CHANGE ISSUE – RTCA/DO-242

MASPS for ADS-B Rev. A

Tracking Information (committee secretary only)	
Change Issue Number	37
Submission Date	5/21/01
Status (open/closed/deferred)	Rev. A – CLOSED
Last Action Date	3/08/02

Short Title for Change Issue:	Air Reference Velocity Vector

MASPS Document Reference:		Originator Information:	
Entire document (y/n)	yes	Name	Richard Barhydt
Section number(s)	2.1.2.2.2, 2.2.2.3.1, 2.2.2.4.1, 3.2.3.1, 3.4.3.1, 3.4.3.2, 3.4.3.3	Phone	(757) 864-2065
Paragraph number(s)		E-mail	r.barhydt@larc.nasa.gov
Table/Figure number(s)	Tables 2-2, 3-1, 3-3, 3-4, 3-5, 3-7, 3-8	Other	Intent Subgroup, WG4

Proposed Rationale for Consideration (originator should check all that apply):	
	Item needed to support of near-term MASPS/MOPS development
	DO-260/ED-102 1090 MHz Link MOPS Rev A
X	ASA MASPS
	TIS-B MASPS
	UAT MOPS
	Item needed to support applications that have well defined concept of operation
	Has complete application description
	Has initial validation via operational test/evaluation
	Has supporting analysis, if candidate stressing application
	Item needed for harmonization with international requirements
	Item identified during recent ADS-B development activities and operational evaluations
X	MASPS clarifications and correction item
X	Validation/modification of questioned MASPS requirement item
	Military use provision item
	New requirement item (must be associated with traffic surveillance to support ASAS)

Nature of Issue:		Editorial		Clarity		Performance	X	Functional

Issue Description:

Note: This Issue Paper is in response to AI 4-14 and is a consolidation of Issue Papers 9, 27 and 28 and the proposed Issue Paper "3X" presented at the April ad hoc meeting in Brussels as 242A-WP-4-07.

Heading and airspeed data offer potentially significant benefits to separation assurance, flight path deconfliction, and flight planning applications. When combined with the ground referenced velocity that is provided in the ADS-B state vector, these data can be used to derive local wind conditions encountered by the transmitting aircraft. This wind information can be used to improve path prediction for in-trail spacing operations, precision Flight Management System (FMS) paths and conflict detection and prevention for aircraft flying by reference to heading or in varying wind fields. These applications are discussed briefly below and in more detail in the attached working paper, 242A-WP-5-13a.

Issue Description (continued):

One concept for in-trail spacing approaches establishes a uniform time interval for aircraft arriving over the runway threshold. To cross the threshold at the proper time, trailing aircraft maintain a specified time spacing behind the leading aircraft up to the point where the lead aircraft slows to its final approach speed. This time is based on the final approach speed of each aircraft and the local wind conditions. Wind affects the assigned time spacing because it changes the amount of time in which the differences in final approach speeds act to close or stretch the gap between aircraft. Wind conditions may change significantly with altitude and current winds aloft data is often sporadic and out-dated. Wind information derived from the air and ground velocity vectors of preceding aircraft could be used to improve the spacing performance of following aircraft. A ground station could be used to process the incoming raw data and make it available to other aircraft.

Precision FMS paths in the terminal area are under consideration to increase throughput and reduce noise. Possible concepts include vertical tunnels in space, fixed radius turns, and required times of arrival. To achieve the higher path prediction accuracy required to accomplish these tasks, accurate local wind information is needed. The FMS generates a descent path to achieve programmed waypoint crossing restrictions prior to reaching top of descent. This path is based on aircraft performance and predicted wind conditions. Unforecast wind conditions encountered on descent require the pilot to add speedbrakes or throttle (may also be done by autothrottle) to maintain the desired descent path and speed. Path intervention leads to higher crew workload and lower fuel efficiency. Better wind conditions could also improve FMS performance in today's operational environment.

State based conflict detection and prevention algorithms could also benefit from local wind information derived from the air and ground velocity vectors. Aircraft are often flown without being controlled to a defined ground track. Heading hold and heading select modes and fly-by and fly-over turns are examples. In these situations, the aircraft's ground velocity vector is difficult to predict if it encounters a changing wind field (common in climb and descent) or if the wind vector changes relative to the aircraft's velocity vector (after a turn).

Originator's proposed resolution:

To support the applications described above, the following proposal is offered:

- Create a requirement for Class A2 and A3 aircraft to be capable of broadcasting heading and airspeed data.
- Data reference (magnetic or true heading, indicated or true airspeed) must also be available (possible implementation would be "Operational Mode Specific Parameters" of current mode status report).
- Requirement could be met by new on-condition report delegated for heading and airspeed or through the state vector.
- Remove all DO-242 references making heading and airspeed required elements of the state vector (Table 3-5) and Section 3.4.3.1, although including the data in the state vector is one way to meet the requirement.
- Broadcast rate requirements for specific applications are TBD.

This proposal is outlined in detail in Working Paper 242A-WP-5-13a, which is available at <http://adsb.tc.faa.gov/242-main>. This proposal represents a consolidation of other issue papers related to this topic (IP9, IP27, IP28, IP3X) With concurrence of the other authors, I propose that those issue papers be closed.

A2 and A3 aircraft participate and support separation assurance and flight path deconfliction, so they should be capable of supporting heading and airspeed data. These data are likely not required at all times for all applications, so they are removed as required elements from the state vector. Broadcast requirements should be levied by the application.

Working Group 6 Deliberations:

May 24, 2001: The ad hoc group agreed that this Issue Paper will be addressed in Revision A of DO-242.

August 30, 2001: This Issue Paper was briefly discussed at the August WG6 meeting. It was proposed that the air-reference velocity vector information be placed in an on-condition report.

September 27, 2001: An initial proposal for an air-reference velocity vector on-condition report was included in working paper 242A-WP-8-01. This material was reviewed by WG6 at their September meeting. All text on defining the conditions for transmitting OC-ARV report elements will be removed, and replaced with "TBD". All times of applicability and resolutions will be left as TBD until the next version of this material is reviewed.

December 14, 2002: The concept of moving air-referenced velocity information from the State Vector to a new on-condition report was briefed to the SC-186 plenary in December. This concept was agreed to provided that it was being done only to clarify that ARV data is only required when ground speed is lost and that no new conditions for the broadcast of the information would be added to revision A.

February 22, 2002: The final text for the section defining the ARV report and the requirements for its broadcast was reviewed and accepted by WG6 at their February meeting. This new section defining the ARV report (§3.4.7) will close this Issue Paper. However, a new Issue Paper (IP63) was accepted by WG6 and deferred to revision B which requests that ARV be broadcast at all times but at a lower rate than State Vector Data.

March 8, 2002: Appendix Q was reviewed and agreed to by WG6.

Working Group 6 Final Resolution:

A new section was created to define the Air-reference velocity (ARV) on-condition report and the conditions under which it is to be broadcast. Section 3.4.7, as it appears in the draft DO-242A delivered to RTCA on March 4, 2002, is found in Attachment A of this Issue Paper. Additionally, a new appendix (Appendix Q) has also been authored which discusses possible future conditions under which ARV reports may be desired and/or required. The reader is referred to Appendix Q of the draft DO-242A.

3.4.7 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 3.4.7 lists the elements of the ARV Report.

Table 3.4.7: Air Referenced Velocity (ARV) Report Definition.

	ARV Elem. #	Contents	[Resolution or # of bits]	Reference Section	Notes
ID	1	Participant Address	[24 bits]	2.1.2.2.2.1	
	2	Address Qualifier	[4 bits]	2.1.2.2.2.2	1
TOA	3	Time of Applicability	[1 s resolution]	3.4.7.3	
Airspeed	4a	Airspeed	[1 knot or 4 knots]	3.4.7.4	
	4b	Airspeed Type and Validity	[2 bits]	3.4.7.5	
Heading	5a	Heading while airborne	[1 degree]	3.4.7.6	2
	5b	Heading Valid	[1 bit]	3.4.7.7	

Notes for Table 3.4.7:

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 shown in the table for the Address Qualifier field is 4 only because experience in encoding that field in MOPS for particular ADS-B data links seems to indicate that 4 bits is sufficient.*

2. *The heading reference direction (true north or magnetic north) is given in the MS report (§3.4.4).*

3.4.7.1 Conditions for Transmitting ARV Report Elements

An airborne ADS-B participant of equipage class A1, A2 or A3 **shall** (R3.125) transmit messages to support the ARV report when a period of 24 seconds has elapsed without the receipt of ground-referenced velocity information from the own-ship navigation equipment. (24 seconds is the maximum coast interval for SV reports.)

Notes:

1. *Airspeed and heading can be used by surveillance systems as a temporary replacement for ground-referenced velocity (N-S and E-W velocity, or alternately ground speed and ground track angle). The condition stated above for transmitting ARV report information is based on that use of the ARV information.*

2. *Additional 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 Q.*

3. *Such additional uses will be associated with additional 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.*

3.4.7.2 ARV Report Update Requirements

When the condition of §3.4.7.1 is met, messages to support the ARV report **shall** (R3.126) be transmitted at a rate sufficient that the ARV report is updated at the same rate as the SV report.

3.4.7.3 Time of Applicability (TOA) Field for ARV Report

The time of applicability relative to local system time **shall** (R3.127) be updated with every Air-Referenced Velocity report update.

3.4.7.4 Airspeed Field

Reported airspeed ranges **shall** (R3.128) be 0-4000 knots airborne. Airspeeds of 600 knots or less **shall** (R3.129) be reported with a resolution of 1 knot or finer. Airspeeds between 600 and 4000 knots **shall** (R3.130) be reported with a resolution of 4 knots or finer.

3.4.7.5 Airspeed Type and Validity

The Airspeed Type and Validity field in the ARV report is a 2-bit field that **shall** (R3.131) be encoded as specified in Table 3.4.7.5.

Table 3.4.7.5: Airspeed Type Encoding

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

3.4.7.6 Heading While Airborne Field

An aircraft's heading (§2.1.2.9) 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** (R3.132) provide heading in those messages. Reported heading range **shall** (R3.133) cover a full circle, from 0 degrees to (almost) 360 degrees. The heading field in ARV reports **shall** (R3.134) 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 Mode-Status report §3.4.4 above).

3.4.7.7 Heading Valid Field

The "Heading Valid" field in the ARV report **shall** (R3.135) be ONE if the "Heading While Airborne" field contains valid heading information, or ZERO if that field does not contain valid heading information.