

## CHANGE ISSUE – RTCA/DO-242

# MASPS for ADS-B Rev. A

Tracking Information (committee secretary only)	
Change Issue Number	63
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Status (open/closed/deferred)	DEFERRED
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<b>Short Title for Change Issue:</b>	Broadcast Conditions and Operational Concept for ARV Reporting
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<b>MASPS Document Reference:</b>		<b>Originator Information:</b>	
Entire document (y/n)		Name	Tony Warren
Section number(s)	3.4.6 (Revision A)	Phone	425-373-2677
Paragraph number(s)	3.4.6.1, 3.3.1.3	E-mail	Anthony.w.warren@boeing.com
Table/Figure number(s)	3-4 (b)	Other	

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

Nature of Issue:	<input type="checkbox"/>	Editorial	<input type="checkbox"/>	Clarity	<input type="checkbox"/>	Performance	<input checked="" type="checkbox"/>	Functional
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**Issue Description:**

The current concept of operations for use of ARV reporting only transmits ARV reports when ground velocity (or position and velocity) source data is lost for some time period at the transmitting source. The Air Reference Velocity is substituted for Ground Velocity in that case, and position reports may be updated using air reference velocity. This concept of operations is deficient on at least three grounds:

- (1) Harmonization with European ADS requirements: The European concept of operations under development at Eurocontrol for both air-ground and air-air uses of ADS-B requires broadcast of “Basic + Enhanced” parameters which approximately corresponds to State Vector, Target State Reports, and Air Reference Velocity (ARV) reports in the Revision A MASPS. The broadcast of ARV reports under conditions other than failure modes is important for harmonization of U.S. and European requirements. Although this is probably a Revision B item, we here note that the proposed solution method below, i.e. low rate broadcast of ARV reports (for Level A1 to A3 systems) could provide a means of harmonizing with the European requirements.

*(continued)*

Issue Description (continued)

- (2) The technical concept of using air reference velocity as a failure mode for ground vector is severely flawed, and has low technical value due to the very large errors inherent in the current concept. This concept can be fixed by the simple expedient of broadcasting ARV reports at a low rate compared to state vector data and calculating a derived wind vector along with ARV reports. In the event of loss of ground vector, a more accurate derived ground vector can be synthesized from current ARV reports and the derived wind vector. This technical concept is much more likely to have some value as a failure backup mode, since the derived ground vector is about an order of magnitude more accurate and reliable for preserving continuity of ADS State reporting. This concept or something similar should be adopted for Revision A, or the use of ARV reports should be deferred for further study.
- (3) In air-air Airborne Conflict Management scenarios using intent data, it is sometimes necessary to perform trajectory predictions for a potential encounter after one of the aircraft completes a large turn maneuver. With no knowledge of either airspeed of the turning aircraft or wind vector, it is not possible to reliably estimate the time of closest approach of the two encounter aircraft, even if the path intercept point is known precisely. This problem can be easily fixed using ARV broadcasts as described above, i.e. broadcasting ARV reports at a low rate, and calculation of a derived wind vector prior to turns and during vertical transitions. Sufficient information for calculating time and distance of closest approach are then available for intent based deconfliction of the encounter aircraft. This scenario illustrates the importance of providing ARV data as well as TCRs to Level A2 and A3 aircraft for performing intent based conflict alerting and deconfliction.
- (4) As an extension to item (3) above, the problem with the proposed implementation of intent in Revision A is that trajectory information is only conveyed directly in two axes, i.e. lateral and vertical with TSRs and TCRs. In the original MASPS, it was thought that longitudinal information along track could be conveyed using TTG estimates, and extra TCP's as necessary. However, TCRs in Revision A are very bandwidth consumptive. It is far more efficient to estimate along track ground speed after a trajectory change point using ARVs to convey airspeed information and to derive along track wind from the vector difference between ground vector and air vector. Thus the use of ARVs at a suitable broadcast rate enables efficient trajectory synthesis in all three axes, lateral, vertical and longitudinal.

Originator's proposed resolution:

The proposal to use air reference vector as a substitute for ground vector is extremely crude since the difference between these quantities is the wind vector which can easily induce 100 knots or more error, especially if the flight trajectory is in the direction of the wind, i.e. a tail wind or a head wind is encountered. Our proposal is to broadcast ARVs at a rate sufficient to estimate the wind vector currently in force as the vector difference between the ground vector in the State reports and the air vector obtained from ARV broadcasts, when both data vectors are available and valid. Thus the ARV reports at the reception side would include a derived wind vector as well as the air reference velocity states. When a failure mode is encountered such as temporary loss of the ADS-B navigation data for state reporting, the ground velocity would be synthesized from air velocity and the most recent derived wind vector. For many aircraft, the wind vector can be estimated with a 95% accuracy on the order of 10 knots or less. Thus, this backup procedure for loss of state data is about an order of magnitude more accurate than the procedure currently proposed for Revision A adoption.

(continued)

Originator's proposed resolution (continued):

With the procedure recommended above, nominal broadcast of ARVs could be compatible with that needed for air-ground meteo broadcasts. The research study in Reference 1 concluded that a broadcast interval of two-minute updates was sufficient for aircraft in level flight, and updates at 2000 foot vertical intervals in climbs and descents in en-route airspace. Since commercial transports often climb or descend At 3000 ft/min rates, this would imply a 95% update interval of 40 seconds or less in all flight phases. The recommended broadcast of meteo data for ascents outside the terminal area in the draft RTCA document for final approval this spring recommends a default value of 20 seconds for air-ground broadcast of wind vector and temperature data. Consequently, a compromise value of 30 seconds is proposed for 95% update interval of received ARV data.

Reference (1): D.A. Forrester and G.C. Dean, "Improvements in forecasting accuracy may allow a significant increase in en-route capacity", ICAO Journal, Jan/Feb. 1997.

Working Group 6 Deliberations:

February 22, 2002: This Issue Paper was reviewed by WG6 at their February 2002 meeting. Due to time considerations and the belief by both WG6 and WG4 that detailed analysis needs to be done to validate these proposals, it was agreed that this Issue Paper will be DEFERRED to a future revision of the MASPS.