CHANGE ISSUE – RTCA/DO-242

# MASPS for ADS-B Rev. A

| Tracking Information (committee secretary only) | |
|---|---|
| Change Issue Number | 26 |
| Submission Date | 2/23/01 |
| Status (open/closed/deferred) | Rev A – CLOSED |
| Last Action Date | 2/22/02 |

| Short Title for Change Issue: | Format for Incorporating Short and Long-Term Intent Information |
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| MASPS Document Reference: | | Originator Information: | |
|---|---|---|---|
| Entire document (y/n) | yes | Name | Richard Barhydt, NASA |
| Section number(s) | 2.1.2.3.2, 2.1.2.3.3, 2.1.2.3.3.1, 2.1.2.3.3.2 | Phone | (757) 864-2065 |
| Paragraph number(s) | | E-mail | r.barhydt@larc.nasa.gov |
| Table/Figure number(s) | | Other | Intent Subgroup, WG4 |

| Proposed Rationale for Consideration (originator should check all that apply): | |
|---|---|
| | Item needed to support of near-term MASPS/MOPS development |
| X | DO-260/ED-102 1090 MHz Link MOPS Rev A |
| X | ASA MASPS |
| | TIS-B MASPS |
| X | 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 |
| | 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 |
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Issue Description:

The Intent Subgroup of SC186, WG4 is investigating the use of intent information in ADS-B messages. One fundamental issue concerns the way in which short and long-term intent information is incorporated into the message. Short-term intent refers to targets from the Mode Control Panel (MCP), such as commanded heading/track, altitude, vertical rate, and airspeed/Mach. Long-term intent is provided by Flight Management System (FMS) generated Trajectory Change Points (TCP's).

Two potential approaches include (and are hereafter referred to as "Method 1" and "Method 2"):

1) Integrating short and long-term intent into TCP's.

2) Sending short and long-term intent parameters separately, along with the current flight mode, and letting the receiving aircraft reconstruct the transmitting aircraft's trajectory. The potential benefits and drawbacks of each method are discussed below. The Intent Subgroup would like direction from the committee on the best way to proceed on this issue.

Issue Description (continued):

*Method 1*
Method 1 appears to be the approach favored by the current ADS-B MASPS (ref. DO-242 Sections 2.1.2.3.3.1 and 2.1.2.3.3.2 and Ref. 1) The transmitting aircraft considers all available intent information and creates TCP's that reflect where the aircraft's trajectory will change.

Benefits
- Requires fewer parameters to be sent.
- Information is less ambiguous, leading to ease in interpretation on receive side.

Drawbacks
- Requires complex trajectory generator on transmitting aircraft that must be capable of generating TCP's from both MCP and FMS parameters.
- Complexity on transmit side could lead to fewer aircraft being equipped to send intent information.

*Method 2*
This method has been the approach of the Intent Subgroup to date. The transmitting aircraft sends intent information from the MCP and FMS. Parameters include MCP settings (heading/track, altitude, vertical rate, and airspeed Mach) and FMS-generated TCP's such as waypoints, top of climb, and bottom of descent. In addition, the transmitting aircraft sends horizontal and vertical flight mode indicators that provide current and armed autopilot states.

Benefits
- Receiving aircraft has knowledge of command and planned trajectories. For instance, VNAV altitude constraints are still available, even if the transmitting aircraft plans to level-off at an intermediate altitude.
- Less complexity on transmit side could lead to earlier and more universal equipage.
    - Receive side trajectory generator could be designed to meet specific application requirements.
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Drawbacks
- Complex trajectory generator on receiving aircraft must re-construct the transmitting aircraft's path by considering the current flight mode and determining the relevant intent parameters.
- Requires large numbers of parameters to be sent.
- Information may be ambiguous.

A potential combined approach would allow TCP's to be generated on the transmit side, consistent with the aircraft's capability. The ability to create TCP's that incorporate short and long-term intent would represent a higher level of equipage. Aircraft that are only able to send TCP's generated within the FMS would supplement that information with at least the MCP selected altitude. In this case, a separate data field would be required to indicate the information provided in the TCP.

**Note**: Additional supporting material is contained in Working Paper 242A-WP-3-04.

**Note**: Also refer to Issue Paper 21, which was Closed and consolidated into this Issue Paper at the October, 2001 WG6 meeting. All Material from IP21 is found in attachment A of this Issue Paper.

Originator's proposed resolution:

The Intent Subgroup would like direction from the committee on the approach to sending intent information that should be pursued. This feedback will enable more detailed implementation work and a clarification of TCP definitions within DO-242.

**Note**: Additional supporting material is contained in Working Paper 242A-WP-3-04.

*Reference:*

1) Airbus, "Downlink of Airborne Parameters, Study on 'Selected Altitude' Parameter", NT 555.1172/00, 2000.

Working Group 6 Deliberations:

May 24, 2001: This Issue Paper was reviewed by the ad hoc group at their May 2001 meeting. It was agreed to edit this IP so that it only addresses short-term intent issues and flight mode indicators. (**AI 5-21:** The long-term intent aspects of this IP will be addressed by Tony Warren in the Appendix produced for IP21.) It was agreed that the edited Issue Paper will be addressed in Revision A. The edited IP will be finalized after deliberations at the ad hoc group's July meeting.

July 19, 2001: At the July WG6 meeting, this Issue Paper was formally CLOSED and replaced with Issue Paper 45 on short-term intent.

August 16, 2001: A joint meeting of WG1 and WG6 was held August 15 & 16 regarding how intent information and TCPs should be addressed in DO-242A. The results of this meeting were initial proposals of two reports that would be able to transmit all available information for short-term intent (Target State Reports) and TCPs/long-term intent (Trajectory Change Report). WG6 will draft a white paper fully defining this proposal and present it to the other SC186 WGs. Target schedule for the white paper is the December plenary. Since both short-term and long-term intent will now be addressed in DO-242A, it was agreed to RE-OPEN this Issue Paper and close IP45.

August 30, 2001: An initial draft of the Intent White Paper was reviewed at the August WG6 meeting. (242A-WP-7-01)

September 27, 2001: A second draft of the Intent White Paper was reviewed at the September WG6 meeting. (242A-WP-8-06)

October 26, 2001: A third draft of the Intent White Paper was reviewed at the October WG6 meeting. (242A-WP-9-02) A telecon was planned for November 20 for a final review of the paper so that it can be distributed before the December plenary. It was also agreed to close IP 21 on TCP Types and Parameters and have this Issue Paper address all TCP and Intent material.

December 14, 2002: The concept of TSRs and TCRs were briefed to plenary at the December SC186 meeting. After much discussion, plenary agreed that WG6 should proceed with developing hard requirements for both short- and long-term intent.

February 1, 2002: This Issue Paper was discussed at great length during the January WG6 meeting. New material was critiqued as part of the review of 242A-WP-11-01, and two teleconferences were held with WG5 and members of WG3 to discuss the acquisition range and update requirements for both TS and TC reports. For more detail on these discussions, please refer to the minutes from this meeting (020128-Minutes.pdf).

Working Group 6 Deliberations (***continued***):

February 22, 2002: Final MASPS text for short- and long-term intent for Sections 2 and 3 were approved by WG6 at their February meeting. This text, along with Appendices N and O will close this Issue Paper.

March 8, 2002: WG6 had a telecon on March 8 to review and accept Appendices N and O. After minor editing, these appendices were approved by WG6 and delivered to RTCA on March 12, 2002.

Working Group 6 Final Resolution:

Sections 2.1.2.19, 3.3.3.1.4, 3.4.8, and 3.4.9 within the draft DO-242A delivered to RTCA March 4, 2002 have undergone major edits or have been newly created in response to this Issue Paper and the redefining of how intent information is to be broadcast within ADS-B systems. Also created are two new appendices (N and O) with supporting information on how these new requirements were derived. The reader of this Issue Paper is refered to the draft DO-242A and these sections of the document.

The following Material is from Issue Paper 21, which was Closed and consolidated with this Issue paper following the October WG6 meeting.

Issue Description:

1. Need to clarify scope of TCP intent, i.e. are all planned changes in trajectory routing, vertical path and speed represented by TCP's or are TCP's only required for first order changes in path routing, and changes in climb, descent, level-off status?

2. Need to specify trajectory change type for each TCP to indicate flight segment change / type , e.g. fly-by turn transition, initiate climb segment, end climb segment (level-off). Without TCP type indicators, it may not be possible to unambiguously define or construct a predicted path segment to the TCP point, e.g. the start of turn for a Fly-By TCP is quite different than for a Fly-Over TCP. Similarly, TCP parameters could potentially be fixed, known values, dynamically estimated values, or path restrictions. TCP types can be used to clarify this ambiguity, e.g. an altitude restriction versus estimated altitude during a vertical transition.

3. TCP's only define the intended end-states (x,y,z,t) for a current or subsequent flight segment. Need to broadcast or report additional parameters to ADS-B applications which unambiguously define a nominal path segment to the TCP point. This is fundamentally an integrity issue, i.e. misleading information may be conveyed to an application if the transmitted ADS-B intent information is insufficient to construct a unique path in space to the TCP point. (The issue of trajectory path containment for separation assurance is an extension of this issue, which will be covered in a separate issue paper.)

Originally from Issue Paper 11 (Capt. Hilb):

4. The use of TCP Data Valid Subfield is not well explained. Proposed resolution is to change the MASPS as shown in Attachment A of this Issue Paper. (*Note: This comment is from Capt. Bob Hilb and was originally contained in Issue Paper 11. It was consolidated into this Issue Paper after consensus to do so was reached by the ad hoc group at their meeting held in May, 2001.*)

Originally from Issue Paper 31 (Tony Warren):

5. Current requirements on update rate for TCP's are implicit requirements and are not directly related to the functional requirements for applications using TCP's:
    - "The rate shall be sufficient to ensure continuous positive assessment by the receiving aircraft at least 2 minutes prior to reaching closest point of approach for class A2 equipage (5 minutes… for Class A3)."
    - "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."

6. Report rate should be lower for TCP's that are remote in time, e.g. whenever TTG to the TCP is larger than some threshold based on functional requirements for intent data.

Most TCP intent data is static or slowly changing until the time to TCP is imminent, or the TCP data changes to reflect new flight plan intent. The reporting rate should reflect this redundancy in most TCP data and not waste transmission bandwidth to update TCP data that is highly redundant.

Proposed Resolutions are on next two pages.

Originator's proposed resolution:

(1) The Intent Subgroup of WG-4 recommends that the scope of TCP intent be limited for DO242A to specific, well defined flight segment types as discussed below, representing basic horizontal and vertical flight segments which are explicitly defined in current FMS / RNP documents, e.g. DO236A. We also recommend that the scope of TCP intent remain consistent with tactical lookahead times as specified currently, or as needed for near term separation assurance applications. We propose to achieve this purpose by specification of Horizontal and Vertical TCP types, such that each flight segment is uniquely specified in ADS-B report formats by
- The Horizontal and Vertical TCP Segment Change Type,
- Parameters defining the Horizontal and Vertical path to the ending TCP, and
- The end-point TCP.

(2) The Intent Subgroup of WG-4 recommends that the scope of TCP intent be limited for DO242A to specific, well defined flight segment types as discussed below, representing basic horizontal and vertical flight segments which are explicitly defined in current FMS / RNP documents, e.g. DO236A. We also recommend that the scope of TCP intent remain consistent with tactical lookahead times as specified currently, or as needed for near term separation assurance applications. We propose to achieve this purpose by specification of Horizontal and Vertical TCP types, such that each flight segment is uniquely specified in ADS-B report formats by
- The Horizontal and Vertical TCP Segment Change Type,
- Parameters defining the Horizontal and Vertical path to the ending TCP, and
- The end-point TCP.

(3) Initial flight segment TCP change types recommended by the Intent Subgroup include:
- Horizontal segment changes: Track to a Fix (TF) and Direct to a Fix (DF) straight line transitions, Fly-By, Fly-Over, and Radius to a Fix (RF) turn transition segments,
- Vertical transition types: Initiate vertical transition (climb/descend), Exit vertical transition (level-off), Continue vertical path, and Altitude Restriction(s) at TCP.

Additional TCP types may be added as needed for near term applications, or in future MASPS as needed for evolving operational concepts, e.g. airspeed changes for medium term conflict alerting and path deconfliction.

Additional supporting material is contained in a separate powerpoint file. Which was resented at February 2001 ad hoc meeting as Working Paper **242A-WP-3-02**.

Originally from Issue Paper 11 (Capt. Hilb):

(4) Proposed MASPS changes from item #4 which was consolidated into this Issue Paper from Issue Paper 11 is found as attachment A.

Originally from Issue Paper 31: (Tony Warren)

(5) Proposed resolution is to broadcast TCP and TCP+1 information at a higher rate when the aircraft is within 2.5 minutes TTG to the affected TCP or TCP+1, and at a lower rate for TTG's larger than 2.5 minutes. (The 2.5 minute criterion is based on a nominal time budget for a flight plan deconfliction application. The time budget includes time for pilot assessment of an assumed Deconfliction Advisory, communications to the ground controller or intruder aircraft, and time to apply a moderate maneuver such as a flight level change to resolve the detected conflict prior to closest approach. See the attached material for further details.)

The high rate broadcasts must be sufficient for high probability of reception within a 10 second interval, i.e. 95% reception probability per 10 second interval. The low rate broadcasts are optional for level A2 equipage, and for level A3 equipage must be sufficient to receive at least one broadcast of TCP intent information with 99% probability between 5 minutes TTG and 2.5 minutes TTG to the affected TCP. (For example, this requirement may be achieved with a low rate broadcast of 30 seconds per transmission interval and a reception probability of at least 70% per broadcast.)

Originator's proposed resolution (continued):

(6) The above 2.5 minute criterion is not a requirement for a level A2 system, i.e. the requirement in section 2.1.2.3.3.1 would become "The rate shall be sufficient to ensure continuous positive assessment by the receiving aircraft at least 2 minutes TTG to the current TCP for class A2 equipage. For class A3 equipage, the transmission rate shall be sufficient to ensure continuous positive assessment by the receiving aircraft at least 2.5 minutes TTG to the affected TCP or TCP+1, and to receive at least one reception of TCP information between 2.5 minutes and 5 minutes TTG to the affected TCP."

(7) Major changes in TCP or TCP+1 intent will be signaled by an appropriate indicator in the Mode Status report. Such changes may require modification of the transmission rate in order to assure reception of changed TCP or TCP+1 intent subject to the same requirements in (2) and (3) above.

The intent of this proposal is to emphasize the importance of TCP information within 2.5 minutes of reaching a TCP point, and to de-emphasize the relative value of any remote TCP information more than 5 minutes away from the affected TCP.

Additional supporting material is contained in the following attachment B pages.