MASPS for ADS-B Rev. A

Tracking Information (committee secretary only)	
Change Issue Number	46
Submission Date	08/15/01
Status (open/closed/deferred)	Rev A - CLOSED
Last Action Date	02/22/02

Short Title for Change Issue:	Revise table 3-3 and 3-4 to better reflect range dependency of requirements rather than application dependency

MASPS Document Reference:		Originator Information:	
Entire document (y/n)	n	Name	Jonathan Hammer
Section number(s)	3	Phone	703-883-5209
Paragraph number(s)		E-mail	Jhammer@mitre.org
Table/Figure number(s)	Table 3-3, Table 3-4	Other	

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	X	Clarity		Performance		Functional

Issue Description:

Table 3-3 and 3-4 were intended to list requirements acquisition and accuracy requirements primarily as a function of range. Instead, these table list applications as the primary delineating variable. Therefore the requirements as a function of range are not clear. The attached modification clarifies these tables.

Also, since our understanding and naming of applications has changed since the publication of DO-242, the applications cited in DO-242 in general are no longer meaningful and should be changed as per the attached tables.

Originator's proposed resolution:

See Attachment A for proposed changes to 3.2.3.1, where green highlighted and blue underlined text is proposed additions, and red highlighted text is proposed deletions.

Working Group 6 Deliberations:

August 30, 2001: This issue paper was reviewed at the August WG6 meeting. It was agreed this Issue Paper will be addressed in Revision A by implementing the MASPS changes proposed in Attachment A of this Issue Paper.

- The acceptance of this Issue Paper means IP03 must be closed since the MASPS changes for this Issue Paper's resolution make IP03 moot.
- While the changes to Table 3-4 are accepted as found in Attachment A, the resolution of IP35 will mean further changes to the Table and Note 7.

January 11, 2002: While working on a resolution to IP35, which requested Note 7 of Table 3-4 be ether deleted or modified, it was proposed that a new note be added to Table 3-4 now that it has been rearranged to stress the range-dependency of the requirements. This note would be cited in the 90 nmi column in the three boxes where 90 nmi is mentioned. The purpose of this note is to clarify the applications and airspace conditions for which the aircraft density requirements were developed for ranges where 40 nmi < R <= 90 nmi. The new note reads as follows: "Air-to-air ranges extending to 90 nmi are intended to support the application of Flight Path Deconfliction Planning, Cooperative Separation in Oceanic/Low Density En Route Airspace, as described in Section 2.2.2.4."

February 1, 2002: This IP was reviewed again by WG6 at their January 2002 meeting. There were arguments from WG5 that the new note proposed in January (see above) did not reflect that the operations for ranges between 40 and 90 nmi are to be capable of being done above more dense terminal airspace. During a SC-186 leadership telecon, Rocky Stone took an action item to reflect this in note "c" of Table 2-3. This will also be reflected in the new note for Table 3-4 and has been reflected in the Final Resolution found below.

Working Group 6 Final Resolution:

The final resolution for this IP was to reorganize Tables 3-1, 3-2(a), 3-2(b), and 3-4(a) as documented in Attachment A of this Issue Paper. However, other changes due to other Issue Papers were also done to some of these tables. For the final state of these tables, the reader is referred to the final draft of DO-242A delivered to RTCA on March 4, 2002 by Working Group 6.

3.2.3.1 Interactive Aircraft/Vehicle ADS-B Subsystems (Class A)

Functional capabilities of interactive aircraft/vehicle subsystems are indicated in the context diagram of Figure 3~~4~~. These subsystems accept own-platform source data, exchange appropriate ADS-B messages with other interactive ADS-B System participants, and assemble ADS-B reports supporting own-platform applications. Such interactive aircraft subsystems, termed Class A subsystems, are further defined by equipage classification according to the provided user capability. The following types of Class A subsystems are defined in (Table 3-1):

- Class A0: Supports minimum interactive capability for participants. Broadcast ADS-B messages are based upon own-platform source data. ADS-B messages received from other aircraft support generation of ADS-B reports ~~which~~ that are used by on-board applications (e.g., CDTI for aiding visual acquisition of other-aircraft tracks by the own-aircraft's air crew). This equipage class may also support interactive ground vehicle needs on the airport surface.
- Class A1 supports all class A0 functionality and additionally supports e.g., ADS-B ~~conflict avoidance~~airborne conflict management and other applications to ranges < 20 nmi. Class A1 is intended for operation in IFR designated airspace.
- Class A2: Supports all class A1 functionality and additionally provides extended range to 40 nmi and information processing to support ~~optimized separation~~ longer range applications, e.g., oceanic climb to co-altitude. This service requires the broadcast and receipt of trajectory change point data (TCP).
- Class A3: Supports all class A2 functionality and ~~additionally~~ has additional range capability out to 90 nmi, supporting, e.g., ~~supports flight path de-confliction~~long range airborne conflict management.~~ Class A3 subsystems support longer look-ahead times with longer operational ranges than class A2~~. Class A3 has the ability to broadcast and receive strategic planning information such as future trajectory change point data (TCP+1).

Table 3-1 Subsystem Classes and Their Features

Class	Subsystem	Example Applications	Features	Comments
Interactive Aircraft/Vehicle Participant Subsystems (Class A)				
A0	Minimum Interactive Aircraft/Vehicle	Enhanced visual acquisition, conflict detection	Lower Tx power and less sensitive Rx than Class A1 permitted.	Minimum interactive capability with CDTI.
A1	Basic Interactive Aircraft	A0 plus Airborne Conflict management, station keeping	Standard Tx and Rx	Provides ADS-B based conflict avoidance and interface to current TCAS surveillance algorithms/ display
A2	Enhanced Interactive Aircraft	A1 plus Merging, conflict management, in-trail climb	Standard Tx power and more sensitive Rx. Interface with avionics source required for TCP data.	Baseline for separation management employing intent information.
A3	Extended Interactive Aircraft	A2 plus long range conflict management	Higher Tx power and more sensitive Rx. Interface with avionics source required for TCP and TCP+1 data	Extends planning horizon for strategic separation employing intent information.
Broadcast-Only Participant Subsystems (Class B)				
B1	Aircraft Broadcast only	Supports A1 applications for other participants	Tx pwr may be matched to coverage needs. NAV input required.	Enables aircraft to be seen by Class A and Class C users.
B2	Ground vehicle Broadcast only	Supports airport surface situational awareness	Tx pwr matched to surface coverage needs. High accuracy NAV input required.	Enables vehicle to be seen by Class A and Class C users.
B3	Fixed obstruction	Supports visual acquisition and airborne conflict management	Fixed coordinates. No NAV input required. Collocation with obstruction not required with appropriate broadcast coverage.	Enables NAV hazard to be detected by Class A users
Ground Receive Subsystems (Class C)				
C1	ATS En route and Terminal Area Operations	Supports ATS cooperative surveillance	Requires ATS certification and interface to ATS sensor fusion system.	En route coverage out to 200 nmi. Terminal coverage out to 60 nmi.
C2	ATS Parallel Runway and Surface Operation	Supports ATS cooperative surveillance	Requires ATS certification and interface to ATS sensor fusion system.	Approach coverage out to 10 nmi. Surface coverage out to 5 nmi.
C3	Flight Following Surveillance	Supports private user operations planning and flight following	Does not require ATS interface. Certification requirements determined by user application.	Coverage determined by application.

Table 3-3(a) Interactive Aircraft/Vehicle Equipage Type Operational Capabilities

Domain ->	Terminal, En-route, Oceanic										Approach		Airport Surface	
Equipage Class | \/	Data Reqd to Support Operational Capability | \/		(R<=10 nmi), eg, Conflict detection, Enhanced visual Acquisition		(R<=20 nmi),e.g., Airborne Conflict management, station keeping		(R<=40 nmi), e.g., Merging, conflict management, in-trail climb		(R<=90 nmi), e.g., Long range conflict management		(R<=10 nmi), e.g., AILS, paired approach		(R<=5 nmi), e.g., Airport Surface Situation Awareness	
	Tx	Rx	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form
A0 Minimum R=10 nmi	SV MS-P	SV	Yes	Yes	Yes	No	No	No	No	No	No	No	Yes	Yes
A1 Basic R=20 nmi	SV MS-P	SV MS-P	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes
A2 Enhanced R=40 nmi	SV MS	SV MS	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes
A3 Extended R=90 nmi	SV MS OC	SV Ms OC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: SV= State Vector; MS-P= (Partial) Mode-status w/o TCP; MS= Mode-status w/TCP; OC= On Condition with TCP+1

* Operation in airspace with high closure rates may require longer range.

** Class A2 and A3 users may equip for low visibility taxi following.

Table 3-3(b) Broadcast and Receive Only Equipage Type Operational Capabilities

	Domain ->		Terminal, En-route, Oceanic								Approach		Airport Surface	
Equipage Class | \/	Data Reqd to Support Operational Capability | \/		(R<=10 nmi), eg, Conflict detection, Enhanced visual Acquisition		(R<=20 nmi),e.g., Airborne Conflict management, station keeping		(R<=40 nmi), e.g., Merging, conflict management, in-trail climb		(R<=90 nmi), e.g., Long range conflict management		(R<=10 nmi), e.g., AILS, paired approach		(R<=5 nmi), e.g., Airport Surface Situation Awareness	
	Tx	Rx	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form
B1 Aircraft	SV MS-P	No	Yes	No	Yes	No	No	No	No	No	No	No	Yes	No
B2 Gnd Vehicle	SV MS-P	No	Yes	No	Yes	No	No	No	No	No	No	No	Yes	No
B3 Fixed Obstruction	SV MS-P	No	Yes	No	Yes	No	No	No	No	No	No	No	Yes	No
C1 ATS En route & Terminal	No	SV MS OC	No	Yes	No	Yes	No	Yes	No	Yes	No	No	No	No
C2 Approach & Surface	No	SV MS OC	No	Yes	No	Yes	No	No	No	No	No	Yes	No	Yes
C3 Flight Following	No	SV MS OC	No	Yes	No	No	No	No	No	No	No	No	No	No

Notes: SV= State Vector; MS-P = (Partial) Mode-status w/o TCP; MS= Mode-status w/TCP; OC= On Condition with TCP+1

Table 3-4 ADS-B Report Accuracy, Update Period, and Acquisition Range Requirements

Operational Domain	Terminal, En-route, Oceanic				Approach	Airport Surface (note 5)
Applicable Range	R<= 10 nmi	R>10 nmi R<=20 nmi	R>20 nmi R<= 40 nmi	R>40 nmi R<=90 nmi	(R<=10 nmi)	(R<=5 nmi)
Equipage Class	A0-A3 B1-B3	A0-A3 B1-B3	A2-A3	A3	A1-A3	A0-A3 B1-B3
Example Applications	Conflict detection, Enhanced visual Acquisition	Airborne Conflict management, station keeping	Merging, conflict management, in-trail climb	Long range conflict management	AILS, paired approach	Surface situational awareness
Required State Vector Acquisition Range	10 nmi	20 nmi	40 nmi	90 nmi (notes 3, 14) (120 nmi desired)	10 nmi	5 nmi
Required Mode-status Acquisition Range (note 8)	10 nmi	20 nmi	40 nmi	90 nmi (notes 3, 14) (120 nmi desired)	10 nmi	5 nmi
Required On Condition Acquisition Range (note 8)	n/a	n/a	n/a	90 nmi (notes 3, 14) (120 nmi desired)	10 nmi	TBD
Required Nominal Update Period (95th percentile) (note 6) ~~(note 7)~~	<= 3 s (3 nmi) <= 5 s (10 nmi) (note 7)	<= 5 s (10 nmi) (1 s desired, note 2) <= 7 s (20 nmi)	<= 7 s (20 nmi) <= 12 s (40 nmi)	<= 12 s	<= 1.5 s (1000 ft runway separation) <= 3 s (1s desired) (2500 ft runway separation)	<= 1.5 s
Required 99th Percentile State Vector Report Received Update Period (Coast Interval) (Note ~~7,~~ 8)	<= 6s (3 nmi) <= 10 s (10 nmi) (note 7)	<= 10 s (10 nmi) <= 14 s (20 nmi)	<= 14 s (20 nmi) <= 24 s (40 nmi)	<= 24 s	<= 3s (1000 ft runway separation) (1s desired, note 2) <= 7s (2500 ft runway separation)	<= 3 s
Example Permitted Total State Vector Errors Required To Support Application (1 sigma, 1D)	σ_{hp} = 200 m σ_{hv} = n/a σ_{vp} = 32 ft σ_{vv} = 1 fps	σ_{hp} = 20 / 50 m (note 1) σ_{hv} = 0.6/ 0.75 m/s (note 1) σ_{vp} = 32 ft σ_{vv} = 1 fps	σ_{hp} = = 20 / 50 m (note 1) σ_{hv} = 0.3/ 0.75 m/s (note 1) σ_{vp} = 32 ft σ_{vv} = 1 fps	σ_{hp} = 200 m σ_{hv} = 5 m/s σ_{vp} = 32 ft σ_{vv} = 1 fps	σ_{hp} = 20 m σ_{hv} = 0.3 m/s σ_{vp} = 32 ft σ_{vv} = 1 fps	σ_{hp} = 2.5 m (note 9) σ_{hv} = 0.3 m/sσ σ_{vp} = n/a σ_{vv} = n/a
Required maximum error contribution due to ADS-B (1 sigma, 1D) (Note 10)	σ_{hp} = 20 m σ_{hv} = 0.25 m/s σ_{vp} = 30 ft σ_{vv} = 1 fps (Note 11)					σ_{hp} = 2.5 m (note 9) σ_{hv} = 0.25 m/s σ_{vp} = n/a σ_{vv} = n/a

Definitions:
σ_{hp}: standard deviation of horizontal position error.
σ_{hv}: standard deviation of horizontal velocity error.
σ_{vp}: standard deviation of vertical position error.
σ_{vv}: standard deviation of vertical velocity error.

Notes:

1. *The lower number represents the desired accuracy for best operational performance and maximum advantage of ADS-B. The higher number, representative of GPS standard positioning service, represents an acceptable level of ADS-B performance, when combined with barometric altimeter.*

2. *The analysis in Appendix J indicates that a 3-second report received update period for the full state vector will yield improvements in both safety and alert rate relative to TCAS II, which does not measure velocity. Further improvement in these measures can be achieved by providing a one-second report received update rate Further definition of ADS-B based separation and conflict avoidance system(s) may result in refinements to the values in the Table.*

3. *The 90 nmi range requirement applies in the forward direction. The required range aft is 30 nmi (40 nmi desired). The required range 90 degrees to port and starboard is 45 nmi (60 nmi desired) (see Appendix H).*

4. *n/a = not applicable; TBD = To be defined*

5. *Requirements apply to both aircraft and vehicles.*

6. *Supporting analyses for update period and update probability are provided in Appendices J and L.*

7 *Requirements for applications for ranges less than 10 nmi are under development. The 3 second update requirement is the minimum update period required to support ACM for aircraft pairs within 3 nmi and 6000 feet vertical separation that are converging at a rate of greater than 500 feet per minute vertically or greater than 6000 feet per minute laterally. Update rate requirements are once per 5 seconds (95%) for aircraft pairs that are not within these geometrical constraints, such as aircraft pairs that are diverging. Requirements for future applications, however, may differ from these requirements.*

8. *The delay for MS or OC report updates after a MS or OC state change should be no more than the coast interval associated with the state vector report (with 95% confidence).*

9. *The position accuracy requirement for aircraft on the airport surface is stated with respect to the certified navigation center of the aircraft.*

10. *This row represents the allowable contribution to total state vector error from ADS-B.*

11. *The horizontal velocity error requirements to aircraft speeds of up to 600 knots. Accuracies required for velocities above 600 knots are TBD.*

12. *Specific system parameter requirements in Table 3-4 can be waived provided that the system designer shows that the application design goals stated in Appendix J or equivalent system level performance can be achieved.*

13. *Update periods for the SV have been emphasized in determining link related performance requirements in this table. Lower rates of MS and OC are under development. These reports should be made available to support the operational capabilities using considerations equivalent to the SV. The requirement should be optimized to ensure that the refresh/update of reports is appropriate for the*

equipment classes and the operations being supported. Refer to the analysis presented in Appendix L for further details.

14. *Air-to-air ranges extending to 90 nmi are intended to support the application of Flight Path Deconfliction Planning, Cooperative Separation in Oceanic/Low Density En Route Airspace, as described in Section 2.2.2.4.*