajectory Intent and System Status Message which uses Type Code 29.

2.2.3.2.7.1.2 "SUBTYPE" Subfield in Aircraft Trajectory Intent and System Status Message

The "SUBTYPE" subfield is a 2 bit ("ME" bit 6 and 7, Message bit 38 and 39) field used to identify the format of the remainder of the Aircraft Trajectory Intent and System Status message in accordance with the encoding defined in Table 2-41.

Table 2-41: "SUBTYPE" Subfield Encoding

Encoding	Meaning
00	Target State and Status Information provided in the subsequent subfields of the message (see 2.2.3.2.7.1.3)
01	Reserved for Trajectory Change information to be conveyed in the subsequent subfields of the message
10	Reserved for Trajectory Change information to be conveyed in the subsequent subfields of the message
11	Reserved for Trajectory Change information to be conveyed in the subsequent subfields of the message

2.2.3.2.7.1.3 Target State and Status Information SUBTYPE=0 Format

TARGET STATE AND STATUS INFORMATION is conveyed by the Aircraft Trajectory Intent and System Status Message (TYPE=29) when SUBTYPE=0.

MSG BIT #	33--37	38---39	40---41	42	43	44---45
ME BIT #	1----5	6---7	8---9	10	11	12---13
FIELD NAME	TYPE=29 [5]	SUBTYPE=0 [2]	VERTICAL DATA AVAILABLE /SOURCE INDICATOR [2]	TARGET ALTITUDE TYPE [1]	BACKWARD COMPATIBILITY FLAG = 0 [1]	TARGET ALTITUDE CAPABILITY [2]
	MSB-- LSB	MSB---LSB	MSB---LSB			MSB---LSB

MSG BIT #	46	47---56	57---58	59---67	68	69
ME BIT #	14	15----24	25---26	27---35	36	37
FIELD NAME	VERTICAL MODE INDICATOR [1]	TARGET ALTITUDE [10]	HORZONTAL DATA AVAILABLE/ SOURCE INDICATOR [2]	TARGET HEADING /TRACK ANGLE [9]	TARGET HEADING /TRACK INDICATOR [1]	HORZ. MODE INDICATOR [1]
		MSB---LSB	MSB--LSB	MSB--LSB	MSB--LSB	

MSG BIT #	70---71	72-75	76-78	79	80---81	82---83	84---85	86---88
ME BIT #	38---39	40-43	44-46	47	48---49	50---51	52---53	54---56
FIELD NAME	not assigned [2]	NAC_P [4]	NAC v [3]	NIC_{baro} [1]	SIL [2]	not assigned [2]	CAPABILTY /MODE CODES [2]	EMERGENCY /PRIORITY [3]
	MSB-- LSB	MSB- -LSB	MSB- -LSB		MSB- LSB		MSB--LSB	MSB--LSB

Figure 2-9 "Target State and Status Information" SUBTYPE=0 Format

2.2.3.2.7.1.3.1 "VERTICAL DATA AVAILABLE/SOURCE INDICATOR" Subfield in Aircraft Trajectory Intent and System Status Message

The "VERTICAL DATA AVAILABLE/SOURCE INDICATOR" subfield is a 2 bit ("ME" bit 8 and 9, Message bit 40 and 41) field used to identify if aircraft vertical state information is available and present as well as the data source for the vertical data when present in the subsequent subfields ("ME" bit 10 through 24, Message bit 42 through 56) of the Aircraft Trajectory Intent and System Status message. The "VERTICAL DATA AVAILABLE/SOURCE INDICATOR" subfield is encoded in accordance with Table 2-41.

Table 2-41: "VERTICAL DATA AVAILABLE/SOURCE INDICATOR" Subfield Encoding

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

2.2.3.2.7.1.3.2 "TARGET ALTITUDE TYPE" Subfield in Aircraft Trajectory Intent and System Status Message

The "TARGET ALTITUDE TYPE" subfield is a 1 bit ("ME" bit 10, Message bit 42) field used to identify the altitude reported in the "TARGET ALTITUDE" subfield is referenced to mean sea level (MSL) or to a flight level (FL) in accordance with the encoding defined in Table 2-42.

Table 2-42: "TRAJECTORY TYPE" Subfield Encoding

Encoding	Meaning
0	Target Altitude referenced to Mean Sea Level (MSL)
1	Target Altitude referenced to Flight Level (FL)

2.2.3.2.7.1.3.3 "BACKWARD COMPATIBILITY FLAG" Subfield in Aircraft Trajectory Intent and System Status Message

The "BACKWARD COMPATIBLITY FLAG" subfield is a 1 bit ("ME" bit 11, Message bit 43) field used to provide backward compatible for version 0 (zero) 1090 MHz. ADS-B systems based on the initial version of these MOPS (i.e., in RTCA DO-260). RTCA DO-260 designated message TYPE = 29 for TCP and TCP+1 messages. RTCA DO-260 required the "TCP/TCP+1 DATA VALID" subfield ("ME" bit 11) to be encoded with a value of zero, indicating the TCP/TCP+1 information in the message is not valid. For the current version of these MOPS where message TYPE = 29 is no longer being used for TCP/TCP+1 messages, backward capability is provided by always setting "ME" bit 11 to a value of zero (0) in order to ensure that any receiving system based on the first version of these MOPS (i.e., based on RTCA DO-260) will ignore the contents of this message. Any TYPE=29 message received with the "Backward Compatibility Flag" set to one (1) indicates an invalid message that should be discarded. The "Backward Compatibility Flag" subfield is encoded in accordance Table 2-43.

Table 2-43: "BACKWARD COMPATIBILITY FLAG" Subfield Encoding

Encoding	Meaning
0	Required Value
1	Invalid Message (discard entire Aircraft Trajectory Intent and System Status Message)

2.2.3.2.7.1.3.4 "TARGET ALTITUDE CAPABILITY" Subfield in Aircraft Trajectory Intent and System Status Message

The "TARGET ALTITUDE CAPABILITY" subfield is a 2 bit ("ME" bit 12 and 13, Message bit 44 and 45) field used to describe the aircraft's capabilities for providing the data reported in the "TARGET ALTITUDE" subfield. The "TARGET ALTITUDE CAPABILITY" subfield is encoded in accordance with Table 2-44.

Table 2-44: "TARGET ALTITUDE CAPABILITY" Subfield Encoding

Encoding	Meaning
00	Capability for reporting holding altitude only
01	Capability for reporting either holding altitude or autopilot control panel selected altitude
10	Capability for reporting either holding altitude, autopilot control panel selected altitude, or any FMS/RNAV level-off altitude
11	Not Assigned

2.2.3.2.7.1.3.5 "VERTICAL MODE INDICATOR" Subfield in Aircraft Trajectory Intent and System Status Message

The "VERTICAL MODE INDICATOR" subfield is a 1 bit ("ME" bit 14, Message bit 46) field used to indicate whether the target altitude is in the process of being acquired (i.e., aircraft is climbing or descending toward the target altitude) or whether the target altitude has been acquired/being held. The "VERTICAL MODE INDICATOR" subfield is encoded according to Table 2-45.

Table 2-45: "TARGET ALTITUDE CAPABILITY" Subfield Encoding

Encoding	Meaning
0	Target altitude in the process of being acquired
1	Target altitude being captured or maintained

2.2.3.2.7.1.3.6 "TARGET ALTITUDE" Subfield in Aircraft Trajectory Intent and System Status Message

The "TARGET ALTITUDE" subfield is a 10 bit ("ME" bit 15 through 24, Message bit 47 through 56) field used to provide aircraft's intended level-off altitude if in a climb or descent, or the aircraft current intended altitude if it is intending to hold its current altitude. The "TARGET ALTITUDE" subfield is encoded in accordance with Table 2-46.

Table 2-46: "TARGET ALTITUDE" Subfield Encoding

Coding (binary)	**Coding** (decimal)	**Meaning**
00 0000 0000	0	Target Altitude = Zero feet
00 0000 0001	1	Target Altitude = 100 feet
00 0000 0010	2	Target Altitude = 200 feet
00 0000 0011	3	Target Altitude = 300 feet
***	***	***
11 1111 1110	1022	Target Altitude = 102,200 feet
11 1111 1111	1023	Target Altitude = 102,300 feet

2.2.3.2.7.1.3.7 "HORIZONTAL DATA AVAILABLE/SOURCE INDICATOR" Subfield in Aircraft Trajectory Intent and System Status Message

The "HORIZONTAL DATA AVAILABLE/SOURCE INDICATOR" subfield is a 2 bit ("ME" bit 25 and 26, Message bit 57 and 58) field used to identify if aircraft horizontal state information is available and present as well as the data source for the horizontal target data when present in the subsequent subfields ("ME" bit 27 through 37, Message bit 59 through 69) of the Aircraft Trajectory Intent and System Status message. The "HORIZONTAL DATA AVAILABLE/SOURCE INDICATOR" subfield is encoded in accordance with Table 2-47.

Table 2-47: "HORIZONTAL DATA AVAILABLE /SOURCE INDICATOR" Subfield Encoding

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

2.2.3.2.7.1.3.8 "TARGET HEADING/TRACK ANGLE" Subfield in Aircraft Trajectory Intent and System Status Message

The "TARGET HEADING/TRACK ANGLE" subfield is a 9 bit ("ME" bit 27 through 35, Message bit 59 through 67) field used to provide aircraft's intended (i.e., target or selected) heading or track. The "TARGET ALTITUDE" subfield is encoded in accordance with Table 2-48.

Table 2-48: "TARGET HEADING/TRACK ANGLE" Subfield Encoding

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

2.2.3.2.7.1.3.9 "TARGET HEADING/TRACK INDICATOR" Subfield in Aircraft Trajectory Intent and System Status Message

The "TARGET HEADING/TRACK INDICATOR" subfield is a 1 bit ("ME" bit 34, Message bit 66) field used to indicate whether an air reference heading angle or a ground referenced track angle is being reported in the "TARGET HEADING/TRACK ANGLE" subfield. The "TARGET HEADING/TRACK INDICATOR" subfield is encoded according to Table 2-49.

Table 2-49: "TARGET HEADING/TRACK INDICATOR" Subfield Encoding

Encoding	Meaning
0	Air reference Heading Angle being reported
1	Ground referenced Track Angle being reported

2.2.3.2.7.1.3.10 "HORIZONTAL MODE INDICATOR" Subfield in Aircraft Trajectory Intent and System Status Message

The "HORIZONTAL MODE INDICATOR" subfield is a 1 bit ("ME" bit 37, Message bit 69) field used to indicate whether the target heading/track is being acquired (i.e., lateral transition toward the target direction is in progress) or whether the target heading/track has be acquired and the currently be maintained. The "HORIZONTAL MODE INDICATOR" subfield is encoded according to Table 2-50.

Table 2-50: "HORIZONTAL MODE INDICATOR" Subfield Encoding

Encoding	Meaning
0	Target heading/track being acquired
1	Target heading/track being captured or maintained

2.2.3.2.7.1.3.11 "NAC_P" Subfield in Aircraft Trajectory Intent and System Status Message

The "NAC_P" subfield is a 4 bit ("ME" bit 40 through 43, Message bit 72 through 75) field used to indicate accuracy category of the navigation information used as the basis for the aircraft reported position. The "NAC_P " subfield is encoded according to Table 2-51.

Table 2-51: "NAC_P" Subfield Encoding

Encoding	Meaning = 95% Horisontal and Vertical Accuracy Bounds (EPU and VEPU)
0000	EPU ≥ 18.52 km (10 NM) - Unknown accuracy
0001	EPU < 18.52 km (10 NM) - RNP-10 accuracy
0010	EPU < 7.408 km (4 NM) - RNP-4 accuracy
0011	EPU < 3.704 km (2 NM) - RNP-2 accuracy
0100	EPU < 1852 m (1NM) - RNP-1 accuracy
0101	EPU < 926 m (0.5 NM) - RNP-0.5 accuracy
0110	EPU < 555.6 m (0.3 NM) - RNP-0.3 accuracy
0111	EPU < 185.2 m (0.1 NM) - RNP-0.1 accuracy
1000	EPU < 92.6 m (0.05 NM) - e.g., GPS (with SA)
1001	EPU < 30 m and VEPU < 45 m - e.g., GPS (SA off)
1010	EPU < 10 m and VEPU < 15 m - e.g., WAAS
1011	EPU < 3 m and VEPU < 4 m - e.g., LAAS
1100-- 1111	Not Assigned

2.2.3.2.7.1.3.12 "NACv" Subfield in Aircraft Trajectory Intent and System Status Message

The "NAC_V" subfield is a 3 bit ("ME" bit 44 through 46, Message bit 76 through 78) field used to indicate accuracy category of the source information used as the basis for the aircraft reported velocity. The "NAC_V " subfield is encoded according to Table 2-52.

Table 2-52: "NAC_V" Subfield Encoding

Encoding	Meaning Horizontal Velocity Error (95%)	Vertical Geometric Velocity Error (95%)
000	Unknown or ≥ 10 m/s	Unknown or ≥ 50 feet (15.24 m) per second
001	< 10 m/s	< 50 feet (15.24 m) per second
010	< 3 m/s	< 15 feet (4.57 m) per second
011	< 1 m/s	< 5 feet (1.52 m) per second
100	<0.3 m/s	<1.5 feet (0.46 m) per second
1001 - 1111	Not Assigned	Not Assigned

2.2.3.2.7.1.3.13 "NIC_{baro}" Subfield in Aircraft Trajectory Intent and System Status Message

The "NIC_{baro}" subfield is a 1 bit ("ME" bit 47, Message bit 79) field used to indicate whether or not the barometric pressure altitude being reported in the Airborne Position Message (2.2.3.2.3) has been cross-checked against another source of pressure altitude. The "NIC_{baro} " subfield is encoded according to Table 2-53.

Table 2-53: "NIC_{baro}" Subfield Encoding

Encoding	Meaning
0	Reported barometric altitude has not been cross-checked against another source of pressure altitude
1	Reported barometric altitude has been cross-checked against another source of pressure altitude and verified as being consistent

Note: The NIC value itself is conveyed within the ADS-B Position message.

2.2.3.2.7.1.3.14 "SIL" Subfield in Aircraft Trajectory Intent and System Status Message

The "SIL" subfield is a 2 bit ("ME" bit 48 through 49, Message bit 80 through 81) field used to define the probability of the integrity containment radius used in the NIC subfield being exceeded, without alerting, including the effects of the airborne equipment condition, which airborne equipment is in use, and which external signals are used by the navigation source. The "SIL " subfield is encoded according to Table 2-54.

Table 2-54: "SIL" Subfield Encoding

Encoding	Meaning Probability of Exceeding the Integrity Containment Radius Reported in the NIC Subfield Without Detection
00	Unknown
01	1×10^{-3} per flight hour or per operation
10	1×10^{-5} per flight hour or per operation
11	1×10^{-7} per flight hour or per operation

2.2.3.2.7.1.3.15 "CAPABILITY/MODE CODES" Subfield in Aircraft Trajectory Intent and System Status Message

The "CAPABILITY/MODE CODES" subfield is a 2 bit ("ME" bit 51 through 53, Message bit 83 through 85) field used to indicate the current operational status of certain systems/functions. The "CAPABILITY/MODE CODES " subfield is encoded according to Table 2-55 as a series of 1-bit length individual data elements that each indicate the status of a specific system or function on the transmitting aircraft

Table 2-55: "CAPABILITY/MODE CODES" Subfield Encoding

Encoding	Meaning
00	TCAS/ACAS not installed or not operational
01	TCAS/ACAS operational – No Resolution Advisory active
10	TCAS/ACAS operational - Resolution Advisory active
00	Reserved

2.2.3.2.7.1.3.16 "EMERGENCY/PRIORITY STATUS" Subfield in Aircraft Trajectory Intent and System Status Message

The "EMERGENCY/PRIORITY STATUS" subfield is a 3 bit ("ME" bit 54 through 56, Message bit 86 through 88) field used to provide additional information regarding aircraft status. The "EMERGENCY/PRIORITY STATUS" subfield is encoded according to Table 2-56.

Table 2-56: "EMERGENCY/PRIORITY STATUS" Subfield Encoding

Encoding	Meaning
000	No emergency
001	General emergency
010	Lifegard/medical
011	Minimum fuel
100	No communications
101	Unlawful interference
110	Reserved
111	Reserved

2.2.3.2.7.1.4 Target Change Information SUBTYPE=1 Format

This section is reserved for future editions of these MOPS to define Target Change Information to be conveyed by the Aircraft Trajectory Intent and System Status Message (TYPE=29) when SUBTYPE=1.

PART 2

The following draft DO-260A material proposes provisions for the version number subfield in the Aircraft Operational Status Message (tentative para. 2.2.3.2.7.3.5). The intent of the proposed changes from the previous reviewed draft text on version numbers is to provide more explicit statements on the backward and forward interoperability of equipment built to different versions of the MOPS.

x.x.x Version Number Subfield in Aircraft Operational Status Message

The "Version Number" subfield is a 3-bit ("ME" bits 41 through 43, Message bits 73 through 75) field used to indicate the Version Number of the formats and protocols in use on the aircraft installation. Encoding of the Version Number subfield shall be as shown in Table 2-xx. Airborne ADS-B systems conformance to the initial version of the 1090 MHz ADS-B MOPS (DO-260) do not broadcast an explicit version number. Therefore, ADS-B Receiving Subsystems conformant with this version of the 1090 MHz MOPS will initially assume a Version Number of ZERO (binary 000), until received Version Number data indicates otherwise.

Future versions of these RTCA MOPS are expected to maintain backward compatibility with DO-260A. Messages originating from 1090 MHz ADS-B aircraft reporting a MOPS VERSION NUMBER value that is indicated in Table 2-xx as "reserved" are to be considered valid. However, all message types and all subfields within messages that are currently "unassigned" or are indicated as being "reserved" by these MOPS shall be ignored and not used for ADS-B report generation.

Table 2-xx: "VERSION NUMBER" Subfield Encoding

Encoding	Meaning
000	Reserved
001	Version Number to be reported for implementations conformant to RTCA DO-260A
010 though 111	Reserved (for implementations conformant to future version of the 1090 MHz ADS-B MOPS).

PART 3

The following draft DO-260A material proposes requirements for event-driven message broadcast rates and provisions for a message scheduling function for event-driven messages. These proposed changes are intended to make the most efficient use of the available 1090ES link capacity for supporting event-driven messages.

2.2.3.3.1.4 ADS-B Event-Driven Message Broadcast Rates

2.2.3.3.1.4.1 ADS-B Aircraft Trajectory Intent and System Status Message Broadcast Rates

a. The Aircraft Trajectory Intent and System Status Message(s) (message TYPE=29, Section 2.2.3.2.7.1) shall be initiated only when the aircraft is airborne and when vertical and/or horizontal trajectory intent information is available and valid as a minimum.

a. The Aircraft Trajectory Intent and System Status Message with a SUBTYPE subfield value of zero (0) shall, for the nominal case, be broadcast at random intervals that are uniformly distributed over the range of 1.2 to 1.3 seconds relative to the previous Aircraft Trajectory Intent Message and System for as long as data is available to satisfy the requirements of subparagraph “a.” above. If any of the parameters within the Aircraft Trajectory Intent and System message change, the broadcast rate shall be increased for a period of 24 seconds (+/- 1 second) such that the broadcasts occur at random intervals that are uniformly distributed over the range of 0.7 to 0.8 seconds.

b. The broadcast rates for Aircraft Trajectory Intent and System Status Messages with a SUBTYPE subfield value of other than zero (0) are not defined by this version of these MOPS.

Note: Future versions of these MOPS may require unique broadcast update intervals for each Aircraft Trajectory Intent and System Status Message SUBTYPE (i.e., unique for each value of the SUBTYPE subfield).

2.2.3.3.1.4.2 ADS-B Aircraft Operational Coordination Message Broadcast Rates

a. The Aircraft Operational Coordination Message(s) (message TYPE=30, section 2.2.3.2.7.2) shall be initiated only when either Paired Address, Runway Threshold Speed, Roll Angle, Go Around, or Engine Out data is available and valid as a minimum.

b. Once initiated, or if the message data content changes, the Aircraft Operational Coordination Message shall be broadcast at random intervals that are uniformly distributed over the range of 1.9 to 2.1 seconds relative to the previous Aircraft Operational Coordination Message for a period of 24 +/- 1 seconds, assuming no additional change in data content occurred during this period. If data does change, the timer is reset, and the content is updated and sent for 24 +/- 1 seconds.

c. After the initial broadcast period defined in (b) above, expires, the Aircraft Operational Coordination Message shall be broadcast at random intervals that are uniformly distributed over the range of 4.8 to 5.2 seconds relative to the previous Aircraft Operational Coordination Message for as long as data is available to satisfy the requirements of (a) above.

2.2.3.3.1.4.3 ADS-B Aircraft Operational Status Message Broadcast Rates

The rate at which the Aircraft Operational Status Messages (message TYPE=31 and SUBTYPE=0, Section 2.2.3.2.7.3) are to be broadcast varies depending on the following conditions:

Condition 1: Aircraft Trajectory Intent and System Status message (2.2.3.2.7.1) is not being broadcast versus being broadcast.

Condition 2: There has been a change within the past 24 seconds in the value of one or more of the following parameters included in the Operational Status Message

a. TCAS/ACAS Operational

b. ACAS/TCAS resolution advisory active

c. NAC_p

d. NAC_v

e. SIL

a. For the two cases where:

   i. the Aircraft Trajectory Intent and System Status message (2.2.3.2.7.1) is not being broadcast and Condition 2 above is not applicable (nominal condition); or

   ii. the Aircraft Trajectory Intent and System Status message is being broadcast regardless of the applicability of Condition 2 above;

   The Aircraft Operational Status message shall be broadcast at random intervals uniformly distributed over the range of 2.4 to 2.6 seconds.

b. For the case where the Aircraft Trajectory Intent and System Status message (2.2.3.2.7.1) is not being broadcast and Condition 2 above is applicable, the Aircraft Operational Status message broadcast rate shall be increased for a period of 24 seconds (+/- 1 second) such that the broadcasts occur at random intervals that are uniformly distributed over the range of 0.65 to 0.75 seconds.

2.2.3.3.1.4.4 "Extended Squitter Aircraft Status" ADS-B Event - Driven Message Broadcast Rate

The rate at which the "Extended Squitter Aircraft Status" (Type 28), "Emergency/Priority Status" ADS-B Event - Driven Message (Subtype =1) shall be broadcast varies depending on whether the "Aircraft Trajectory Intent and System Status Message" (2.2.3.2.7.1) is not being broadcast versus being broadcast.

a. In the case where the "Aircraft Trajectory Intent and System Status Message" with Subtype = zero (0) is not being broadcast the "Emergency/Priority Status" shall be broadcast at random intervals that are uniformly distributed over the range of 0.7 to 0.8 seconds relative to the previous Emergency/Priority Status Message for the duration of the emergency condition established in accordance with Appendix A, Figure A-9, Note 2.

b. In the case where the "Aircraft Trajectory Intent and System Status Message" with Subtype = zero (0) is being broadcast the "Emergency/Priority Status" shall not be broadcast. This is a result of the "Aircraft Trajectory Intent and System Status Message" with Subtype = zero (0) including the essential emergency/priority status information.

2.2.3.3.1.4.5 "TYPE 23 (TEST)" ADS-B Event - Driven Message Broadcast Rate

The "TEST" ADS-B Event - Driven Messages shall be broadcast NOT MORE THAN ONCE each time the Event Driven Test Information is updated to the transponder

2.2.3.3.1.4.6 "TYPE 24 - 27" ADS-B Event - Driven Message Broadcast Rate

In general, TYPE 24 - 27 ADS-B Event - Driven Messages shall be broadcast ONCE each time the Event Driven TYPE 24 - 27 Information is updated to the transponder.

2.2.3.3.1.4.7 ADS-B Message Transmission Scheduling

An ADS-B message scheduling function shall be used to determine the sequence of ADS-B messages to be broadcast and to control the overall transmission rate of event-driven messages.

2.2.3.3.1.4.7.1 Event-Driven Message Scheduling Function

The Event-driven Message Scheduling Function shall ensure that the total Event-Driven message rate does not exceed 2 transmitted messages per second. This is consistent with the required overall maximum allowed transmission rate specified in section 2.2.3.3.1.3.

The Event-Driven Message Scheduling Function shall 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 shall 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 (2.2.3.2.7.9) is active for the broadcast of an Emergency/Priority Condition (message TYPE=28 and SUBTYPE=1), it shall continue to be transmitted at the rate specified in Section 2.2.3.3.1.4.4 for the duration of the emergency/priority condition.

   ii. When an Aircraft Trajectory Intent and System Status Message (2.2.3.2.7.1) is active for the broadcast of trajectory state information (message TYPE=29 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 as per Section 2.2.3.3.1.4.1, the Aircraft Trajectory Intent and System Status message shall be transmitted at the rate specified in section 2.2.3.3.1.4.1.

   iii. This priority level is reserved for the case when an Aircraft Trajectory Intent and System Status Message (2.2.3.2.7.1) is active for the broadcast of trajectory change information (message TYPE=29 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.

   iv. When an Aircraft Operational Status Message (2.2.3.2.7.3) is active (message TYPE=31 and SUBTYPE=0) and there has been a change in one or more of the message parameters within the past 24 seconds that results in a higher update rate reporting requirement, the Aircraft Operational Status Message shall be transmitted at the rate specified in section 2.2.3.3.1.4.3.

   v. When an Aircraft Operational Coordination Message (2.2.3.2.7.2) is active (message TYPE=30 and SUBTYPE=0) and there has been a change in one or more of the message parameters within the past 24 seconds that results in a higher update rate reporting requirement, the Aircraft Operational Status Message shall be transmitted at the rate specified in section 2.2.3.3.1.4.2.

   vi. When an Aircraft Trajectory Intent and System Status Message (2.2.3.2.7.1) is active for the broadcast of trajectory state information (message TYPE=29 and SUBTYPE=0) under nominal conditions (i.e., no change in message parameter values within the past 24 seconds, the Aircraft Trajectory Intent and System Status message shall be transmitted at the rate specified in section 2.2.3.3.1.4.1.

   vii. This priority level is reserved for the case when an Aircraft Trajectory Intent and System Status Message (2.2.3.2.7.1) is active for the broadcast of trajectory change information (message TYPE=29 and SUBTYPE > 0) under nominal conditions.

viii. When an Aircraft Operational Status Message message (2.2.3.2.7.3) is active (message TYPE=31 and SUBTYPE=0) and is being broadcast at a nominal rate, the Aircraft Operational Status Message shall be transmitted at the rate specified in section 2.2.3.3.1.4.3.

ix. When an Aircraft Operational Coordination message (2.2.3.2.7.2) is active (message TYPE=30 and SUBTYPE=0) and is being generated at the nominal rate, the Aircraft Operational Status Message shall be transmitted at the rate specified in section 2.2.3.3.1.4.2.

x. 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 are to be delivered to the transponder on a first-in-first-out basis at equal priority.

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

Note: *It is possible that future versions of these MOPS (i.e., requiring a complementary change to the Mode S transponder MOPS) will allow for Event-Driver messages to be transmitted at a rate of greater than the current limit of two (2) messages per second. Therefore a means should be provided to allow for a future adjustment to the value used for the message rate limit in the Event-Driven Message scheduling function.*

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

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

e. If (b) above results in a queue of messages awaiting delivery to the transponder, then pending message(s), shall be deleted from the message transmission queue if not delivered to the transponder for transmission, or not updated with a newer message of the same message Type and Subtype, within the Message Lifetime value specified in the Table 2-64 below:

Table 2-64: Event-Drive Message Lifetime

Message TYPE	Message SUBTYPE	Message Lifetime (seconds)
23		reserved for future use
24		reserved for future use
25		reserved for future use
26		reserved for future use
27		reserved for future use
28	0	1.5 seconds (+/- 0.2 sec.)
29	0	1.5 seconds (+/- 0.2 sec.)
30	0	5.5 seconds (+/- 0.2 sec.)
31	0	5.5 seconds (+/- 0.2 sec.)

2.2.3.3.2 Transmission Rates for Stand - Alone Transmitters

a. Transmitters for Class A0 and Class B equipment may be implemented independent of a Mode S transponder. Such transmitters shall meet the transmission rate requirements of section 2.2.3.3.1.3 and the message update rate requirements specified in the following subparagraphs.

b. Extended squitter messages shall be transmitted at random intervals that are uniformly distributed over the specified time interval using a time quantization no greater than 15 milliseconds.

Note: *The possible transmission time epochs should not be correlated with UTC to preclude inadvertent synchronization of transmissions from different aircraft.*

2.2.3.3.2.1 Power-On Initialization and Start Up

2.2.3.3.2.1.1 Power-On Initialization

a. At power-up initialization, the ADS-B transmission device shall start operations in a mode in which it transmits **NO** messages.

b. Given that appropriate message data is provided to the ADS-B transmission device, the transmission device shall be capable of transmitting ADS-B messages no later than 2.0 seconds after Power-On.

c. After a power-up initialization exceeding the momentary power interruption capability of the equipment, the total set of BITE tests that check all necessary functions of the ADS-B device shall be completed within 20 seconds. As a minimum, the BITE tests shall include RAM, ROM, I/O, Timing, CPU instruction integrity, and any associated RF hardware tests necessary to ensure proper functioning of the ADS-B device.

2.2.3.3.2.1.2 Start Up

a. The ADS-B transmission device shall initiate broadcast transmissions of the Airborne Position, Surface Position, Aircraft Identification and Type, Velocity, Trajectory Intent, Operational Coordination, Aircraft Status, and/or Event - Driven messages only once it has received appropriate data to structure at least one variable data field of the respective message. As such, each message shall be initiated individually and independently of the other messages.

The single exception is presented by Altitude data in the Airborne Position message which shall be processed as follows:

The ADS-B transmission device shall not initiate broadcast of the Airborne Position message until horizontal position data has been received. That is, that altitude data alone shall not be sufficient to initiate broadcast of the Airborne Position Message.

b. Once ADS-B message transmission has been initiated the transmission rate of each type of ADS-B message shall be as provided in the following paragraphs.

2.2.3.3.2.2 ADS-B Airborne Position Message Broadcast Rate

Once started, ADS-B Airborne Position Messages shall be broadcast by the transmission device when in the Airborne state at random intervals that are uniformly distributed over the range of 0.4 to 0.6 seconds relative to the previous Airborne Position Message, with the exceptions as specified in subparagraph 2.2.3.3.2.9.

2.2.3.3.2.3 ADS-B Surface Position Message Broadcast Rate

a. Once started, ADS-B Surface Position Messages shall be broadcast by the transmission device when in the On-Ground state using either the “High” or “Low” rate which has been selected as follows:

(1). <u>Switching from “High” rate to “Low” Rate</u>:

(a). The broadcast rate shall be changed from “High” to “Low” when the navigation source position data has not changed more than 10 meters in a 30 second sampling interval.

<u>Note:</u> *It is acceptable to compute the 10 meter distance using either rectangular or polar coordinates.*

(b). Upon selecting the “Low” rate, the transmission device shall save the Position data at the time that the “Low” rate was selected.

(2). <u>Switching from “Low” rate to “High” Rate</u>:

The broadcast rate shall be changed from “Low” to “High” when the position of the transmission device has changed by 10 meters or more since the “Low” rate was selected.

<u>Note:</u> *It is acceptable to compute the 10 meter distance using either rectangular or polar coordinates.*

b. If the “High” rate is selected, then the Surface Position Message shall be transmitted at random intervals that are uniformly distributed over the range of 0.4 to 0.6 seconds relative to the previous Surface Position Message.

c. If the “Low” rate is selected, then the Surface Position Messages shall be transmitted at random intervals that are uniformly distributed over the range of 4.8 to 5.2 seconds relative to the previous Surface Position Message.

<u>Note:</u> *Pending further study and analysis of surface broadcast rates and their triggering mechanisms by regulatory authorities, it is widely assumed that the “Low” rate will be raised to a nominal rate approaching once per second.*

d. In the event that the transmission device cannot determine the required transmission rate, then the “High” rate shall be used as the default transmission rate.

e. Exceptions to these transmission rate requirements are defined in subparagraph 2.2.3.3.2.9.

2.2.3.3.2.4 ADS-B Aircraft Identification and Type Message Broadcast Rate

a. Once started, ADS-B Aircraft Identification and Type Messages shall be broadcast by the transmission device at random intervals that are uniformly distributed over the range of 4.8 to 5.2 seconds relative to the previous Identification and Type Message, when the ADS-B transmitting device is reporting the Airborne Position Message, or when reporting the Surface Position Message at the high rate.

b. When the Surface Position Message is being reported at the low surface rate, then the Aircraft Identification and Type Message shall be broadcast at random intervals that are uniformly distributed over the range of 9.8 to 10.2 seconds relative to the previous Identification and Type Message.

c. When neither the Airborne Position Message nor the Surface Position Message is being transmitted, then the Aircraft Identification and Type Message shall be broadcast at the rate specified in subparagraph a.

d. Exceptions to these transmission rate requirements are defined in subparagraph 2.2.3.3.2.9.

2.2.3.3.2.5 ADS-B Velocity Information Message Broadcast Rate

a. Once started, ADS-B Velocity Information Messages shall be broadcast by the transmission device at random intervals that are uniformly distributed over the range of 0.4 to 0.6 seconds relative to the previous Velocity Information Message.

b. Exceptions to these transmission rate requirements are defined in subparagraph 2.2.3.3.2.9.

2.2.3.3.2.6 ADS-B Trajectory Intent, Operational Coordination, and Status Message Broadcast Rates

2.2.3.3.2.6.1 ADS-B Aircraft Trajectory Intent and System Status Message Broadcast Rates

a. The requirements of Section 2.2.3.3.1.4.1 are applicable.

c. The Aircraft Trajectory Intent and System Message shall, for the nominal case, be broadcast at random intervals that are uniformly distributed over the range of 1.4 to 1.6 seconds relative to the previous Aircraft Trajectory Intent Message and System for as long as data is available to satisfy the requirements of subparagraph “a.” above. If any of the parameters within the Aircraft Trajectory Intent and System message changes, the broadcast rate shall be increased for a period of 24 seconds (+/- 1 second) at random intervals that are uniformly distributed over the range of 0.7 to 0.8 seconds.

b. Exceptions to these transmission rate requirements are defined in subparagraph 2.2.3.3.2.9.

2.2.3.3.2.6.2 ADS-B Aircraft Operational Coordination Message Broadcast Rates

a. The provisions of Section 2.2.3.3.1.4.2 are applicable.

b. Exceptions to these transmission rate requirements are defined in subparagraph 2.2.3.3.2.9.

2.2.3.3.2.6.3 ADS-B Aircraft Operational Status Message Broadcast Rates

a. The requirements of Section 2.2.3.3.1.4.3 are applicable.

b. Exceptions to these transmission rate requirements are defined in subparagraph 2.2.3.3.2.9.

2.2.3.3.2.6.4 "Extended Squitter Aircraft Status" ADS-B Event - Driven Message Broadcast Rate

The requirements of Section 2.2.3.3.1.4.4 are applicable. The exceptional conditions specified in 2.2.3.3.2.9 shall be observed.

2.2.3.3.2.7 "TYPE 23 (TEST)" ADS-B Event - Driven Message Broadcast Rate

The "TEST" ADS-B Event - Driven Messages shall be broadcast ***NOT MORE Than*** ONCE each time the Event Driven Test Information is updated to the ADS-B transmission device. The delay conditions specified in 2.2.3.3.2.9 shall be observed.

2.2.3.3.2.8 "TYPE 24 - 27" ADS-B Event - Driven Message Broadcast Rate

In general, TYPE 24 - 27 ADS-B Event - Driven Messages shall be broadcast ONCE each time the Event Driven TYPE 24 - 27 Information is updated to the ADS-B transmission device. The delay conditions specified in 2.2.3.3.2.9 shall be observed.

2.2.3.3.2.9 ADS-B Message Transmission Scheduling

An ADS-B message scheduling function shall be used to determine the sequence of ADS-B messages to be broadcast and to control the overall transmission rate of event-driven messages.

The Mode S transponder is defined by DO-181C provides priority to the transmission of position, velocity and flight ID squitters.

As an exception to the general requirement for the transmission of ADS-B messages, the scheduled message transmission shall be delayed if a Mutual Suppression interface is active.

An Event-Driven Message Scheduling function shall:

a. Ensure that the total Event-Driven message rate does not exceed 2 transmitted messages per second. This is consistent with the required overall maximum allowed transmission rate specified in section 2.2.3.3.2.10.

   <u>Note:</u> *It is possible that future versions of these MOPS (i.e., requiring a complementary change to the Mode S transponder MOPS) will allow for Event-Driver messages to be transmitted at a rate of greater than the current limit of two (2) messages per second. Therefore a means should be provided to allow for a future adjustment to the value used for the message rate limit in the Event-Driven Message scheduling function.*

b. Apply the rules specified in Section 2.2.3.3.1.4.7.1 as the means of prioritizing the Event-Driven message transmissions and controlling the transmission rates.

2.2.3.3.2.10 Maximum ADS-B Message Transmission Rates

The maximum ADS-B message transmission rate of non-transponder ADS-B transmitter implementations shall not exceed 6.2 transmitted messages per second.