

Table 3-4 Note 7 Emails

(Changes for IP35 are shown in yellow highlight.)

(Changes for IP46 are shown in green highlight.)

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)	$\sigma_{hp} = 200$ m $\sigma_{hv} = n/a$ $\sigma_{vp} = 32$ ft $\sigma_{vv} = 1$ fps	$\sigma_{hp} = 20 / 50$ m (note 1) $\sigma_{hv} = 0.6 / 0.75$ m/s (note 1) $\sigma_{vp} = 32$ ft $\sigma_{vv} = 1$ fps	$\sigma_{hp} = 20 / 50$ m (note 1) $\sigma_{hv} = 0.3 / 0.75$ m/s (note 1) $\sigma_{vp} = 32$ ft $\sigma_{vv} = 1$ fps	$\sigma_{hp} = 200$ m $\sigma_{hv} = 5$ m/s $\sigma_{vp} = 32$ ft $\sigma_{vv} = 1$ fps	$\sigma_{hp} = 20$ m $\sigma_{hv} = 0.3$ m/s $\sigma_{vp} = 32$ ft $\sigma_{vv} = 1$ fps	$\sigma_{hp} = 2.5$ m (note 9) $\sigma_{hv} = 0.3$ m/s $\sigma_{vp} = n/a$ $\sigma_{vv} = n/a$
Required maximum error contribution due to ADS-B (1 sigma, 1D) (Note 10)	$\sigma_{hp} = 20$ m $\sigma_{hv} = 0.25$ m/s $\sigma_{vp} = 30$ ft $\sigma_{vv} = 1$ fps (Note 11)					$\sigma_{hp} = 2.5$ m (note 9) $\sigma_{hv} = 0.25$ m/s $\sigma_{vp} = n/a$ $\sigma_{vv} = n/a$

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 at 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.*

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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.*

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-----Original Message-----

From: Jonathan Hammer <jhammer@mitre.org>
Sent: Thursday, January 03, 2002 9:52 AM
To: Stuart Searight; Steve Heppe <SteveHeppe@aol.com>; Bill Harman <harman@ll.mit.edu>; Tom Foster <tefoster@collins.rockwell.com>
Subject: Table 3-4, Note 7

Hi All,

Steve and I have discussed the subject above and we propose the following text to replace note 7. We will keep table 3-4 as per the proposed revision, and replace note 7. Note 7 will now only reference the column labeled R < 10 NM. Here is our proposal:

Note 7:

"Requirements for airborne conflict management (ACM) 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 500 feet per minute vertically or 6000 feet per minute laterally. Update rate requirements may be relaxed to once per 5 seconds (95%) for aircraft pairs that are not within these geometrical constraints, i.e., aircraft pairs that are diverging, and for applications other than ACM."

Sincerely, Steve H

-----Original Message-----

From: William Harman <harman@ll.mit.edu>
Sent: Friday, January 04, 2002 11:40 AM
To: Jonathan Hammer <jhammer@mitre.org>
Cc: Stuart Searight; Steve Heppe <SteveHeppe@aol.com>; Tom Foster <tefoster@collins.rockwell.com>
Subject: Re: Table 3-4, Note 7

Hi Jonathan and Steve, I'm having trouble understand the meaning of this draft. Here are some questions in my mind:

(1) The draft wording seems ambiguous to me in one respect. The final sentence says, "... requirements may be relaxed..." Does this mean, "... requirements are relaxed..." ? or does it mean "... requirements may be relaxed in the future, but they are not relaxed now.?" The first sentence suggests changes in the future.

(2) The term Airborne Conflict Management (ACM) seems confusing as drafted in the first sentence. Although the new note would apply only to the R<10 nmi column, the applications listed in this column do not include ACM, but they do include ACM for most of the other columns.

Thinking back on my original comment, there is a definite inconsistency in the existing Note 7. To delete the note would correct the inconsistency. But if we replace it with some other wording, I hope we can make it clear.

Bill

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----- Original Message -----

Subject: Re: [Fwd: Table 3-4, Note 7]
Date: Fri, 04 Jan 2002 11:57:58 -0500
From: "Stanley R. Jones" <sjones@mitre.org>
To: Jonathan Hammer <jhammer@mitre.org>, <sjones@mitre.org>

Jonathan, This notion levels me uneasy. All our previous thinking on collision avoidance was based on the assumption that even though for some reason, you might be experiencing poor reception when in the presence of a potential threat, you were still broadcasting at a high enough rate to assure that the threat saw you with an appropriate alert time. We have lost that assurance (and the associated safety margin) with this adaptive rate concept. Collision avoidance should not depend on adaptive behavior since it is a last resort capability. I think our 95% received update interval requirement should be linear with separation range from 3 sec at 3 nmi to 12 sec at 40 nmi, regardless of any neighbor's behavior. Without a continuous broadcast rate adequate for any unexpected loss of reception interval, I don't see how we can ever hope to provide an acceptable collision avoidance capability.

Stan

-----Original Message-----

From: SteveHeppe@aol.com
Sent: Saturday, January 05, 2002 12:33 PM
To: Stuart Searight; jhammer@mitre.org; harman@ll.mit.edu; sjones@mitre.org; tefoster@collins.rockwell.com
Cc: pn@adsi-m4.com; steve@adsi-m4.com Subject: Re: Note 7

Dear Jonathan et. al.,

Thanks for your forwarded comments from Bill and Stan (who I have included in this response). Here is a slightly clarified text which does not change any of the intended meaning (only clarifies what I believe we agreed by telephone). It also responds to some of Bill's concerns. Other comments to Bill and Stan are added below. I'll be around over the weekend and early next week, to hopefully close out this action.

Clarified text (inserts "greater than" in two places to emphasize a threshold, and replaces "may be relaxed to" with "are"):

"Requirements for airborne conflict management (ACM) 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, i.e., aircraft pairs that are diverging, and for applications other than ACM."

I'll leave it to you, Jonathan, to answer the ACM question in relation to the columns. (I'm not up to speed on this one).

Regarding Stan's concern, I would say that the MASPS should capture performance requirements. The way a requirement is achieved should be left up to the designer. If we agree that the requirement is well-captured by the above wording, than it is left to the system designer to ensure proper behavior. If a system designer (or certifying authority) believes that a

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higher update rate must be commanded "early" in order to ensure a given behavior, than so be it. But the MASPS should only state the requirement.

An operational algorithm can "anticipate" if needed to compensate for occasional message drop-outs and thereby ensure proper satisfaction of the requirement. This works for the poor reception case noted by Stan, with either or both aircraft experiencing poor reception. I'll emphasize again that all implementation details for a particular link are down at the MOPS level and should be excluded from the MASPS, which focuses on system performance.

Complete reception failure for an extended period of time is a major hardware failure since it affects two frequencies and all antennas. This can be ignored from a MASPS standpoint (e.g., the FAA is not requiring redundant hardware for ADS-B, and airlines today can dispatch with failed TCAS).

We need to be very careful about defining terms such as "Collision avoidance". I'll again leave it to you, Jonathan, to resolve this issue and correlate with ACM.

Regarding the linear interpolation of update rate with range, I am not sure where this comes from. The only application under discussion is the short-range threat probe application within ACM. All other applications either have update rate requirements longer than 5 seconds, or can be commanded to a quicker rate as needed (eg, parallel approach). The short-range threat probe application within ACM is a binary situation where we either have a potential threat or we don't. If we have a potential threat, we want a higher update rate. If there is no threat, the higher update rate is not required. We should not fear the principle of adaptive behavior. Many aeronautical systems employ adaptive behavior (including TCAS).

In summary, I do not see any "holes" in the concept at the present time (but of course we need to define ACM if it is not defined elsewhere).

I look forward to further discussion, and hopefully consensus.

Sincerely, Steve Heppe

-----Original Message-----

From: Jonathan Hammer <jhammer@mitre.org>
Sent: Monday, January 07, 2002 6:42 AM
To: SteveHeppe@aol.com
Cc: Stuart Searight; harman@ll.mit.edu; sjones@mitre.org; tefoster@collins.rockwell.com; pn@ads-i-m4.com; steve@ads-i-m4.com
Subject: Re: Note 7

Hi All,

It seems to me that this should be a topic for discussion at the January 28 - February 1 WG6 meeting. I feel that Steve and I have a proposal on the table that should be reviewed by the WG. I also feel that Stan has some valid concerns that should also be discussed.

We've gone back and forth on this thing for quite a while now, and we've had a lot of proposals put forward to try and resolve it. The process has been made difficult and much more lengthy by our inability to get all the interested parties together at the same time to try and reach resolution. I

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know that Stuart plans to make a conference phone line available during the meeting. Can we pre-plan this specific discussion so that we make it available to all interested parties at a mutually agreed time?

We are approaching the deadline for the plenary ballot of this document. Those who choose not to participate in these discussions should consider forfeiting the option to non-concur on the ballot regarding this issue, or face the wrath of the rest of the group and the plenary.

Thanks & Regards,

Jonathan

-----Original Message-----

From: William Harman [mailto:harman@ll.mit.edu]
Sent: Tuesday, January 08, 2002 12:10 PM
To: Stuart Searight
Cc: SteveHeppe@aol.com; sjones@mitre.org; tefoster@collins.rockwell.com; steve@adsi-m4.com
Subject: Relax rate within 10 nmi?

Stuart, Steve, & Jonathan,
Steve's revision is effective in answering my first question (now saying clearly that this is a relaxation in the report rate requirement within 10 nmi).

Steve didn't try to answer my second question, and I'm still wondering about it (use of the term ACM). The draft we are considering is inconsistent with itself. It gives the appearance that the authors don't understand even the basics.

If we deleted note 7 as originally proposed in IP-35, we wouldn't have that problem.

In my view, Steve is proposing a separate change from the one proposed in IP-35. Steve's proposal is to relax the update rate requirement for the applications within 10 nmi. Whether the MASPS should be changed in that way is really a question for Working Group 1, which developed the material in section 1 and section 2.

Bill

-----Original Message-----

From: Stanley R. Jones [mailto:sjones@mitre.org]
Sent: Wednesday, January 09, 2002 12:15 PM
To: Stuart Searight; SteveHeppe@aol.com; harman@ll.mit.edu; tefoster@collins.rockwell.com; steve@adsi-m4.com; Jonathan Hammer;
Subject: Re: Note 7

Stu,
Mercifully, I got into this discussion a little late so I'm not sure what Steve's problem is. He wrote in a note Jonathan replied to on Jan 2, "ACAS is a unique application because it is a "safety net" associated with the failure of normal separation assurance functions, hence it

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cannot be commanded from an external entity." It seems to me we are therefore in agreement that broadcast rates should not be adaptive for the collision avoidance application.

Based on Figure J-12 in the MASPS, the choice of required reception rate at 95% is proportional to the acceptable loss in conflict alert time (for the rates at issue). Although the curve for 5 sec is not shown, a good inference is that you lose almost 2 sec relative to the 3 sec curve. If this is acceptable, we should change the MASPS, but notice that the higher broadcast rate after a threat detection at a lower reception rate does nothing except (as with TCAS) improve the burn through in interference to maintain the desired update rate. BTW, I don't even want to think about how you would certify Steve's adaptive rate notion.

As for my suggestion of a linear increase in update rate with range, it is nothing more than linear interpolation between points given in Table 3-4 as we originally intended. The step function interpretation yields double update values at the same range, implies that supported applications have discrete boundaries and can accept constant alert losses over considerable reductions in separation range. This is senseless.

Hope this helps.
Stan

-----Original Message-----

From: William Harman <harman@ll.mit.edu>
Sent: Friday, January 11, 2002 2:48 PM
To: Stuart Searight
Subject: Air-air surveillance to 90 nmi

Jonathan,

Earlier this week, we were discussing the new format for table 3-4, and in particular the aircraft density requirement for ranges to 90 nmi. To summarize what we said:

- (a) The existing MASPS adopted these requirements from the applications cited in section 2. For ranges to 90 nmi, the application is called "Flight Path Deconfliction Planning, Cooperative Separation in Oceanic/Low Density En Route Airspace". But where this application is cited in Table 3-4, the title is limited to just "Flight Path Deconfliction Planning."
- (b) I prefer the reformatting of the Table as you have proposed. It's similar to the way I have been using the table, but your version is better--very clear.
- (c) You made the point that your intention was to clarify the material in the table, not to change it, which I agree with. And furthermore that the original application to oceanic and low density enroute conditions might be clarified by a note.

Following is a draft of a note that might be used for this purpose. This could be new number, such as note 14. The note would be cited in the 90 nmi column, in the three boxes where 90 nmi is mentioned.

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Note 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.

Bill