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Proposed §3.5 – Messages and Reports (from the) Proposed Table of Contents for the Combined DO-242A+ and DO-289+ ➔ DO-3xx Super MASPS

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SUMMARY
This Working Paper is a draft for section 3.5 of the new combined ASA/ADS-B MASPS to describe the ADS-B/TIS-B/ADS-R Messages and Reports that will feed into the ASSAP Application.

3.5 Messages and Reports

The ADS-B/TIS-B and ADS-R Receive Subsystem receives ADS-B, TIS-B and ADS-R Messages, processes them, and converts them into ADS-B/TIS-B/ADS-R reports for ASSAP.

3.5.1 ADS-B Messages and Reports

This section provides requirements and definition of ADS-B reports and the relationship between these reports and the received messages. The ADS-B output report definitions establish the standard contents and conditions for outputting data qualified for user applications. Exchange of broadcast messages and report assembly considerations are discussed in §3.5.1.2. Report data elements are specified in §3.5.1.3 to §3.5.1.8 and standardized according to content, nomenclature, parameter type, applicable coordinate system, logical content, and operational conditions. Reports required for each Equipment Class and supporting message contents are defined in §3.2.1.4.2. Report contents and message requirements are based on the information requirements summarized in Table 2-6. These definitions provide the basis for:

- Independence between applications and broadcast link technologies
- Interoperability of applications utilizing different ADS-B technologies.

Specific digital formats are not defined since interface requirements will determine those details. Such interfaces may be internal processor buses or inter-system buses such as those described in ARINC, IEEE, and military standards. Additional information requirements may develop in the future and result in expansion to the report definitions specified in this document. ADS-B system designs should be sufficiently flexible to accommodate such future expansion.

3.5.1.1 Report Assembly Design Considerations

Four report types are defined as ADS-B outputs to applications. They provide flexibility in meeting delivery and performance requirements for the information needed to support the operations identified in Section 2. Report types are:

- Surveillance State Vector Report (SV, §3.5.1.3);
- Mode-Status Report (MS, §3.5.1.4);
- Various On-Condition Reports (OC, §3.5.1.5) – a category that includes the following report types:
  - Air Referenced Velocity Report (ARV, §3.5.1.6),
  - Target State Report (TS, §3.5.1.7), and
  - Other On-Condition Reports, which may possibly be defined in future versions of this MASPS.

All interactive participants must receive messages and assemble reports specified for the respective equipage class (Table 3.2.1.4.2a). All transmitting participants must output at least the minimum data for the SV and MS reports. The minimum requirements for exchanged information and report contents applicable for equipage classes are provided in §3.2.1.4.2.

3.5.1.2 ADS-B Message Exchange Technology Considerations in Report Assembly

ADS-B participants can vary both in the information exchanged and in the applications supported. ADS-B reports are assembled from received ADS-B messages. Message formats are defined in MOPS or equivalent specifications for each link technology chosen for ADS-B implementation. Reports are independent of the particular message format and network protocol. In some ADS-B broadcast exchange technologies the information may be conveyed as a single message, while others may utilize multiple messages which require assembly in the receiving subsystem to generate the ADS-B report. The report assembly function must be performed by the ADS-B subsystem prior to disseminating the report to the application.

Broadcast technologies vary in broadcast rate and probability of message reception. The receiving subsystem, therefore, must process messages compatibly with the message delivery performance to satisfy required performance as observed in the ADS-B report outputs. Also, data compression techniques may be used to reduce the number of transmitted bits in message exchange designs.

The messages **shall** (242AR3.40) be correlated, collated, uncompressed, re-partitioned, or otherwise manipulated as necessary to form the output reports specifically defined in §3.5.1.3 to §3.5.1.8 below. The message and report assembly processing capability of the receiving subsystem **shall** (242AR3.41) support the total population of the participants within detection range provided by the specific data link technology.

Receiving subsystem designs must provide reports based on all decodable messages received, i.e., for each participant the report **shall** (242AR3.42) be updated and made available to ADS-B applications any time a new message containing all, or a portion of, its component information is received from that participant with the exception that no type of report is required to be issued at a rate of greater than once per second. The Report Assembler function converts the received messages into the reports appropriate to the information conveyed from the transmitting participant. The applicable reports **shall** (242AR3.43) be made available to the applications on a continual basis in accordance with the local system interface requirements.

Each ADS-B report contains an address, for the purpose of enabling the receiver to associate the receptions into a single track. If the ADS-B design uses the ICAO 24-bit address, then there **shall** (242AR3.44) be agreement between the address currently being used by the Mode S transponder and the reported ADS-B address, for aircraft with both transponder and ADS-B.

3.5.1.3 ADS-B State Vector Report

Table 3-6 lists the report elements that comprise the State Vector (SV) report. The SV report contains information about an aircraft or vehicle's current kinematic state. Measures of the State Vector quality are contained in the NIC element of the SV report and in the NAC_P, NAC_V, NIC_{BARO} and SIL elements of the Mode Status Report (§3.5.1.4 below).

Table 3-6: State Vector Report Definition

	SV Elem. #	Contents	[Resolution or # of bits]	Required from surface participants	Required from airborne participants	Reference Section	Notes
ID	1	Participant Address	[24 bits]	•	•	3.3.2.2.1	
	2	Address Qualifier	[1 bit]	•	•	3.3.2.2.2	1
TOA	3	Time Of Applicability	[0.2 s]	•	•	3.5.1.3.3	
Geometric Position	4a	Latitude (WGS-84)		•	•	3.5.1.3.4	2, 3
	4b	Longitude (WGS-84)		•	•		
	4c	Horizontal Position Valid	[1 bit]	•	•	3.5.1.3.5	
	5a	Geometric Altitude		•		3.5.1.3.6	3, 4
	5b	Geometric Altitude Valid	[1 bit]	•		3.5.1.3.7	
Horizontal Velocity	6a	North Velocity while airborne		•		3.5.1.3.8	3
	6b	East Velocity while airborne		•			3
	6c	Airborne Horizontal Velocity Valid	[1 bit]	•		3.5.1.3.9	
	7a	Ground Speed while on the surface	[1 knot]		•	3.5.1.3.10	
	7b	Surface Ground Speed Valid	[1 bit]		•	3.5.1.3.11	
Heading	8a	Heading while on the Surface	[6° or better (6 bits)]		•	3.5.1.3.12	
	8b	Heading Valid	[1 bit]		•	3.5.1.3.13	
Baro Altitude	9a	Pressure Altitude		•		3.5.1.3.14	3, 4
	9b	Pressure Altitude Valid	[1 bit]	•		3.5.1.3.15	
Vertical Rate	10a	Vertical Rate (Baro/Geo)		•		3.5.1.3.16	3
	10b	Vertical Rate Valid	[1 bit]	•		3.5.1.3.17	
NIC	11	Navigation Integrity Category	[4 bits]	•	•	3.5.1.3.18	
Report Mode	12	SV Report Mode	[2 bits]			3.5.1.3.19	

Notes for Table 3-6:

1. *The minimum number of bits required by this MASPS for the Address Qualifier field is just one bit. However, when ADS-B is implemented on a particular data link, more than one bit may be required for the address qualifier if that data link supports other services in addition to the ADS-B service. The number of bits allocated for the Address Qualifier field may be different on different ADS-B data links.*
2. *A horizontal position resolution finer than 20 m will be required if the NAC_P element of the MS report (§3.5.1.4) is 9 or greater (§3.3.11).*
3. *Resolution requirements of these elements must be sufficient to meet the error requirements specified in Table 3.2.1.4.3.1.1a.*
4. *Future revisions of this MASPS may not require that both geometric and pressure altitudes – if available – to be broadcast at the SV rate. Conditions will need to be specified as to when each altitude must be the "primary" altitude being sent at the SV rate.*

3.5.1.3.1 Air/Ground State

A transmitting ADS-B participant's air/ground state is an internal state in the transmitting ADS-B subsystem that affects which SV report elements are to be broadcast, but which is not required to be broadcast in ADS-B messages from that participant.

Notes:

1. *It is possible that a future edition of this MASPS would require a participant's air/ground state to be broadcast. This would occur if an operational concept for a user application that needs air/ground state were to be included in a future version of this MASPS.*

2. *A transmitting ADS-B participant's air/ground state also affects whether the aircraft size (length and width) codes in the MS report are to be broadcast. (See §3.5.1.4.6 below.)*

A transmitting participant's air/ground state has the following possible values:

- "Known to be airborne,"
- "Known to be on the surface," and
- "Uncertain whether airborne or on the surface."

3.5.1.3.1.1 Determination of Air/Ground State

A transmitting ADS-B participant applies the following tests to determine its air/ground state:

1. If a transmitting ADS-B participant is not equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and that participant's emitter category is one of the following, then it **shall** (242AR3.45) set its air/ground state to "known to be airborne:"

   a. Light Aircraft

   b. Glider or Sailplane

   c. Lighter Than Air

   d. Unmanned Aerial Vehicle

   e. Ultralight, Hang Glider, or Paraglider

   f. Parachutist or Skydiver

   g. Point Obstacle

   h. Cluster Obstacle

   i. Line Obstacle

   Note 1: *Because it is important for fixed ground or tethered obstacles to report altitude, Point Obstacles, Cluster Obstacles, and Line obstacles always report the "Airborne" state.*

2. If a transmitting ADS-B participant is not equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and that participant's emitter category is one of the following, then that participant **shall** (242AR3.46) set its air/ground state to "known to be on the surface:"

   a. Surface Vehicle – Emergency

   b. Surface Vehicle – Service

3. If a transmitting ADS-B participant is not equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and that participant's emitter category is "rotorcraft," then that participant **shall** (242AR3.47) set its air/ground state to "uncertain whether airborne or on the surface."

   Note 2: *Because of the unique operating capability of rotorcraft (i.e., hover, etc.) an operational rotorcraft always reports the "uncertain" air/ground state, unless the "surface" state is specifically declared. This causes the rotorcraft to transmit those SV elements that are required from airborne ADS-B participants.*

4. If a transmitting ADS-B participant is not equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and its ADS-B emitter category is not one of those listed under tests 1, 2, and 3 above, then that participant's ground speed (GS), airspeed (AS) and radio height (RH) **shall** (242AR3.48-A) be examined, provided that some or all of those three parameters are available to the transmitting ADS-B subsystem. If GS < 100 knots, or AS < 100 knots, or RH < 50 feet, then the transmitting ADS-B participant **shall** (242AR3.48-B) set its Air/Ground state to "known to be on the surface."

5. If a transmitting ADS-B participant is equipped with a means, such as a weight-on-wheels switch, to determine automatically whether it is airborne or on the surface, and that automatic means indicates that the participant is airborne, then that participant **shall** (242AR3.49) set its air/ground state to "known to be airborne."

6. If a transmitting ADS-B participant is equipped with a means, such as a weight-on-wheels switch, to determine automatically whether it is airborne or on the surface, and that automatic means indicates that the participant is on the surface, then the following additional tests **shall** (242AR3.50) be performed to validate the "on-the-surface" condition:

   a. If the participant's ADS-B emitter category is any of the following:

      - "Small Aircraft" or
      - "Medium Aircraft" or
      - "High-Wake-Vortex Large Aircraft" or
      - "Heavy Aircraft" or
      - "Highly Maneuverable Aircraft" or
      - "Space or Trans-atmospheric Vehicle"

      AND one or more of the following parameters is available to the transmitting ADS-B system:

      - Ground Speed (GS) or
      - Airspeed (AS) or
      - Radio height from radio altimeter (RH)

      AND any of the following conditions is true:

      - GS > 100 knots or
      - AS > 100 knots or
      - RH > 100 50 ft,

      THEN, the participant **shall** (242AR3.51-A) set its Air/Ground state to "known to be airborne."

   b. Otherwise, the participant **shall** (242AR3.51-B) set its Air/Ground state to "known to be on the surface."

3.5.1.3.1.2 Effect of Air/Ground State

The set of SV elements to be broadcast by ADS-B participants is determined by those participants' air/ground state as follows:

a. ADS-B participants that are known to be on the surface **shall** (242AR3.52) transmit those State Vector report elements that are indicated with bullets ("•") in the "required from surface participants" column of Table 3-6.

b. ADS-B participants that are known to be airborne **shall** (242AR3.53) transmit those SV report elements that are indicated by bullets ("•") in the "required from airborne participants" column of Table 3-6.

c. ADS-B participants for which the air/ground state is uncertain **shall** (242AR3.54) transmit those SV report elements that are indicated by bullets in the "required from airborne participants" column. It is recommended that such participants should also transmit those SV elements that are indicated with bullets in the "required from surface participants" column.

3.5.1.3.2 SV Report Update Requirements

Required SV report update rates, described by operating range, are given in Table 3.2.1.4.3.1.1a in §3.2.1.4.3.1.1 above.

a. A receiving ADS-B subsystem **shall** (242AR3.55) update the SV report that it provides to user applications about a transmitting ADS-B participant whenever it receives messages from that participant providing updated information about any of the SV report elements with the exception that SV reports are not required to be issued at a rate of greater than once per second.

b. For ADS-B systems that use segmented messages for SV data, time-critical SV report elements that are not updated in the current received message **shall** (242AR3.56) be estimated whenever the SV report is updated. The time-critical SV elements are defined as the following:

   i. Geometric position (latitude, longitude, geometric height, and their validity flags – elements 4a, 4b, 4c, 5a, 5b);

   ii. Horizontal velocity and horizontal velocity validity (elements 6a, 6b, 6c, 7a, 7b);

   iii. Heading while on the surface (elements 8a, 8b);

   iv. Pressure altitude (elements 9a, 9b);

   v. Vertical rate (elements 10a, 10b); and

   vi. NIC (element 11).

   Note 1: *Estimation of NIC is done by simply retaining the last reported value.*

c. For time-critical elements of the SV report, a receiving ADS-B subsystem's report assembly function **shall** (242AR3.57) indicate "no data available" if no data are received in the preceding coast interval specified in Table 3.2.1.4.3.1.1a (§3.2.1.4.3.1.1 above).

   Note 2: *A receiving ADS-B subsystem may mark data elements as "no data available" by setting the associated validity bit(s) to ZERO. For NIC this is done by setting the value of NIC to ZERO.*

3.5.1.3.3 Time of Applicability (TOA) Field for SV Report

The Time of Applicability (TOA) field in the SV report describes the time at which the elements of that report are valid.

Note: *As mentioned in the definition of latency in §3.2.1.4.3.1.2 above, the times of applicability of position and velocity may differ. The TOA field in the SV report contains the time of applicability of position.*

The time of applicability (TOA) relative to local system time **shall** (242AR3.58) be updated with each State Vector report update.

Requirements on the accuracy of the TOA field in the SV report are given in §3.2.1.4.3.2.2 above, and may be paraphrased as follows:

a. The standard deviation of the SV report time error is to be less than 0.5 s.

b. The mean report time error for the position elements of the SV report is not to exceed 0.5 s.

c. The mean report time error for the velocity elements of the SV report is not to exceed 1.5 s.

Note: *The recommended TOA resolution of 0.2 s specified in Table 3-6 will meet the specifications in items a, b, and c above.*

3.5.1.3.4 Horizontal Position

Horizontal position (§3.3.4) **shall** (242AR3.59) be reported as WGS-84 latitude and longitude. Horizontal position **shall** (242AR3.60) be reported with the full range of possible latitudes (-90° to +90°) and longitudes (-180° to +180°).

Horizontal position **shall** (242AR3.61) be communicated and reported with a resolution sufficiently fine that it does not compromise the accuracy reported in the NAC_P field of the Mode-Status report (§3.3.11 and §3.5.1.4). Moreover, horizontal position **shall** (242AR3.62) be communicated and reported with a resolution sufficiently fine that it does not compromise the one-sigma maximum ADS-B contribution to horizontal position error, σ_{hp}, listed in Table 3.2.1.4.3.1.1a 20 m for airborne participants, or σ_{hp} = 2.5 m for surface participants.

3.5.1.3.5 Horizontal Position Valid Field

The Horizontal Position Valid field in the SV report **shall** (242AR3.63-A) be set to ONE if a valid horizontal position is being provided in geometric position (latitude and longitude) fields of that report; otherwise, the Horizontal Position Valid field **shall** (242AR3.63-B) be ZERO.

3.5.1.3.6 Geometric Altitude Field

Geometric altitude **shall** (242AR3.64) be reported with a range from -1,000 feet up to +100,000 feet. If the NAC_P code reported in the MS report (§3.5.1.4) is 9 or greater (§3.3.11), geometric altitude **shall** (242AR3.65) be communicated and reported with a resolution sufficiently fine that it does not compromise the vertical accuracy reported in the NAC_P field. Moreover, geometric altitude **shall** (242AR3.66) be communicated and reported with a resolution sufficiently fine that it does not compromise the one-sigma maximum ADS-B contribution to vertical position error, σ_{vp}, listed in Table 3.2.1.4.3.1.1a σ_{vp} = 30 feet for airborne participants.

Note: *A resolution of 100 feet or finer is sufficient not to compromise the one-sigma (one standard deviation) ADS-B contribution to vertical position error listed in Table 3.2.1.4.3.1.1a. This is because the error introduced by rounding altitude to the nearest multiple of 100 feet has a uniform probability distribution, for which the standard deviation is 100 feet divided by the square root of 12, that is, about 28.9 feet.*

3.5.1.3.7 Geometric Altitude Valid Field

The Geometric Altitude Valid field in the SV report is a one-bit field which **shall** (242AR3.67) be ONE if valid data is being provided in the Geometric Altitude field (§3.5.1.3.6), or ZERO otherwise.

3.5.1.3.8 Geometric Horizontal Velocity

Geometric horizontal velocity is the horizontal component of the velocity of an A/V with respect to the earth (or with respect to an earth-fixed reference system, such as the WGS-84 ellipsoid). The range of reported horizontal velocity **shall** (242AR3.68) accommodate speeds of up to 250 knots for surface participants and up to 4000 knots for airborne participants. Horizontal velocity **shall** (242AR3.69) be communicated and reported with a resolution sufficiently fine that it does not compromise the accuracy reported in the NAC_V field of the Mode-Status report. Moreover, horizontal velocity **shall** (242AR3.70) be communicated and reported with a resolution sufficiently fine that it does not compromise the one-sigma maximum ADS-B contribution to horizontal velocity error, σ_{hv}, listed in Table 3.2.1.4.3.1.1a that is, 0.5 m/s (about 1 knot) for airborne participants with speeds of 600 knots or less, or 0.25 m/s (about 0.5 knot) for surface participants.

Note: *The rounding of velocity to the nearest encoded representation may be modeled with a uniform probability distribution. As such, the standard deviation (one-sigma velocity error, σ_{hv}) due to rounding to the nearest possible encoded representation is the weight of the LSB divided by the square root of 12. Thus, σ_{hv} = 0.5 m/s (about 1 knot) for airborne participants implies a resolution of $res_{hv} = \sigma_{hv} \cdot \sqrt{12}$ = 1.73 m/s (about 3.4 knots), so even a horizontal velocity resolution of 2 knots is sufficiently fine to meet the constraint imposed by Table 3.2.1.4.3.1.1a on airborne participants with speeds up to 600 knots. Likewise, a horizontal velocity resolution of 1 knot is sufficiently fine to satisfy the constraint imposed by Table 3.2.1.4.3.1.1a for surface participants.*

3.5.1.3.9 Airborne Horizontal Velocity Valid Field

The Airborne Horizontal Velocity Valid field in the SV report is a one-bit field which **shall** (242AR3.71-A) be set to ONE if a valid horizontal geometric velocity is being provided in the "North Velocity while airborne" and "East velocity while airborne" fields of the SV report; otherwise, the "Airborne Horizontal Velocity Valid" field **shall** (242AR3.71-B) be ZERO.

3.5.1.3.10 Ground Speed While on the Surface Field

The ground speed (the magnitude of the geometric horizontal velocity) of an A/V that is known to be on the surface **shall** (242AR3.72) be reported in the "ground speed while on the surface" field of the SV report. For A/Vs moving at ground speeds less than 70 knots, the ground speed **shall** (242AR3.73) be communicated and reported with a resolution of 1 knot or finer. Moreover, the resolution with which the "ground speed

while on the surface" field is communicated and reported **shall** (242AR3.74) be sufficiently fine so as not to compromise the accuracy of that speed as communicated in the NAC_V field of the MS report (§3.5.1.4).

3.5.1.3.11 Surface Ground Speed Valid Field

The Surface Ground Speed Valid field in the SV report is a one-bit field which **shall** (242AR3.75) be ONE if valid data is available in the Ground Speed While on the Surface field (§3.5.1.3.10), or ZERO otherwise.

3.5.1.3.12 Heading While on the Surface Field

Heading (§3.3.7) indicates the orientation of an A/V, that is, the direction in which the nose of an aircraft is pointing. ADS-B Participants are not required to broadcast heading if their length code (part of the aircraft size code, Table 3.3.4.1a above) is Zero (0). However, each ADS B participant that reports a length code of 2 or greater **shall** (242AR3.76) transmit messages to support the heading element of the SV report when that participant is on the surface and has a source of heading available to its ADS-B transmitting subsystem.

Heading **shall** (242AR3.77-A) be reported for the full range of possible headings (the full circle, from 0° to nearly 360°). The heading of surface participants **shall** (242AR3.77-B) be communicated and reported with a resolution of 6 degrees of arc or finer.

Notes:

1. *If heading is encoded as a binary fraction of a circle, a resolution of 6° of arc or finer would require at least 6 binary bits.*
2. *The reference direction for heading (true north or magnetic north) is communicated in the True/Magnetic Heading Flag of the Mode-Status report (§3.5.1.4.16).*
3. *For operations at some airports, heading may be required to enable proper orientation and depiction of an A/V by applications supporting those surface operations.*

3.5.1.3.13 Heading Valid Field

The "heading valid" field in the SV report **shall** (242AR3.78-A) be ONE if a valid heading is provided in the "heading while on the surface" field of the SV report; otherwise, it **shall** (242AR3.78-B) be ZERO.

3.5.1.3.14 Pressure Altitude Field

Barometric pressure altitude **shall** (242AR3.79) be reported referenced to standard temperature and pressure (1013.25 hPa or mB, or 29.92 in Hg). Barometric pressure altitude **shall** (242AR3.80) be reported over the range of -1,000 feet to +100,000 feet.

If a pressure altitude source with 25-foot or better resolution is available to the ADS-B transmitting subsystem, then pressure altitude from that source **shall** (242AR3.81-A) be communicated and reported with 25-foot or finer resolution. Otherwise, if a pressure altitude source with 100-foot or better resolution is available, pressure altitude from that source **shall** (242AR3.81-B) be communicated and reported with 100-foot or finer resolution.

3.5.1.3.15 Pressure Altitude Valid Field

The "pressure altitude valid" field in the SV report is a one-bit field which **shall** (242AR3.82-A) be ONE if valid information is provided in the "pressure altitude" field; otherwise, the "pressure altitude valid" field **shall** (242AR3.82-B) be ZERO.

3.5.1.3.16 Vertical Rate Field

The "vertical rate" field in the SV report contains the altitude rate of an airborne ADS-B participant. This **shall** (242AR3.83) be either the rate of change of pressure altitude or of geometric altitude, as specified by the "vertical rate type" element in the MS report. The range of reported vertical rate **shall** (242AR3.84) accommodate up to ±32000 ft/min for airborne participants. Geometric vertical rate **shall** (242AR3.85) be communicated and reported with a resolution sufficiently fine that it does not compromise the accuracy reported in the NAC_V field of the Mode-Status report. Moreover, vertical rate **shall** (242AR3.86) be communicated and reported with a resolution sufficiently fine that it does not compromise the one-sigma maximum ADS-B contribution to vertical rate error, σ_{vv}, listed in Table 3.2.1.4.3.1.1a, that is, 1.0 ft/s for airborne participants.

3.5.1.3.17 Vertical Rate Valid Field

The "vertical rate valid" field in the SV report is a one-bit field which **shall** (242AR3.87-A) be ONE if valid information is provided in the "vertical rate" field; otherwise, the "vertical rate valid" field **shall** (242AR3.87-B) be ZERO.

3.5.1.3.18 Navigation Integrity Category (NIC) Field

The NIC field in the SV report is a 4-bit field that **shall** (242AR3.88) report the Navigation Integrity Category described in Table 3.3.10a in §3.3.10 above.

3.5.1.3.19 Report Mode Field

The "Report Mode" provides a positive indication when SV and MS acquisition is complete and all applicable data sets and modal capabilities have been determined for the participant or that a default condition is determined by the Report Assembly function. The information for this SV element is not transmitted over the ADS-B data link, but is provided by the report assembly function at the receiving ADS-B participant. Table 3.5.1.3.19 lists the possible values for the SV Report Mode.

Table 3.5.1.3.19: SV Report Mode Values.

Value	Meaning
0	Acquisition
1	Track
2	Default

3.5.1.4 Mode Status Report

The mode-status (MS) report contains current operational information about the transmitting participant. This information includes participant type, mode specific parameters, status data needed for certain pair-wise operations, and assessments of the integrity and accuracy of position and velocity elements of the SV report. Specific requirements for a participant to supply data for and/or generate this report subgroup will vary according to the equipage class of each participant. §3.2.1.4.2 defines the required capabilities for each Equipage Class defined in §3.2.1.3.3. Equipage classes define the level of MS information to be exchanged from the source participant to support correct classification onboard the user system.

The Mode-Status report for each acquired participant contains the unique participant address for correlation purposes, static and operational mode information and Time of Applicability. Contents of the Mode-Status report are summarized in Table 3.5.1.4.

The static and operational mode data includes the following information:

- Capability Class (CC) Codes – used to indicate the capabilities of a transmitting ADS-B participant.
- Operational Mode (OM) Codes – used to indicate the current operating mode of a transmitting ADS-B participant.

For each participant the Mode-status report **shall** (242AR3.89) be updated and made available to ADS-B applications any time a new message containing all, or a portion of, its component information is accepted from that participant.

Table 3.5.1.4: Mode-Status (MS) Report Definition.

	MS Elem. #	Contents [Resolution or # of bits]	Elements That Require Rapid Update	Reference Section	Notes
ID	1	Participant Address [24 bits]		3.3.2.2.1	
	2	Address Qualifier [1 bit]		3.3.2.2.2	1
TOA	3	Time of Applicability [1 s resolution]		3.5.1.4.2	
Version	4	ADS-B Version Number [3 bits]		3.5.1.4.3	
ID, Continued	5a	Call Sign [up to 8 alpha-numeric characters]		3.5.1.4.4	
	5b	Emitter Category [5 bits]		3.5.1.4.5	
	5c	A/V Length and Width Codes [4 bits]		3.5.1.4.6	2
Status	6a	Mode-Status Data Available [1 bit]		3.5.1.4.7	
	6b	Emergency/Priority Status [3 bits]		3.5.1.4.8	3
CC, Capability Codes	7	Capability Class Codes [16 bits]		3.5.1.4.9	
		7a: TCAS/ACAS operational [1 bit]	•	3.5.1.4.9.1	4
		7b: 1090 MHz ES Receive Capability [1 bit]		3.5.1.4.9.2	
		7c: (Reserved for Service Level) [4 bits]		3.5.1.4.9.3	
		7d: ARV report Capability Flag [1 bit]		3.5.1.4.9.4	
		7e: TS report Capability Flag [1 bit]		3.5.1.4.9.5	
		7f: TC report Capability Level [2 bits]		3.5.1.4.9.6	
		7g: UAT Receive Capability [1 bit]		3.5.1.4.9.7	
		(CC Codes reserved for future growth) [3 bits]		3.5.1.4.9.8	
OM, Operational Mode	8	Operational Mode Parameters [16 bits]		3.5.1.4.10	
		8a: TCAS/ACAS resolution advisory active [1 bit]	•	3.5.1.4.10.1	4
		8b: IDENT Switch Active [1 bit]		3.5.1.4.10.2	3
		8c: Reserved for Receiving ATC services [1 bit]		3.5.1.4.10.3	
		8d: Single Antenna Flag [1 bit]		3.5.1.4.10.4	
		8e: System Design Assurance [2 bits]		3.5.1.4.10.5	
		8f: GPS Antenna Offset [8 bits]		3.5.1.4.10.6	
		(Reserved for future growth) [2 bits]		3.5.1.4.10.7	
SV Quality	9a	Nav. Acc. Category for Position (NAC_P) [4 bits]	•	3.5.1.4.11	4
	9b	Nav. Acc. Category for Velocity (NAC_V) [3 bits]	•	3.5.1.4.12	4
	9c	Source Integrity Level (SIL) [2 bits]	•	3.5.1.4.13	4
	9d	NIC_{BARO} - Altitude Cross Checking Flag [1 bit]		3.5.1.4.14	
	9e	(Reserved for future growth) [2 bits]		3.5.1.4.15	
Data Reference	10a	True/Magnetic Heading [1 bit]		3.5.1.4.16	
	10b	Vertical Rate Type (Baro./Geo.) [1 bit]		3.5.1.4.17	
Other	11	Reserved for Flight Mode Specific Data [3 bits]		3.5.1.4.18	

Notes for Table 3.5.1.4:

1. *The minimum number of bits required by this MASPS for the Address Qualifier field is just one bit. However, when ADS-B is implemented on a particular data link, more than one bit may be required for the address qualifier if that data link supports other services in addition to the ADS-B service. For example, address qualifier bits might be needed to distinguish reports about TIS-B targets from reports about ADS-B targets. The number of bits allocated for the Address Qualifier field may be different on different ADS-B data links.*

2. *The aircraft size code only has to be transmitted by aircraft above a certain size, and only while those aircraft are on the ground. (See §3.5.1.4.6 for details.)*

3. *These elements are primarily for air-to-ground use. Update rate requirements for ground applications are not defined in this MASPS. If higher rates are later deemed to be required, they will be addressed in a future revision of this MASPS.*

4. *Changes to the values of these elements may trigger the transmission of messages conveying the changed values at higher than nominal update rates. (Only those elements whose values have changed need be updated, not the entire MS report.) These update rates, the duration for which those rates must be maintained, and the operational scenario to be used to evaluate these requirements are to be defined in a future revision of this MASPS.*

3.5.1.4.1 MS Report Update Requirements

The report assembly function **shall** (242AR3.90-A) provide update when received. For those elements indicated in Table 3.5.1.4 as "elements that require rapid update", the report assembly function **shall** (242AR3.90-B) indicate the data has not been refreshed with the "Mode Status Data Available" bit (§3.5.1.4.7) if no update is received in the preceding 24 second period.

Note: *The 24-second period before which the "Mode-Status Data Available" bit is cleared was chosen as being the longest coast interval for SV reports, as indicated in Table 3.2.1.4.3.1.1a.*

3.5.1.4.2 Time of Applicability (TOA) Field for MS Report

The time of applicability relative to local system time **shall** (242AR3.91) be updated with every Mode-Status report update.

3.5.1.4.3 ADS-B Version Number

The ADS-B Version Number is a 3-bit field that specifies the ADS-B version of the transmitting ADS-B system. The ADS-B Version Number **shall** (242AR3.92) be defined as specified in Table 3.5.1.4.3 below.

Table 3.5.1.4.3: ADS-B Version Number

Value	ADS-B Version
0	DO-242
1	DO-242A
2	DO-260B & DO-282B
3-7	Reserved for future growth.

Note: *Messages transmitted to support this report element might signify lower level document (i.e., MOPS) version. However, ADS-B reports need to – at a minimum – signify MASPS version so that applications can appropriately interpret received ADS-B data.*

3.5.1.4.4 Call Sign Field

An ADS-B participant's call sign (§3.3.2.1) is conveyed in the Call Sign field of the MS report. The call sign **shall** (242AR3.93) consist of up to 8 alphanumeric characters. The characters of the call sign **shall** (242AR3.94) consist only of the capital letters A-Z, the decimal digits 0-9, and – as trailing pad characters only – the "space" character.

3.5.1.4.5 Emitter Category Field

An ADS-B participant's category code (§3.3.2.3) is conveyed in the Emitter Category field of the MS report. The particular encoding of the emitter category is not specified in this MASPS, being left for lower level specification documents, such as the MOPS for a particular ADS-B data link. Provision in the encoding **shall** (242AR3.95) be made for at least 24 distinct emitter categories, including the particular categories listed in §3.3.2.3 above.

3.5.1.4.6 A/V Length and Width Codes

The "A/V Length and Width Codes" field in the MS field is a 4-bit field that describes the amount of space that an aircraft or ground vehicle occupies. The aircraft/vehicle length and width codes **shall** (242AR3.96) be as described in Table 3.3.4.1a. The aircraft size code is a four-bit code, in which the 3 most significant bits (the length code) classify the aircraft into one of eight length categories, and the least significant bit (the width code) classifies the aircraft into a "narrow" or "wide" subcategory.

Each aircraft **shall** (242AR3.97) be assigned the smallest length and width codes for which its overall length and wingspan qualify it.

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. But since the wingspan exceeds 34 m, it will not fit within even the "wide" subcategory of length category 1. Such an aircraft would be assigned length category 4 and width category 1, meaning "length less than 55 m and wingspan less than 52 m."*

Each aircraft ADS-B participant for which the length code is 2 or more (length greater than or equal to 25 m or wingspan greater than 34 m) **shall** (242AR3.98) transmit its aircraft size code while it is known to be on the surface. For this purpose, the determination of when an aircraft is on the surface **shall** (242AR3.99) be as described in §3.5.1.3.1.1.

3.5.1.4.7 Mode-Status Data Available Field

The Mode-Status Data Available field is a one-bit field in the MS report. The report assembly function **shall** (242AR3.100-A) set this field to ZERO if no data has been received within 24 seconds under the conditions specified in §3.5.1.4.1; otherwise the report assembly function **shall** (242AR3.100-B) set this bit to ONE.

3.5.1.4.8 Emergency/Priority Field

The emergency/priority status field in the MS report is a 3-bit field which **shall** (242AR3.101) be encoded as indicated in Table 3.3.15a.

3.5.1.4.9 Capability Class (CC) Code Fields

A transmitting ADS-B participant broadcasts Capability Class (CC) codes (§3.3.8) so as to indicate capabilities that may be of interest to other ADS-B participants. The subfields of the CC codes field are described in the following subparagraphs.

3.5.1.4.9.1 TCAS/ACAS Operational

The CC code for "TCAS/ACAS operational" **shall** (242AR3.102-A) be set to ONE if the transmitting subsystem receives information from an appropriate interface that indicates that the TCAS/ACAS system is operational. Otherwise, this CC code **shall** (242AR3.102-C) be set to ZERO.

Notes:

1. *ADS-B does not consider TCAS/ACAS Operational equal to ONE (1) unless the TCAS/ACAS is in a state which can issue an RA (e.g., RI=3 or 4). RTCA DO-181E (EUROCAE ED-73E) Mode-S Transponders consider that the TCAS 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 RI=2, 3 or 4. (Refer to RTCA DO-181E (EUROCAE ED-73E), Appendix B, Table B-3-16.) RI=0 is STANDBY, RI=2 is TA ONLY and RI=3 is TA/RA.*

2. *A change in the value of this field will trigger the transmission of messages conveying the updated value. These messages will be consistent with higher report update rates to be specified in a future version of this MASPS. The duration for which the higher report update requirements are to be maintained will also be defined in a future version of this MASPS.*

3.5.1.4.9.2 1090 MHz ES Receive Capability

The CC Code for "1090ES IN" in **shall** (242AR3.103-C) be set to ONE (1) if the transmitting aircraft also has the capability to receive ADS-B 1090ES Messages. Otherwise, this CC code subfield **shall** (242AR3.103-D) be set to ZERO (0).

3.5.1.4.9.3 Reserved for Service Level of Transmitting A/V

At least four bits (sixteen possible encodings) **shall** (242AR3.104) be reserved in the Capability Class codes for the "service level" of the transmitting ADS-B participant. ADS-B equipment conforming to the current version of this MASPS (RTCA DO-3xx) **shall** (242AR3.105) set the Service Level code bits to ZERO.

Note: *When Service Levels are defined in future versions of this MASPS then Service Levels other than ZERO will be assigned.*

3.5.1.4.9.4 ARV Report Capability Flag

The ARV Report Capability Flag is a one-bit field that **shall** (242AR3.106) be encoded as in Table 3.5.1.4.9.4.

Table 3.5.1.4.9.4: ARV Report Capability Flag

ARV Capability Flag	Meaning
0	No capability for Air Reference Velocity Reports.
1	Capability of sending Air Reference Velocity Reports.

3.5.1.4.9.5 TS Report Capability Flag

The TS Report Capability Flag is a one-bit field that **shall** (242AR3.107) be encoded as in Table 3.5.1.4.9.5.

Table 3.5.1.4.9.5: TS Report Capability Flag

TS Report Capability Flag	Meaning
0	No capability for Target State Reports.
1	Capability of sending Target State Reports.

3.5.1.4.9.6 TC Report Capability Level

The TC Report Capability Level is a two-bit field that **shall** (242AR3.108) be encoded as in Table 3.5.1.4.9.6.

Table 3.5.1.4.9.6: TC Report Capability Levels

TC Report Capability Level	Meaning
0	No capability for Trajectory Change Reports
1	Capability of sending information for TC+0 report only.
2	Capability of sending information for multiple TC reports.
3	(Reserved for future use.)

3.5.1.4.9.7 UAT Receive Capability

The "UAT IN" CC Code **shall** (242AR3.109-C) be set to ZERO (0) if the aircraft is NOT fitted with the capability to receive ADS-B UAT Messages. The "UAT IN" CC Code **shall** (242AR3.109-D) be set to ONE (1) if the aircraft has the capability to receive ADS-B UAT Messages.

3.5.1.4.9.8 Other Capability Codes

Other capability codes are expected to be defined in later versions of this MASPS.

3.5.1.4.10 Operational Mode (OM) Parameters

Operational Mode (OM) codes are used to indicate the current operational modes of transmitting ADS-B participants. Specific operational mode codes are described in §3.5.1.4.10.1 to §3.5.1.4.10.4 below.

3.5.1.4.10.1 TCAS/ACAS Resolution Advisory Active Flag

The CC code for "TCAS/ACAS Resolution Advisory Active" **shall** (242AR3.110-A) be set to ONE if the transmitting aircraft has a TCAS II or ACAS computer that is currently issuing a Resolution Advisory (RA). Likewise, this CC code **shall** (242AR3.110-B) be set to ONE if the transmitting ADS-B equipment cannot ascertain whether the TCAS II or ACAS computer is currently issuing an RA. This CC code **shall** (242AR3.110-C) be ZERO only if it is explicitly known that a TCAS II or ACAS computer is not currently issuing a Resolution Advisory (RA).

Note: *A change in the value of this field will trigger the transmission of messages conveying the updated value. These messages will be consistent with higher report update rates to be specified in a future version of this MASPS. The*

duration for which the higher report update requirements are to be maintained will also be defined in a future version of this MASPS

3.5.1.4.10.2 IDENT Switch Active Flag

The "IDENT Switch Active" Flag is a one-bit OM code that is activated by an IDENT switch. Upon activation of the IDENT switch, this flag **shall** (242AR3.111-B) be set to ONE for a period of 20 ± 3 seconds; thereafter, it **shall** (242AR3.111-C) be reset to ZERO.

Note: *This MASPS does not specify the means by which the "IDENT Switch Active" flag is set. That is left to lower-level documents, such as the MOPS for a particular ADS-B data link.*

3.5.1.4.10.3 Reserved for Receiving ATC Services Flag

The "Reserved for Receiving ATC Services" flag is a one-bit OM code. If implemented into future versions of this MASPS, when set to ONE, this code **shall** (242AR3.112) indicate that the transmitting ADS-B participant is receiving ATC services; otherwise this flag should be set to ZERO.

Note: *The means by which the "Reserved for Receiving ATC Services" flag is set is beyond the scope of this MASPS and is not specified in this document.*

3.5.1.4.10.4 Single Antenna Flag

The "Single Antenna Flag" is a 1-bit field that **shall** (242AR3.112-A) be used to indicate that the ADS-B Transmitting Subsystem is operating with a single antenna. The following conventions **shall** (242AR3.112-B) apply both to Transponder-Based and Stand Alone ADS-B Transmitting Subsystems:

a. Non-Diversity, i.e., those transmitting functions that use only one antenna, **shall** (242AR3.112-C) set the Single Antenna subfield to "ONE" at all times.

b. Diversity, i.e., those transmitting functions designed to use two antennas, **shall** (242AR3.112-D) set the Single Antenna subfield to "ZERO" at all times that both antenna channels are functional.

At any time that the diversity configuration cannot guarantee that both antenna channels are functional, then the Single Antenna Flag **shall** (242AR3.112-E) be set to "ONE."

Note: *Certain applications may require confirmation that each participant has functioning antenna diversity for providing adequate surveillance coverage.*

3.5.1.4.10.5 System Design Assurance (SDA)

The position transmission chain includes the ADS-B transmission equipment, ADS-B processing equipment, position source, and any other equipment that processes the position data and position quality metrics that will be transmitted.

The "System Design Assurance" (SDA) field is a 2-bit field that **shall** (242AR3.112-F) define the failure condition that the position transmission chain is designed to support as defined in Table 3.5.1.4.10.5.

The supported failure condition will indicate the probability of a position transmission chain fault causing false or misleading position 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).

Table 3.5.1.4.10.5: "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 6000 pounds do not apply.*
4. *Includes probability of transmitting false or misleading latitude, longitude, or associated accuracy and integrity metrics.*

3.5.1.4.10.6 GPS Antenna Offset

The "GPS Antenna Offset" field is an 8-bit field in the OM Code Subfield of surface format Aircraft Operational Status Messages that **shall** (242AR3.112-G) define the position of the GPS antenna in accordance with the following.

a. Lateral Axis GPS Antenna Offset:

The Lateral Axis GPS Antenna Offset **shall** (242AR3.112-H) be used to encode the lateral distance of the GPS Antenna from the longitudinal axis (Roll) axis of the aircraft. Encoding **shall** (242AR3.112-I) be established in accordance with Table 3.5.1.4.10.6A.

Table 3.5.1.4.10.6A: Lateral Axis GPS Antenna Offset Values

0 = left 1 = right	Values		Upper Bound of the GPS Antenna Offset Along Lateral (Pitch) Axis Left or Right of Longitudinal (Roll) Axis	
	Bit 1	Bit 0	Direction	(meters)
0	0	0	LEFT	NO DATA
	0	1		2
	1	0		4
	1	1		6
1	0	0	RIGHT	0
	0	1		2
	1	0		4
	1	1		6

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. If the distance is greater than 6 meters, then the encoding should be set to 6 meters.*
4. *The "No Data" case is indicated by encoding of "000" as above, while the "ZERO" offset case is represented by encoding of "100" as above.*
5. *The accuracy requirement is assumed to be better than 2 meters, consistent with the data resolution.*

b. Longitudinal Axis GPS Antenna Offset:

The Longitudinal Axis GPS Antenna Offset **shall** (242AR3.112-J) be used to encode the longitudinal distance of the GPS Antenna from the NOSE of the aircraft. Encoding **shall** (242AR3.112-K) be established in accordance with Table 3.5.1.4.10.6B. If the Antenna Offset is compensated by the Sensor to be the position of the ADS-B participant's ADS-B Position Reference Point (See §3.3.4.1), then the encoding is set to binary "00001" in Table 3.5.1.4.10.6B.

Table 3.5.1.4.10.6B: Longitudinal Axis GPS Antenna Offset Encoding

Longitudinal Axis GPS Antenna Offset Encoding					
Values					**Upper Bound of the GPS Antenna Offset Along Longitudinal (Roll) Axis Aft From Aircraft Nose**
Bit 4	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**	**(meters)**
0	0	0	0	0	**NO DATA**
0	0	0	0	1	Position Offset Applied by Sensor
0	0	0	1	0	2
0	0	0	1	1	4
0	0	1	0	0	6
*	*	*	*	*	***
*	*	*	*	*	***
*	*	*	*	*	***
1	1	1	1	1	60

Notes:

1. *Maximum distance aft from aircraft nose is 60 meters or 196.85 feet. If the distance is greater than 60 meters, then the encoding should be set to 60 meters.*
2. *The accuracy requirement is assumed to be better than 2 meters, consistent with the data resolution.*

3.5.1.4.10.7 Other Operational Mode Codes

Other operational mode (OM) codes are expected to be defined in later versions of this MASPS.

3.5.1.4.11 Navigation Accuracy Category for Position (NAC_P) Field

The Navigation Accuracy Category for Position (NAC_P, §3.3.11) is reported so that surveillance applications may determine whether the reported position has an acceptable level of accuracy for the intended use. The NAC_P field in the MS report is a 4-bit field which **shall** (242AR3.113) be encoded as described in Table 3.3.11a in §3.3.11 above.

Note: *A change in the value of this field will trigger the transmission of messages conveying the updated value. These messages will be consistent with higher report update rates to be specified in a future version of this MASPS. The duration for which the higher report update requirements are to be maintained will also be defined in a future version of this MASPS.*

3.5.1.4.12 Navigation Accuracy Category for Velocity (NAC_V) Field

The Navigation Accuracy Category for Velocity (NAC_V, §3.3.12) is reported so that surveillance applications may determine whether the reported velocity has an acceptable level of accuracy for the intended use. The NAC_V field in the MS report is a 3-bit field which **shall** (242AR3.114) be encoded as described in Table 3.3.12a in §3.3.12 above.

Note: *A change in the value of this field will trigger the transmission of messages conveying the updated value. These messages will be consistent with higher report update rates to be specified in a future version of this MASPS. The duration for which the higher report update requirements are to be maintained will also be defined in a future version of this MASPS.*

3.5.1.4.13 Source Integrity Level (SIL) Field

The SIL field in the MS report is a 2-bit field which **shall** (242AR3.115) be coded as described in Table 3.3.13a in §3.3.13 above.

Note: *A change in the value of this field will trigger the transmission of messages conveying the updated value. These messages will be consistent with higher report update rates to be specified in a future version of this MASPS. The duration for which the higher report update requirements are to be maintained will also be defined in a future version of this MASPS.*

3.5.1.4.14 NIC_{BARO} Field

The NIC_{BARO} field in the MS report is a one-bit flag that indicates whether or not the barometric pressure altitude provided in the State Vector Report has been cross-checked against another source of pressure altitude. A transmitting ADS B participant **shall** (242AR3.117-A) set NIC_{BARO} to ONE in the messages that it sends to support the MS report only if there is more than one source of barometric pressure altitude data and cross-checking of one altitude source against the other is performed so as to clear the "barometric altitude valid" flag in the SV report if the two altitude sources do not agree. Otherwise, it **shall** (242AR3.117-B) set this flag to ZERO.

3.5.1.4.15 Reserved for MS Report

A 2-bit field in the MS Report **shall** (242AR3.116) is be reserved for future use.

3.5.1.4.16 True/Magnetic Heading Flag

The True/Magnetic Heading Flag in the Mode-Status report is a one-bit field which **shall** (242AR3.118) be ZERO to indicate that heading is reported referenced to true north, or ONE to indicate that heading is reported referenced to magnetic north.

Note: *The True/Magnetic Heading Flag applies to the heading being reported in the SV report while on the surface (§3.5.1.3.12), heading reported in the ARV report while airborne (§3.5.1.6.6), and the selected target heading reported in the TS report (§3.5.1.7.9).*

3.5.1.4.17 Vertical Rate Type Field

The Primary Vertical Rate Type field in the MS report is a one-bit flag which **shall** (242AR3.119) be ZERO to indicate that the vertical rate field in the SV report §3.5.1.3.16 holds the rate of change of barometric pressure altitude, or ONE to indicate that the vertical rate field holds the rate of change of geometric altitude.

3.5.1.4.18 (Reserved for) Flight Mode Specific Data Field

A 3-bit field in the MS Report is reserved for future use as a "Flight Mode Specific Data" field. In the current version (DO-3xx) of this MASPS, the "Reserved for Flight Mode Specific Data" field **shall** (242AR3.120) be ZERO.

3.5.1.5 On-Condition Reports

The following paragraphs (§3.5.1.6 to §3.5.1.7) describe various On Condition (OC) reports. The OC reports are those for which messages are not transmitted all the time, but only when certain conditions are satisfied. Those OC report types currently defined are as follows:

ARV: Air Referenced Velocity (ARV) Report (§3.5.1.6).

TS: Target State (TS) Report (§3.5.1.7).

Other On-Condition reports may be defined in future versions of these MASPS.

3.5.1.6 Air Referenced Velocity (ARV) Report

The Air Referenced Velocity (ARV) report contains velocity information that is not required from all airborne ADS-B transmitting participants, and that may not be required at the same update rate as the position and velocity elements in the SV report. Table 3.5.1.6 lists the elements of the ARV Report.

Table 3.5.1.6: Air Referenced Velocity (ARV) Report Definition

	ARV Elem. #	Contents	[Resolution or # of bits]	Reference Section	Notes
ID	1	Participant Address	[24 bits]	3.3.2.2.1	
	2	Address Qualifier	[1 bit]	3.3.2.2.2	1
TOA	3	Time of Applicability	[1 s resolution]	3.5.1.6.3	
Airspeed	4a	Airspeed	[1 knot or 4 knots]	3.5.1.6.4	
	4b	Airspeed Type and Validity	[2 bits]	3.5.1.6.5	
Heading	5a	Heading while airborne	[1 degree]	3.5.1.6.6	2
	5b	Heading Valid	[1 bit]	3.5.1.6.7	

Notes for Table 3.5.1.6:

1. *The minimum number of bits required by this MASPS for the Address Qualifier field is just one bit. However, when ADS-B is implemented on a particular data link, more than one bit may be required for the address qualifier if that data link supports other services in addition to the ADS-B service. The number of bits allocated for the Address Qualifier field may be different on different ADS-B data links.*
2. *The heading reference direction (true north or magnetic north) is given in the MS report (§3.5.1.4).*

3.5.1.6.1 Conditions for Transmitting ARV Report Elements

There are no conditions specified in this MASPS for which it is required to transmit messages supporting ARV reports. Possible future conditions being considered for requiring ARV reports are discussed in Appendix I.

Notes:

1. *Uses of the ARV report are anticipated for future applications such as in-trail spacing, separation assurance when the transmitting aircraft is being controlled to an air-referenced heading, and for precision turns. For example, ARV report information allows wind conditions encountered by the transmitting aircraft to be derived. Current heading also provides a consistent reference when the aircraft is being controlled to a target heading. Such anticipated uses for ARV information are described in Appendix I.*

2. *Such uses will be associated with conditions for transmitting messages to support the ARV report. It is anticipated that when the requirements for such future applications are better understood, that additional conditions for transmitting the ARV report information may be included in a future revision of this MASPS.*

3.5.1.6.2 ARV Report Update Requirements

This section is reserved for update rate requirements when future versions of this MASPS define conditions under which the support of ARV reports is required.

Note: *It is expected that required ARV report update rates will not exceed those for State Vector (SV) reports.*

3.5.1.6.3 Time of Applicability (TOA) Field for ARV Report

The time of applicability relative to local system time **shall** (242AR3.121) be updated with every Air-Referenced Velocity report update.

3.5.1.6.4 Airspeed Field

Reported airspeed ranges **shall** (242AR3.122) be 0-4000 knots airborne. Airspeeds of 600 knots or less **shall** (242AR3.123) be reported with a resolution of 1 knot or finer. Airspeeds between 600 and 4000 knots **shall** (242AR3.124) be reported with a resolution of 4 knots or finer.

3.5.1.6.5 Airspeed Type and Validity

The Airspeed Type and Validity field in the ARV report is a 2-bit field that **shall** (242AR3.125) be encoded as specified in Table 3.5.1.6.5.

Table 3.5.1.6.5: Airspeed Type Encoding

Airspeed Type	Meaning
0	Airspeed Field Not Valid
1	True Airspeed (TAS)
2	Indicated Airspeed (IAS)
3	Reserved for Mach

3.5.1.6.6 Heading While Airborne Field

An aircraft's heading (§3.3.7) is reported as the angle measured clockwise from the reference direction (magnetic north or true north) to the direction in which the aircraft's nose is pointing. If an ADS B participant broadcasts messages to support ARV reports, and heading is available to the transmitting ADS-B subsystem, then it **shall** (242AR3.126) provide heading in those messages. Reported heading range **shall** (242AR3.127) cover a full circle, from 0 degrees to (almost) 360 degrees. The heading field in ARV reports **shall** (242AR3.128) be communicated and reported with a resolution at least as fine as 1 degree of arc.

Note: *The reference direction for heading (true north or magnetic north) is reported in the True/Magnetic Heading Flag of the Mode-Status report §3.5.1.4.16 above).*

3.5.1.6.7 Heading Valid Field

The "Heading Valid" field in the ARV report **shall** (242AR3.129) be ONE if the "Heading While Airborne" field contains valid heading information, or ZERO if that field does not contain valid heading information.

3.5.1.7 Target State (TS) Report

The Target State (TS) Report provides information on the current status of the MCP/FCU or FMS Selected Altitude and the Selected Heading. Table 3.5.1.7 lists the elements of this report.

Table 3.5.1.7: Target State (TS) Report Definition

	TS Report Elem. #	Contents	[Resolution or # of bits]	Reference Section
ID	1	Participant Address	[24 bits]	3.3.2.1
	2	Address Qualifier	[1 bit]	3.3.2.2
TOA	3	Time of Applicability	[1 s resolution]	3.5.1.7.3
Selected Altitude	4a	Selected Altitude Type	[1 bit]	3.5.1.7.4
	4b	MCP/FCU or FMS Selected Altitude	[16 bits]	3.5.1.7.5
	4c	Barometric Pressure Setting (minus 800 millibars)	[16 bits]	3.5.1.7.6
Selected Heading	5	Selected Heading	[16 bits]	3.5.1.7.9
Mode Indicators	6a	Autopilot Engaged	[1 bit]	3.5.1.7.11
	6b	VNAV Mode Engaged	[1 bit]	3.5.1.7.12
	6c	Altitude Hold Mode	[1 bit]	3.5.1.7.13
	6d	Approach Mode	[1 bit]	3.5.1.7.14
	6e	LNAV Mode Engaged	[1 bit]	3.5.1.7.15
Reserved		(Reserved for Future Growth)	[4 bits]	

3.5.1.7.1 Conditions for Transmitting TS Report Information

An airborne ADS-B participant of equipage class A2 or A3 **shall** (242AR3.130) transmit messages to support the TS report when airborne and target state information is available.

Note: *TS Reports are also optional for A1 equipment. If A1 equipment chooses to support TS reports those reports must meet the requirements specified in §3.5.1.7 and all of its subsections.*

3.5.1.7.2 TS Report Update Requirements

The nominal update interval for TS Report information is specified in §3.2.1.4.3.1.4 and Table 3.2.1.4.3.1.1d.

The higher "state change" update interval requirements specified for TS report information in §3.2.1.4.3.1.4 and Table 3.2.1.4.3.1.1d **shall** (242AR3.131) be met whenever there is a change in the value of any of the TS report fields. Editor's Note: ➔ We should talk about this. ➔

3.5.1.7.3 Time of Applicability (TOA) field for TS Report

The time of applicability relative to local system time **shall** (242AR3.132) be updated with every Target State report update.

3.5.1.7.4 Selected Altitude Type

a. The "Selected Altitude Type" subfield is a 1-bit field that is used to indicate the source of Selected Altitude data. Encoding of the "Selected Altitude Type" **shall** (242AR3.132-A) be in accordance with Table 3.5.1.7.4.

b. Whenever there is no valid MCP / FCU or FMS Selected Altitude data available, then the "Selected Altitude Type" subfield **shall** (242AR3.132-B) be set to ZERO (0).

Note: *Users of this data are cautioned that the selected altitude value transmitted by the ADS-B Transmitting Subsystem does not necessarily reflect the true intention of the airplane during certain flight modes (e.g., during certain VNAV or Approach modes), and does not necessarily correspond to the target altitude (the next altitude level at which the aircraft will level off).*

In addition, on many airplanes, the ADS-B Transmitting Subsystem does not receive selected altitude data from the FMS and will only transmit Selected Altitude data received from a Mode Control Panel / Flight Control Unit (MCP / FCU).

Table 3.5.1.7.4: Selected Altitude Type Field Values

Coding	Meaning
0	Data being used to encode the Selected Altitude data field is derived from the Mode Control Panel / Flight Control Unit (MCP / FCU) or equivalent equipment.
1	Data being used to encode the Selected Altitude data field is derived from the Flight Management System (FMS).

3.5.1.7.5 MCP/FCU or FMS Selected Altitude Field

a. The "MCP / FCU Selected Altitude or FMS Selected Altitude" subfield is an 11-bit field that **shall** (242AR3.133-A) contain either the MCP / FCU Selected Altitude or the 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 **shall** (242AR3.133-B) be used to encode the Selected Altitude data field in accordance with Table 3.5.1.7.5. Use of MCP / FCU Selected Altitude **shall** (242AR3.133-C) then be declared in the "Selected Altitude Type" subfield as specified in Table 3.5.1.7.4.

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 **shall** (242AR3.133-D) be used to encode the Selected Altitude data field in accordance with Table 3.5.1.7.5 provided in paragraph "d." Use of FMS Selected Altitude **shall** (242AR3.133-E) then be declared in the "Selected Altitude Type" subfield as specified in Table 3.5.1.7.4.

d. Encoding of the Selected Altitude data field **shall** (242AR3.133-F) be in accordance with Table 3.5.1.7.5. Encoding of the data **shall** (242AR3.133-G) be 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 **shall** (242AR3.133-H) be set to ZERO (0) as indicated in Table 3.5.1.7.5.

Note: *Users of this data are cautioned that the selected altitude value transmitted by the ADS-B Transmitting Subsystem does not necessarily reflect the true intention of the airplane during certain flight modes (e.g., during certain VNAV or Approach modes), and does not necessarily correspond to the target altitude (the next altitude level at which the aircraft will level off).*

In addition, on many airplanes, the ADS-B Transmitting Subsystem does not receive selected altitude data from the FMS and will only transmit Selected Altitude data received from a Mode Control Panel / Flight Control Unit (MCP / FCU).

Table 3.5.1.7.5: "MCP/FCU Selected Altitude or FMS Selected Altitude" Field Values

Coding		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

3.5.1.7.6 Barometric Pressure Setting (Minus 800 millibars) Field

a. The "Barometric Pressure Setting (Minus 800 millibars)" subfield is a 9-bit field that **shall** (242AR3.136-A) contain 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 **shall** (242AR3.136-B) be encoded in accordance with Table 3.5.1.7.6.

c. Encoding of Barometric Pressure Setting data **shall** (242AR3.136-C) 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 **shall** (242AR3.136-D) be set to ZERO (0) as indicated in Table 3.5.1.7.6.

e. Whenever the Barometric Pressure Setting data is greater than 1208.4 or less than 800 millibars, then the "Barometric Pressure Setting (Minus 800 millibars)" subfield **shall** (242AR3.136-E) be set to ZERO (0).

Note: *This Barometric Pressure Setting data can be used to represent QFE or QNH/QNE, depending on local procedures. It represents the current value being used to fly the aircraft.*

Table 3.5.1.7.6: Barometric Pressure Setting (Minus 800 millibars) Field Values

Value (Binary)	Value (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

3.5.1.7.7 Selected Heading Status Field

The "Selected Heading Status" is a 1-bit field that **shall** (242AR3.137-A) be used to indicate the status of Selected Heading data that is being used to encode the Selected Heading data in accordance with Table 3.5.1.7.7.

Table 3.5.1.7.7: Selected Heading Status Field Values

Value	Meaning
0	Data being used to encode the Selected Heading data is either **NOT** Available or is **INVALID**. See Table 3.5.1.7.9.
1	Data being used to encode the Selected Heading data is Available and is **VALID**. See Table 3.5.1.7.9.

3.5.1.7.8 Selected Heading Sign Field

The "Selected Heading Sign" is a 1-bit field that **shall** (242AR3.138-A) be used to indicate the arithmetic sign of Selected Heading data that is being used to encode the Selected Heading data in accordance with Table 3.5.1.7.8.

Table 3.5.1.7.8: Selected Heading Sign Field Values

Value	Meaning
0	Data being used to encode the Selected Heading data 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 3.5.1.7.9.
1	Data being used to encode the Delected Heading data 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 3.5.1.7.9.

3.5.1.7.9 Selected Heading Field

a. The "Selected Heading" is an 8-bit field that **shall** (242AR3.139-A) contain Selected Heading data encoded in accordance with Table 3.5.1.7.9.

b. Encoding of Selected Heading data **shall** (242AR3.139-B) 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 **shall** (242AR3.139-C) be set to ZERO (0) as indicated in Table 3.5.1.7.9.

Note: *On many airplanes, the ADS-B Transmitting Subsystem receives Selected Heading from a Mode Control Panel / Flight Control Unit (MCP / FCU). Users of this data are cautioned that the Selected Heading value transmitted by the ADS-B Transmitting Subsystem does not necessarily reflect the true intention of the airplane during certain flight modes (e.g., during LNAV mode).*

Table 3.5.1.7.9: Selected Heading Status, Sign and Data Field Values

Values for Selected Heading:			Meaning
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

3.5.1.7.10 Status of MCP/FCU Mode Bits

The "Status of MCP / FCU Mode Bits" is a 1-bit field that **shall** (242AR3.140-A) be used to indicate whether the mode indicator bits are actively being populated (e.g., set) in accordance with Table 3.5.1.7.10.

If information is provided to the ADS-B Transmitting Subsystem to set the Mode Indicator bits to either "0" or "1," then the "Status of MCP/FCU Mode Bits" **shall** (242AR3.140-B) be set to ONE (1). Otherwise, the "Status of MCP/FCU Mode Bits" **shall** (242AR3.140-C) be set to ZERO (0).

Table 3.5.1.7.10: Status of MCP/FCU Mode Bits Field Values

Values	Meaning
0	No Mode Information is being provided in the Mode Indicator bits
1	Mode Information is deliberately being provided in the Mode Indicator bits

3.5.1.7.11 Mode Indicator: Autopilot Engaged Field

The "Mode Indicator: Autopilot Engaged" subfield is a 1-bit field that **shall** (242AR3.142-A) be used to indicate whether the autopilot system is engaged or not.

a. The ADS-B Transmitting Subsystem **shall** (242AR3.142-B) accept information from an appropriate interface that indicates whether or not the Autopilot is engaged.

b. The ADS-B Transmitting Subsystem **shall** (242AR3.142-C) set the Mode Indicator: Autopilot Engaged field in accordance with Table 3.5.1.7.11.

Table 3.5.1.7.11: Mode Indicator: Autopilot Engaged Field Values

Values	Meaning
0	Autopilot is NOT Engaged or Unknown (e.g., not actively coupled and flying the aircraft)
1	Autopilot is Engaged (e.g., actively coupled and flying the aircraft)

3.5.1.7.12 Mode Indicator: VNAV Mode Engaged Field

The "Mode Indicator: VNAV Mode Engaged" is a 1-bit field that **shall** (242AR3.146-A) be used to indicate whether the Vertical Navigation Mode is active or not.

a. The ADS-B Transmitting Subsystem **shall** (242AR3.146-B) accept information from an appropriate interface that indicates whether or not the Vertical Navigation Mode is active.

b. The ADS-B Transmitting Subsystem **shall** (242AR3.146-C) set the Mode Indicator: VNAV Mode Engaged field in accordance with Table 3.5.1.7.12.

Table 3-3.4.7.12: "Mode Indicator: VNAV Engaged" Field Values

Values	Meaning
0	VNAV Mode is NOT Active or Unknown
1	VNAV Mode is Active

3.5.1.7.13 Mode Indicator: Altitude Hold Mode Field

The "Mode Indicator: Altitude Hold Mode" is a 1-bit field that **shall** (242AR3.147-A) be used to indicate whether the Altitude Hold Mode is active or not.

a. The ADS-B Transmitting Subsystem **shall** (242AR3.147-B) accept information from an appropriate interface that indicates whether or not the Altitude Hold Mode is active.

b. The ADS-B Transmitting Subsystem **shall** (242AR3.147-C) set the Mode Indicator: Altitude Hold Mode field in accordance with Table 3.5.1.7.13.

Table 3.5.1.7.13: "Mode Indicator: Altitude Hold Mode" Field Values

Values	Meaning
0	Altitude Hold Mode is NOT Active or Unknown
1	Altitude Hold Mode is Active

3.5.1.7.14 Mode Indicator: Approach Mode Field

The "Mode Indicator: Approach Mode" is a 1-bit field that **shall** (242AR3.148-A) be used to indicate whether the Approach Mode is active or not.

a. The ADS-B Transmitting Subsystem **shall** (242AR3.148-B) accept information from an appropriate interface that indicates whether or not the Approach Mode is active.

b. The ADS-B Transmitting Subsystem **shall** (242AR3.148-C) set the Mode Indicator: Approach Mode field in accordance with Table 3.5.1.7.14.

Table 3.5.1.7.14: "Mode Indicator: Approach Mode" Field Values

Values	Meaning
0	Approach Mode is NOT Active or Unknown
1	Approach Mode is Active

3.5.1.7.15 Mode Indicator: LNAV Mode Engaged Field

The "Mode Indicator: LNAV Mode Engaged" is a 1-bit field that **shall** (242AR3.149-A) be used to indicate whether the Lateral Navigation Mode is active or not.

a. The ADS-B Transmitting Subsystem **shall** (242AR3.149-B) accept information from an appropriate interface that indicates whether or not the Lateral Navigation Mode is active.

b. The ADS-B Transmitting Subsystem **shall** (242AR3.149-C) set the Mode Indicator: LNAV Mode Engaged field in accordance with Table 3.5.1.7.15.

Table 3.5.1.7.15: "Mode Indicator: LNAV Mode Engaged" Field Values

Values	Meaning
0	LNAV Mode is NOT Active
1	LNAV Mode is Active

3.5.2 Traffic Information Services – Broadcast (TIS-B) Messages and Reports

3.5.2.1 Introduction to TIS-B

The formats and coding for a Traffic Information Service Broadcast (TIS-B) are based on the same ADS-B signal transmission.

TIS-B complements the operation of ADS-B by providing ground-to-air broadcast of surveillance data on aircraft that are not equipped for 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 ADS-B broadcasts and can therefore be accepted by an ADS-B receiver.

TIS-B data content on the signal does not include all of the parameters, such as the System Design Assurance (SDA) and the SIL Supplement, which are normally associated with ADS-B transmissions from aircraft. Those parameters that are not broadcast will need to be provided by the TIS-B Service Provider.

TIS-B service is the means for providing a complete surveillance picture to ADS-B users during a transition period. After transition, it also provides a means to cope with a user that has lost its ADS-B capability, as well as a means to provide ADS-B users with information from surface or approach multi-lateration systems.

3.5.2.2 TIS-B Message Processing and Report Generation

The information received in TIS-B Messages is reported directly to applications. In the most common case, a particular target will result in TIS-B Message receptions or ADS-B Message receptions, but not both. It is possible, however, for both types of messages to be received for a single target. If this happens, the TIS-B information is processed and reported independently of the ADS-B receptions and reporting.

Whereas ADS-B reports are classified as to "State Vector Reports" and certain other defined types, TIS-B reports are not. Instead, TIS-B reporting follows the general principle that all received information is reported directly upon reception.

In the absence of TIS-B Message receptions, it is possible for reports to be generated, but this is not required. Such additional reports might be useful as a means of counteracting possible flaws in an on-board data bus between ADS-B and an application.

3.5.3 ADS-B Rebroadcast Service (ADS-R) Messages and Reports

The formats and coding for an ADS-B Rebroadcast Service (ADS-R) are based on the same ADS-B signal transmission characteristics as are defined for each individual ADS-B data link.

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 ADS-B-1, but are equipped with an alternate form of ADS-B (e.g., ADS-B-2). The basis for the ADS-R transmission is the ADS-B Report received at the Ground Station using a receiver compatible with the alternate ADS-B data link.

The ADS-R ground-to-air transmissions use the same signal formats as the respective ADS-B data links and can therefore be accepted by an alternate ADS-B Receiving Subsystem