

RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS

Meeting #10

**Draft 3 of the Proposed Appendix B
The ADS-B MASPS Cross Reference Matrix**

Presented by Greg Kuehl, UPS Airlines

SUMMARY

Appendix B
MASPS Compliance Matrix

B.1 Introduction

This Appendix compares the ADS-B system requirements stated in the ADS-B MASPS with minimum operational requirements stated in the UAT MOPS. The data is presented in tabular format, ordered by MASPS requirement. The compliance column of the matrix indicates the level of UAT MOPS compliance with each MASPS requirement where MASPS requirements are not totally accommodated.

B.2 MASPS Compliance Matrix

See matrix on following pages.

Table B-1: MASPS Compliance Matrix

MASPS Ref. #	Requirement	MOPS Ref. #	Title / Description	Compliance
R2.1	When the full resolution of available aircraft data cannot be accommodated within an ADS-B message, a common quantization algorithm shall be used to ensure consistent performance across different implementations.	Table 2.2.4.1-B	Basic ADS-B Message Payload Fields	
R2.2	The output of ADS-B shall be standardized so that it can be translated without compromising accuracy.	2.2.4.1	Basic ADS-B Message Format and Encoding	
R2.3	Time of applicability shall be provided in all reports.	2.2.4.2.2	Transmission Epoch	
R2.4	The ADS-B system shall be capable of transmitting messages containing the information specified in the following subsections.	N/A	(reference to following requirements)	
R2.5	The basic identification information to be conveyed by ADS-B shall include the following elements: 1. Call Sign (see also R2.7) 2. Address (see also R2.8, R2.9) 3. Category (see also R2.11)	2.2.4.2.1.2 2.2.4.1.3 2.2.4.2.1	Flight ID (Call Sign) Characters Aircraft Address Participant Category Code & Call Sign	
R2.6	The ADS-B system design shall accommodate a means to ensure anonymity whenever pilots elect to operate under flight rules permitting an anonymous mode.	2.2.4.1.2 2.2.4.1.3 Table 2.2.4.1.2	Address Qualification Aircraft Address Address Qualifier Codes	
R2.7	ADS-B shall convey an aircraft call sign of up to 7 alphanumeric characters in length.	2.2.4.2.1.2 Table 2.2.4.2.1-13	Flight ID (Call Sign) Characters Base 40 Character Code for Flight ID	
R2.8	The ADS-B system design shall include a means (e.g., an address) to: 1 - correlate all ADS-B messages transmitted from the A/V, and 2 - differentiate it from other A/Vs in the operational domain.	2.2.4.1.2 Table 2.2.4.1.2-4 2.2.4.1.3	Address Qualification Address Qualification Codes Aircraft Address	
R2.9	Aircraft with Mode-S transponders using an ICAO 24 bit address shall use the same 24 bit address for ADS-B.	N/A (2.2.4.1.3)	Out of Scope: Installation Certification Issue (Aircraft Address)	Installation Certification Requirement (accommodated)
R2.10	All aircraft/vehicle addresses shall be unique within the operational domain(s) applicable.	N/A	Out of Scope: Installation/Operational Certification Issue	Equipment Certification (TSO) requirement?

Table B-1: MASPS Compliance Matrix (continued)

MASPS Ref. #	Requirement	MOPS Ref. #	Title / Description	Compliance
R2.11	Aircraft/vehicle category, as defined by ICAO, shall be one of the following: 1. Light aircraft - 7,000 kgs (15,500 lbs) or less 2. Reserved 3. Medium aircraft - more than 7,000 kgs and less than 136,000 kgs (300,000 lbs) 4. Reserved 5. Heavy aircraft 136,000 kgs or more	2.2.4.2.1 2.2.4.2.1.1 Table 2-12	Participant Category Code & Call Sign Participant Category Code ADS-B Emitter Category Codes	
R2.12	Aircraft/vehicle state vector information shall include the following elements: 1. Three-dimensional position 2. Three-dimensional velocity 3. Airborne turn indication 4. Navigation uncertainty category	2.2.4.1 Table 2.2.4.1-A-2 2.2.4.1.10 2.2.4.1. 67 2.2.4.1. 88 2.2.4.1. 79	Basic ADS-B Message Format & Encoding Format of Basic ADS-B Message Payload Turn Indicator NUCp (or NIC) Turn Indicator TI or BAO(Barometric Altitude Quality) Integrity Level NAC p	
R2.13	All non-stationary ADS-B subsystem installations shall provide dynamic state vector reporting.	N/A	Out of Scope; Installation Certification issue	Installation Certification Requirement
R2.14	Position information shall be transmitted in a form that can be translated, without loss of accuracy and integrity, to latitude, longitude, and barometric altitude and geometric height.	2.2.4.1.4 2.2.4.1. 45 2.2.4.1. 56 2.2.4.1.1 46 2.2.4.2. 14	Latitude Longitude Valid Pressure Altitude Geometric Altitude	
R2.15	All geometric position elements shall be referenced to the WGS-84 ellipsoid.	2.2.4.1.4 2.2.4.1. 45 2.2.4.1. 132-3 2.2.4.1.13	Latitude Longitude Geometric Altitude	
R2.16	Horizontal latitude and longitude position shall be reported as a geometric position.	2.2.4.1.4 2.2.4.1. 45	Latitude Longitude	
R2.17	Both barometric pressure altitude and geometric height shall be reported, if available.	2.2.4.1.14 2.2.4.1. 132-3	Primary essure Altitude Geometric Altitude Type	
R2.18	Barometric pressure altitude shall be reported referenced to standard temperature and pressure.	2.2.7.1.6.1	Input Data refers to "pressure altitude"	Reference not specified
R2.19	Altitude shall be provided with a range of -1,000 ft up to 100,000 ft.	2.2.4.1.14	Pressure Altitude	

Table B-1: MASPS Compliance Matrix (continued)

MASPS Ref. #	Requirement	MOPS Ref. #	Title / Description	Compliance																								
R2.20	The transmitting A/V shall provide the following information: 1. Horizontal Velocity Vector 2. Vertical Rate	2.2.4.1.1 12 2.2.4.1.1 23 2.2.4.1.1 56 2.2.4.2.4	North Velocity or Ground Speed East Velocity or Heading Pressure Altitude Rate Geometric Altitude Rate																									
R2.21	ADS-B geometric velocity information shall be referenced to WGS-84			Reference not specified																								
R2.22	The horizontal velocity vector components are defined as the north-south and east-west velocity relative to the WGS-84 earth ellipsoid. Reported ranges shall be [0–250] knots on the surface and [0–4000 knots] airborne.	2.2.4.1.1 12 2.2.4.1.1 23	North Velocity or Ground Speed East Velocity or Heading																									
R2.23	Altitude rate shall be designated as climbing or descending and shall be reported up to 32,000 feet per minute (fpm).	2.2.4.1.1 56	Pressure Altitude Rate																									
R2.24	For NUCP values 8 and 9, geometric altitude rate shall be reported.	2.2.4.1.15 Table 2-7	Primary Altitude Rate Navigation Accuracy Category Codes	Use Pressure altitude for NAC 8; geometric rate use not required in MOPS																								
R2.25	For other NUC values, barometric altitude rate or inertially augmented barometric altitude rate shall be reported.	2.2.4.1.15 Table 2-7	Primary Altitude Rate Navigation Accuracy Category Codes	Geometric and barometric rates can be reported. No MOPS req. related to NxC.																								
R2.26	An Airborne turn indication shall be designated as turning right, turning left, or not turning.	2.2.4.1. 840	Turn Indicator (TD)[or BAO (Barometric Altitude Quality)]																									
R2.27	The velocity uncertainty category of the least accurate velocity component being supplied by the reporting A/V's source of velocity data shall be as indicated in Table 2-1b: <table border="1"> <thead> <tr> <th>NUC</th> <th>R</th> <th>Horiz. 95%</th> <th>Vert. 95%</th> </tr> </thead> <tbody> <tr> <td>0</td> <td></td> <td>Unk.</td> <td>Unk.</td> </tr> <tr> <td>1</td> <td></td> <td><10 m/s</td> <td>> 50 f/s</td> </tr> <tr> <td>2</td> <td></td> <td>< 3 m/s</td> <td>< 15 f/s</td> </tr> <tr> <td>3</td> <td></td> <td>< 1 m/s</td> <td>< 5 f/s</td> </tr> <tr> <td>4</td> <td></td> <td>< 0.3 m/s</td> <td>< 1.5 f/s</td> </tr> </tbody> </table>	NUC	R	Horiz. 95%	Vert. 95%	0		Unk.	Unk.	1		<10 m/s	> 50 f/s	2		< 3 m/s	< 15 f/s	3		< 1 m/s	< 5 f/s	4		< 0.3 m/s	< 1.5 f/s	2.2.4.1.1 67 Table 2. 2.4.1.16-10 NACv Codes	NUC_R [or NAC_v]NAC_v	
NUC	R	Horiz. 95%	Vert. 95%																									
0		Unk.	Unk.																									
1		<10 m/s	> 50 f/s																									
2		< 3 m/s	< 15 f/s																									
3		< 1 m/s	< 5 f/s																									
4		< 0.3 m/s	< 1.5 f/s																									
R2.28	The ADS-B system shall be capable of supporting broadcast of emergency and priority status	2.2.4.2. 6 Table 2. 2.4.2.6-11	Type 1 Long ADS-B Message Payload Format & Encoding Format of Long Type 1 ADS-B Payload																									

Table B-1: MASPS Compliance Matrix (continued)

MASPS Ref. #	Requirement	MOPS Ref. #	Title / Description	Compliance
R2.29	Status shall include the following: 1. No emergency / Not reported 2. General emergency 3. Lifeguard/medical 4. Minimum fuel 5. No communications 6. Unlawful interference 7. Spare 8. Spare	2.2.4.2.6 Table 2.2.4.2.6	Emergency/Priority Status	
R2.30	The ADS-B system shall provide the capability to exchange Trajectory Change Point (TCP) and Trajectory Change Point + 1 (TCP+1) data defined below.	2.2.4.4	Long Type 3 Message (Original format for TCP and TCP+1)	
R2.31	ADS-B transmissions shall indicate the ability of the transmitting participant to engage in path monitoring and/or de-confliction operations.	2.2.4.2.4 Table 2-14	Capability Class (CC) Codes	TCAS/ACAS ops.
R2.32	The transmitting A/V shall also indicate its capability to use intent information received from other participants			
R2.33	The rate shall be sufficient to ensure continuous positive assessment by the receiving aircraft at least 2 minutes (5 minutes within the range limitations specified in Table 2-3) prior to reaching closest point of approach for class A2 (A3) equipage			
R2.34	The aircraft planning the change shall issue the TCP+1 information at least 5 minutes prior to commencing the trajectory change associated with the TCP.			Out of Scope; FMS/Navigation function must provide timely info.
R2.35	TCP+1 information, shall be provided until commencing the change maneuver.			Out of Scope; FMS/Navigator function
R2.36	The TCP+1 required transmission rate shall be the same as that of the TCP	2.2.6.1.3	Table 2.2.6.1.3: ADS-B Message Type Assignment to MTO (see Long Type 3)	
R2.37	The ADS-B system shall be expandable so as to support information transfer requirements for additional applications not specifically identified in this MASPS.	2.2.4 Table 2.2.4	The ADS-B Message Payload ADS-B Message Payload Types	

Table B-1: MASPS Compliance Matrix (continued)

MASPS Ref. #	Requirement	MOPS Ref. #	Title / Description	Compliance
R2.38	While the individual parameter values in the table (Table 2-4a) may not be directly applicable to the ADS-B system, the ADS-B System shall support equivalent or better overall system level performance for the cited applications			
R3.1	Equipage of a class designated in Table 3-1 shall have, at a minimum, the indicated capabilities.	2.1.11	Equipage Classes	
R3.2	ADS-B equipage classes summarized in Table 3-1 shall provide the air-to-air coverage specified in Table 3-2(a).			
R3.3	The effective radiated power (ERP) and minimum signal detection capabilities shall support the associated pair-wise minimum operational ranges listed in Table 3-2(b).	2.1.12 Table 2-3	Transmitting Subsystem Transmitter Power Requirements	Refer to Appendix TBD for range capability.
R3.4	Broadcast only aircraft (class B1) shall have ERP values equivalent to those of class A0, A1, or A2 as determined by own aircraft maximum speed, operating altitude, and corresponding coverage requirements	2.1.11 Table 2-1	Equipage Classes UAT Installed Equipment Classes	
R3.5	Ground vehicles operating on the airport surface (class B2) shall provide a 5 nmi coverage range for an A1 class receiver.	2.1.11 Table 2-1	Equipage Classes UAT Installed Equipment Classes	Refer to Appendix TBD for range capability.
R3.6	Such ground vehicles (class B2) shall automatically prohibit ADS-B transmissions when outside the surface movement area (i.e., runways and taxiways)			
R3.7	Fixed obstruction (class B3) broadcast coverage shall be sufficient to provide a 10 nmi coverage range from the location of the obstruction.	2.1.11 Table 2-1	Equipage Classes UAT Installed Equipment Classes	Refer to Appendix TBD for range capability.
R3.8	Each equipage class shall meet the required information broadcast and receiving capability at the indicated range to support the applications indicated in Table 3-3.	2.1.11 Table 2-1	Equipage Classes UAT Installed Equipment Classes	Refer to Appendix TBD for range capability.

Table B-1: MASPS Compliance Matrix (continued)

MASPS Ref. #	Requirement	MOPS Ref. #	Title / Description	Compliance
R3.9	Report accuracy, update period and acquisition range requirements are derived from the sample scenarios of Chapter 2, and are specified in Table 3-3(a). The state vector report shall meet the update period and 99 percentile update period requirements for each application listed.			
R3.10	For all of the scenarios included in Table 3-4, the state vector shall be acquired with a 95% confidence by the range specified for the scenario.			
R3.11	The minimum range at which mode status and on-condition reports shall be acquired with 95% confidence is specified in Table 3-4.			
R3.12	Acquisition shall be considered accomplished when all report elements required for an operational scenario have been received by an ADS-B participant.			
R3.13	Required ranges for acquisition shall be as specified in Table 3-4.			
R3.14	The ADS-B system shall satisfy the error budget requirements specified in the table in order to assure satisfaction of ADS-B report accuracies.			
R3.15	If a smoothing filter or tracker is used in the ADS-B design, the quality of the reports shall be sufficient to provide equivalent track accuracy implied in Table 3.3-3 over the period between reports, under target centripetal accelerations of up to 0.5g with aircraft velocities of up to 600 knots.			
R3.16	For NUC_P less than 8, ADS-B latency of the reported information shall be less than 1.2 s with 95 percent confidence.	2.2.6.3	Time of Applicability of ADS-B Message Payload Fields	
R3.17	For NUC_P \geq 8, ADS-B latency shall be less than 0.4 s with 95% confidence.	2.2.6.3.3	Latency of OtherMessage Payload Fields (UTC or Non-UTC Coupled)	
R3.18	The standard deviation of the report time error shall be less than 0.5 s (1 sigma).			
R3.19	The mean report time error for position shall not exceed 0.5 s.			
R3.20	The mean report time error for velocity shall not exceed 1.5 s			

Table B-1: MASPS Compliance Matrix (continued)

MASPS Ref. #	Requirement	MOPS Ref. #	Title / Description	Compliance
R3.21	The ADS-B system shall be capable of operating in the traffic density shown by the highest curve in Figure 3-8 which indicates a total count of 1,000 units (moving and stationary) within a radius of 60 nmi.			
R3.22	The ADS-B Medium shall be suitable for all-weather operation, and ADS-B System performance will be specified relative to a defined standard interference environment for the medium.			
R3.23	Radio frequencies used for ADS-B Message transmission shall operate in an internationally allocated Aeronautical Radio Navigation bands	2.2.2.1	Transmission Frequency "...[978] MHz +/- 20 PPM."	
R3.24	ADS-B availability shall be 0.9995 for class A0 through class A3 and class B0 through class B3 transmission subsystems.			
R3.25	ADS-B availability shall be 0.95 for class A0 receiver subsystems.			
R3.26	Class A1, A2, and A3 receiver subsystems shall have an availability of 0.9995.			
R3.27	The probability that the ADS-B System, for a given ADS-B Message Generation Function and in-range ADS-B Report Generation Processing Function, is unavailable during an operation, presuming that the System was available at the start of that operation, shall be no more than 2×10^{-4} per hour of flight.			
R3.28	The integrity of the ADS-B System shall be 10^{-6} or better on a per report basis.			
R3.29	The messages shall be correlated, collated, uncompressed, re-partitioned, or otherwise manipulated as necessary to form the output reports specifically defined in Section 3.4.3.			
R3.30	The message and report assembly processing capabilities of the receiving system shall support the total population of participants within detection range provided by the specific data link technology			

Table B-1: MASPS Compliance Matrix (continued)

MASPS Ref. #	Requirement	MOPS Ref. #	Title / Description	Compliance
R3.31	Receiving subsystem designs must provide reports based on all decodable messages received, i.e., for each participant the report shall 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.			
R3.32	The applicable reports shall be made available to the applications on a continual basis in accordance with the local system interface requirements.			
R3.33	If the ADS-B design uses the ICAO 24-bit address, then there shall 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.			
R3.34	The pressure altitude reported in ADS-B (SV element 11) shall be derived from the same source as the pressure altitude reported in Mode C and Mode S for aircraft with both transponder and ADS-B			Out of Scope: Installation Certification responsibility
R3.35, R3.36	For systems utilizing segmented messages for SV data, critical state vector fields not updated in the current received message shall be estimated when the report is updated; otherwise fields shall be updated as new data is received.			
R3.37	The time of applicability relative to local system time shall be updated with State Vector report update.			
R3.38	For other elements of the SV report the assembly function shall provide update when received or indicate 'no data available' if none is received in the preceding 10 second period.			
R3.39	The NUC data elements shall be those determined by the originating participant as defined in Section 2.1.2.2.4.			
R3.40	ADS-B State vector reports for each participant shall be available to applications as soon as each participant is detected.			

Table B-1: MASPS Compliance Matrix (continued)

MASPS Ref. #	Requirement	MOPS Ref. #	Title / Description	Compliance
R3.41	For each participant the Mode Status report shall 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.			
R3.42	The time of applicability relative to local system time shall be updated with every Mode Status report update.			
R3.43	For all elements of the MS report the assembly function shall provide update when received or indicate 'no data available' if none is received in the preceding 10 second period			
R3.44	For each message received containing on-condition information, the on-condition report shall be updated and made available to ADS-B applications.	2.2.9	Report Generation Requirements "...Exactly one report shall be generated for each message successfully received."	
R3.45	The time of applicability relative to local system time shall be updated with every On-Condition report update.	2.2.9.1.2	Report Contents "Reports shall contain...b. An explicit message time of applicability..."	

Note: *MG = Message Generation; ME = Message Exchange; ME(T) = Message Exchange (transmit); ME® = Message Exchange (receive); RG = Report Generation*