Department of Transportation
Federal Aviation Administration
Aircraft Certification Service
Washington, D.C.

TSO-C195

Effective
Date: 9/27/10

Technical Standard Order

Subject: ***Avionics Supporting Automatic Dependent Surveillance – Broadcast (ADS-B) Aircraft Surveillance Applications (ASA)***

1. PURPOSE. This technical standard order (TSO) is for manufacturers applying for a TSO authorization (TSOA) or letter of design approval (LODA). In it, we (the Federal Aviation Administration, or FAA) tell you what minimum performance standards (MPS) your ADS-B ASA systems and equipment must first meet for approval and identification with the applicable TSO marking.

2. APPLICABILITY. This TSO affects new applications submitted after its effective date.

3. REQUIREMENTS. New models of ADS-B ASA systems and equipment identified and manufactured on or after the effective date of this TSO must meet the MPS set forth in Section 2 of RTCA Document No. (RTCA/DO-317), *Minimum Operational Performance Standards for Aircraft Surveillance Applications System*, dated April 14, 2009 as modified by the functional equipment classes and other changes in Appendix 1 and Appendix 2 of this TSO.

Functional equipment classes for this TSO are defined by the avionics equipment functionality they provide for one or more of the four applications defined in Appendix 1. The three equipment functionalities are Cockpit Display of Traffic Information (CDTI) (Surface Only), CDTI, and Airborne Surveillance and Separation Assurance Processing (ASSAP). Applicable performance standards for these classes are identified in Appendix 2 and are based on Section 2 of RTCA/DO-317 as revised by Appendix 1. The functional equipment classes are shown in the following table.

Avionics / Application	CDTI (Surface Only) (A)	CDTI (B)	ASSAP (C)
Airborne (1)	Not Permitted	**CLASS B1**	**CLASS C1**
Surface (2) (Runways Only)	**CLASS A2**	**CLASS B2**	**CLASS C2**
Surface (3) (Runways & Taxiways)	**CLASS A3**	**CLASS B3**	**CLASS C3**
Enhanced Visual Approach (4)	Not Permitted	**CLASS B4**	**CLASS C4**

Table 1 – ASA Functional Equipment Classes

> **Note:** Appendix 1 does not revise or delete any requirements for the Conflict Detection application from RTCA/DO-317. DO-317 identifies the need for additional development of these requirements and acknowledges they "are not intended to be referenced by regulatory guidance". DO-317 requirements for the Conflict Detection application are not invoked in this TSO.

a. Functionality. This TSO's standards apply to equipment intended to be used in aircraft to display traffic using ADS-B message data from other aircraft. Applications 1 through 4 support a pilot's see and avoid responsibility. No existing responsibility is changed by virtue of installation of this equipment. Equipment authorized under this TSO must also comply with TSO-C165 when implementing Surface Applications. This TSO shall take precedence where it differs from TSO-C165. For example, databases must meet medium quality as defined in DO-272A to be considered compliant with this TSO. Equipment authorized under this TSO must contain or interface with equipment complying with TSO-C154c or TSO-C166b and TSO-C119b (if TCAS installed).

> **Note 1:** Equipment authorized under this TSO may include or interface with airborne multipurpose electronic display equipment complying with TSO-C113.

> **Note 2:** Position Sources interfaced to this equipment must meet TSO-C129, TSO-C145, TSO-C146, or TSO-C196 or equivalent.

b. Failure Condition Classifications. Failure of the function defined in paragraph **3a** of this TSO has been determined to be a major failure condition for malfunctions causing the display of hazardously misleading information in airborne aircraft and aircraft on the ground greater than 80 knots. Failure of the function defined in paragraph **3a** of this TSO has been determined to be a minor failure condition for malfunctions causing the display of hazardously misleading information in aircraft on the ground less than 80 knots groundspeed. Loss of function has been determined to be a minor failure condition. Develop the system to, at least, the design assurance level equal to these failure condition classifications.

c. Functional Qualification. Demonstrate the required functional performance under the test conditions specified in RTCA/DO-317, Sections 2.5 and 2.6 as modified by Appendix 1 and Appendix 2. All equipment authorized under this TSO **must demonstrate interoperability with an FAA ADS-R service broadcast.** In addition, equipment authorized under this TSO that includes a TIS-B function **must demonstrate interoperability with an FAA TIS-B service broadcast**.

> **Note:** Equipment designed for installations that include a TCAS processor are not required to implement TIS-B.

d. Environmental Qualification. Demonstrate the required performance under the test conditions specified in RTCA/DO-317, Section 2.4 using standard environmental conditions and test procedures appropriate for airborne equipment.

> **Note:** Although no specific version of RTCA/DO-160 environmental conditions and test procedures are specified, use of RTCA/DO-160D (with Changes 1 and 2 only, incorporated) or earlier version will require substantiation via the deviation process as discussed in paragraph **3g** of this TSO.

e. Software Qualification. If the article includes software, develop the software according to RTCA, Inc. document RTCA/DO-178B, *Software Considerations in Airborne Systems and Equipment Certification*, dated December 1, 1992. The software design assurance level should be consistent with the failure condition classification defined in paragraph **3b** of this TSO. All software included in the article definition must be developed according to RTCA/DO-178B.

f. Electronic Hardware Qualification. If the article includes a complex custom micro-coded component to accomplish the function, develop the component according to RTCA, Inc. document RTCA/DO-254, *Design Assurance Guidance for Airborne Electronic Hardware*. The hardware design assurance level should be consistent with the failure condition classification defined in paragraph **3b** of this TSO. All complex custom micro-coded components included in the article definition must be developed according to RTCA/DO-254.

g. **Deviations.** We have provisions for using alternate or equivalent means of compliance to the criteria in the MPS of this TSO. If you invoke these provisions, you must show that your equipment maintains an equivalent level of safety. Apply for a deviation under 14 CFR 21.609.

4. MARKING.

a. Mark at least one major component permanently and legibly with all the information in 14 CFR 21.607(d). The marking must include the serial number and functional equipment class(es) in accordance with Table 1 of paragraph **3**.

b. Also, mark the following permanently and legibly, with at least the manufacturer's name, subassembly part number, and the TSO number:

(1) Each component that is easily removable (without hand tools), and

(2) Each subassembly of the article that you determined may be interchangeable.

c. If the article includes a deviation per paragraph **3g** of this TSO, the marking must include a means to indicate a deviation was granted.

d. If the component includes a digital computer, then the part number must include hardware and software identification. Or, you can use a separate part number for hardware and software. Either way, you must include a means to show the hardware and software configuration, where applicable.

> **Note:** Similar software versions, developed and tested to different software levels, must be differentiated by part number.

5. APPLICATION DATA REQUIREMENTS. You must give the FAA aircraft certification office (ACO) manager responsible for your facility a statement of conformance, as specified in 14 CFR 21.605(a)(1) and one copy each of the following technical data to support your design and production approval. Under 14 CFR 21.617(a)(2), LODA applicants submit the same data (excluding paragraph **5h**) through their civil aviation authority.

a. Operating instructions and equipment limitations in an installation manual (IM), sufficient to describe the equipment's operational capability. Describe in detail any FAA-approved deviations. If needed, identify equipment by part number, version, revision, and criticality level of software/hardware, classification for use, and environmental categories.

b. Installation procedures and limitations in an IM, sufficient to ensure that the ADS-B ASA equipment, when installed according to the installation procedures, still meets this TSO's requirements. Limitations must identify any unique aspects of the installation. The limitations must include a note with the following statement:

This article meets the minimum performance and quality control standards required by a technical standard order (TSO). If you are installing this article on or in a specific type or class of aircraft, you must obtain separate approval for installation.

c. Schematic drawings of the installation procedures.

d. Wiring diagrams of the installation procedures.

e. List of line replaceable components, by part number, that makes up the ADS-B ASA equipment article. Include vendor part number cross-references, when applicable.

f. A component maintenance manual (CMM) or IM, as appropriate, covering periodic maintenance, calibration, and repair, for the continued airworthiness of ADS-B ASA equipment. Include recommended inspection intervals and service life.

g. Material and process specifications list.

h. The quality control system (QCS) description required by 14 CFR 21.143 and 21.605(a)(3), including functional test specifications. The QCS should ensure that you will detect any change to the approved design that could adversely affect compliance with the TSO MPS, and reject the article accordingly. (Not required for LODA applicants.)

i. Manufacturer's TSO qualification report showing results of testing accomplished according to paragraph **3c** of this TSO.

j. Nameplate drawing with the information required by paragraph **4** of this TSO.

k. List of all drawings and processes (including revision level) that define the article's design.

l. A summary of the test conditions and categories used for environmental qualifications for each component of the article. For example, a form as described in RTCA/DO-160F, *Environmental Conditions and Test Procedures for Airborne Equipment,* Appendix A.

m. If the article includes software: a plan for software aspects of certification (PSAC), software configuration index, and software accomplishment summary. We recommend that you submit the PSAC early in the software development process. Early submittal allows us to quickly resolve issues, such as partitioning and determining software design assurance levels.

n. If the article includes a complex custom micro-coded component: a plan for hardware aspects of certification (PHAC), hardware verification plan, top-level drawing, and hardware accomplishment summary. We recommend that you submit the PHAC early in the hardware development process. Early submittal allows us to quickly resolve issues such as determining hardware design assurance levels.

o. Identify functionality, features or performance contained in the article not evaluated under paragraph **3** of this TSO (that is, non-TSO functions). Non-TSO functions are accepted in parallel with the TSO authorization. You must declare these functions and include the following information in your TSO application:

(1) Description of the non-TSO function(s), such as performance specifications and software, hardware, and environmental qualification levels. Add a statement confirming that the non-TSO functions don't interfere with the article's compliance with the requirements of paragraph **3**.

(2) Installation and operating instructions/limitations for the non-TSO function(s).

(3) Instructions for continued performance applicable to the non-TSO function(s) defined in paragraph **5o(1).**

(4) Interface requirements and applicable installation test procedures to ensure compliance with the performance data defined in paragraph **5o(1).**

(5) Results of test/analysis, as appropriate, to verify that performance of the article in the hosting TSO is not affected by the non-TSO function(s).

(6) Results of test/analysis, as appropriate, to verify intended function of the declared non-TSO function(s) as described in paragraph **5o(1).**

p. If the software level and electronic hardware qualification limit the equipment to be eligible on certain aircraft types (e.g., Part 23 airplanes), identify the software level and electronic hardware qualification and that the equipment has not been determined to be eligible for all aircraft types. Advisory Circular (AC) 23.1309-1D, "System Safety Analysis and Assessment for Part 23 Airplanes", dated January 16, 2009, states that RTCA/DO-178B Level D software may be associated with a major failure condition classification for certain aircraft types. Other limitations applicable to the failure condition classification should also be identified (e.g., display required to conduct a particular flight operation).

q. When applicable, identify the article as an incomplete system or a multi-use system and describe the functions that are intended to be provided by the article.

6. <u>MANUFACTURER DATA REQUIREMENTS</u>. Besides the data given directly to us, have the following technical data available for review by the responsible ACO or civil aviation authority:

a. Functional qualification specifications for qualifying each production article to ensure compliance with this TSO.

b. Equipment calibration procedures.

c. Corrective maintenance procedures (within 12 months after TSOA or LODA).

d. Schematic drawings.

e. Wiring diagrams.

f. Material and process specifications.

g. The results of the environmental qualification tests conducted according to paragraph **3d** of this TSO.

h. If the article includes software, the appropriate documentation defined in RTCA/DO-178B including all data supporting the applicable objectives in RTCA/DO-178B *Annex A, Process Objectives and Outputs by Software Level*.

i. If the article includes a complex micro-coded component, the appropriate hardware life cycle data in combination with design assurance level, as defined in RTCA/DO-254, Appendix A, Table A-l.

j. If the article contains non-TSO function(s), you must also make available items **6a** through **6i** as they pertain to the non-TSO function(s).

7. FURNISHED DATA REQUIREMENTS.

a. If furnishing one or more articles manufactured under this TSO to one entity (such as an operator or repair station), provide one copy or on-line access to the data in paragraphs **5a** through **5f** and **5l** of this TSO. Add any other data needed for the proper installation, certification, use, or for continued compliance with the TSO, of the ADS-B ASA equipment.

b. If the article contains non-TSO function(s), include one copy of the data in paragraphs **5o(1)** through **5o(4).**

8. HOW TO GET REFERENCED DOCUMENTS.

a. Order RTCA documents from RTCA Inc., 1828 L Street NW, Suite 805, Washington, D.C. 20036. Telephone (202) 833-9339, fax (202) 833-9434. You can also order copies online at www.rtca.org.

b. Order copies of 14 CFR parts from the Superintendent of Documents, Government Printing Office, P.O. Box 979050, St. Louis, MO 63197. Telephone (202) 512-1800, fax (202) 512-2250. You can also order copies online at www.access.gpo.gov. Select “Access,” then “Online Bookstore.” Select “Aviation,” then “Code of Federal Regulations.”

c. You can find a current list of technical standard orders and advisory circulars on the FAA Internet website Regulatory and Guidance Library at http://rgl.faa.gov/. You will also find the TSO Index of Articles at the same site.

Susan J. M. Cabler
Assistant Manager, Aircraft Engineering
Division

APPENDIX 1. MINIMUM PERFORMANCE STANDARD FOR ADS-B ASA EQUIPMENT

This appendix defines changes to MOPS for ADS-B ASA equipment. The applicable standard is RTCA/DO-317, "*Minimum Operational Performance Standards (MOPS) For Aircraft Surveillance Applications System (ASAS)*", dated April 14, 2009. The changes shown in this appendix modify DO-317 in three ways:

1) to include changes required for Version 2 of the 1090ES and UAT link MOPS;
2) to adopt agreed harmonization with Safety, Performance and Interoperability Requirements documents developed by the Requirements Focus Group; and
3) to create a functional equipment class structure for this initial ADS-B ASA equipment that accommodates the evolutionary development of future functional classes of equipment.

Modifications to DO-317 are shown in this Appendix in italicized text. For text in notes that is already italicized, the text is underlined. In some cases, some of the original text may be deleted and no markings are shown.

While not invoked as part of the requirements, changes to key concepts and background in Section 1 and appendices of DO-317 are also provided. Acronyms are as shown in DO-317 Appendix A unless indicated otherwise.

Positioning system requirements to achieve the required horizontal and vertical position quality are not addressed in this TSO, but can be found in advisory guidance.

1. DO-317 is modified as follows:

1.1 Page 4, replace paragraph 1.3.1 with:

Initial Applications

The five initial applications defined in DO-289 are all considered to be traffic "situation awareness" applications because the applications do not add new pilot tasks and responsibilities. For these applications, the CDTI provides additional information to augment current flight crew tasks such as see and avoid (14 Code of Federal Regulations (CFR) 91.113(b)).

- Enhanced Visual Acquisition (EVAcq).

- Conflict Detection (CD)
- Airport Surface Situational Awareness (ASSA).
- Final Approach and Runway Occupancy Awareness (FAROA).
- Enhanced Visual Approach (EVApp).

EVAcq defines the basic use of ASAS for enhanced traffic situational awareness when airborne, and support for this application is the minimum requirement for all airborne ASAS implementations. Other applications that may be used when airborne (CD, ASSA, FAROA and EVApp) are optional.

A description of each of these supported applications follows:

Enhanced Visual Acquisition: CDTI provides traffic information to assist the flight crew in visually acquiring traffic out the window when airborne. The CDTI can be used to initially acquire traffic (that the pilot might not have known about otherwise) or as a supplement to an Air Traffic Control (ATC) traffic advisory. This application is expected to improve both safety and efficiency by providing the flight crew enhanced traffic awareness.

Note: While there is no defined application for general traffic situational awareness beyond the visual range, CDTI will display traffic to enable such awareness using the requirements for the EVAcq application.

Conflict Detection (CD): The CDTI is used to alert the flight crew of situations in which a loss of separation (LOS) or collision is predicted. The conflict and collision alerts may prompt the flight crew to exercise see-and-avoid procedures or to contact ATC. Conflict avoidance maneuvers are not provided by this application. This application is expected to improve safety by advising the flight crew of non-TCAS equipped aircraft about potential conflicting traffic and by providing information that can augment current flight crew tasks of see and avoid per 14 CFR 91.113(b).

Note: Conflict detection is not included under this TSO. If it is implemented, the applicant should identify this functionality as a non-TSO function. Reference paragraph 5.o in main body of this TSO.

Airport Surface Situational Awareness (ASSA), and Final Approach and Runway Occupancy Awareness (FAROA): In these applications, the CDTI is used to support the flight crew in making decisions about taxiing, takeoff and landing. These applications are expected to increase efficiency of operations on the airport surface and reduce the possibility of runway incursions and collisions.

Enhanced Visual Approach (EVApp): The CDTI is used to assist the flight crew in acquiring and maintaining visual contact during visual approaches. The CDTI is also used in conjunction with visual, out-the-window contact to follow the lead aircraft during the approach (i.e., during conduct of the visual separation task). The application is expected to improve both the safety and the performance of visual approaches. It could allow for the continuation of visual approaches when they otherwise would have to be suspended due to the difficulty of visually acquiring and tracking the other aircraft.

Requirements Focus Group Applications

The Requirements Focus Group (RFG) has also developed initial traffic situation awareness applications based in part on DO-289, but also designed to satisfy the safety, performance and interoperability requirements of DO-264. The RFG's comparable traffic situation awareness applications also augment current flight crew tasks of see and avoid per 14 CFR 91.113(b). The following applications represent situational awareness applications approved by RTCA SC-186:

- *Enhanced traffic situational awareness during flight operations*
- *Enhanced visual separation on approach*
- *Enhanced traffic situational awareness on the airport surface*

A description of each of these equivalent applications follows:

Enhanced traffic situational awareness during flight operations (ATSA-AIRB): This application enhances the flight crew's traffic situational awareness through the provision of an appropriate on-board graphical display of airborne surrounding traffic that transmits ADS-B data of a sufficient quality. It is expected that this enhanced traffic situational awareness will contribute to improve flight safety and flight operations.

Enhanced visual separation on approach (ATSA-VSA): This application enhances the flight crew's traffic situational awareness during visual approaches through the provision of an appropriate on-board graphical display of traffic that they may use in the visual search for preceding traffic they are cleared to follow on a visual approach. The graphical display of traffic for this application may also be used to support flight crews in maintaining visually a safe distance from this preceding aircraft.

Enhanced traffic situational awareness on the airport surface (ATSA-SURF): This application enhances the flight crew's traffic situational awareness during taxi, take-off, final approach, and landing operations. It is expected to reduce the potential for errors, runway and taxiway incursions, and collisions while operating an aircraft on the airport surface.

Equivalence of Initial DO-317 and RFG Situational Awareness Applications

The following table indicates the TSO application name that will be used to describe equivalent situational awareness applications along with the respective DO-317 and RFG application names.

***Table 1-1* TSO Application Name Equivalence**

TSO Application Name	***DO-317 Initial Application Name***	***Requirements Focus Group Application Name***
Airborne	***Enhanced Visual Acquisition (EVAcq)***	***Enhanced traffic situational awareness during flight operations (ATSA-AIRB)***
Enhanced Visual Approach	***Enhanced Visual Approach (EVApp)***	***Enhanced visual separation on approach (ATSA-VSA)***
Surface (Runways & Taxiways)	***Airport Surface Situational Awareness (ASSA) / Final Approach Runway Occupancy Awareness (FAROA)***	***Enhanced traffic situational awareness on the airport surface (ATSA-SURF)***
Surface (Runways Only)	***Final Approach Runway Occupancy Awareness (FAROA)***	***No Equivalent***

1.2 Page 7, replace paragraph 1.5.1.4 with:

1090ES Duplicate 24 Bit Address

In the 1090ES system, decoding messages and correlating data to the correct aircraft/vehicle depends on unique addresses. Although duplicate address events should be unlikely, provisions are included to handle such occurrences. 1090ES receiving subsystems compliant with DO-260B or later are required to output separate reports for aircraft/vehicles containing a duplicate address. The 1090ES receiver produces and outputs separate reports when duplicate addressed aircraft/vehicles are within receiver coverage. Although non-position information is included, it cannot be correctly associated with the proper aircraft/vehicle. Data from the other participant will often be contained in a report. Therefore, ASSAP cannot correlate the information to the proper individual track unless additional processing is performed. These tracks are identified by the 1090ES receiver as duplicates so ASSAP should discard non-position information, unless ASSAP includes additional processing to improve correlation beyond the minimum *requirements of DO-260B. Without additional data tracking, tracks identified as duplicates will be processed as Version 0 since the status messages which contain the Version indication cannot be correlated.*

Version 1 compliant 1090ES receiving subsystems providing reports to ASSAP designed to the minimum requirements do not detect duplicate address conditions and will output position reports for a single track from aircraft/vehicles with duplicate addresses. In these cases, ASSAP will not be aware of a duplicate address condition. ASSAP processing of a report that results from multiple aircraft/vehicles containing a duplicate address could result in depictions on the CDTI of erratic, misleading and missing traffic information.

1.3 Page 8, replace paragraph 1.5.1.6 with:

Dual Link Receiver

ASSAP requirements and test scenarios and the reference system design in Appendix C do not address the case of dual link receivers on the ownship. *The FAA Ground infrastructure utilizes bits in the Version 2 ADS-B transmissions to detect the receiver capability on the aircraft. However, d*ual link receivers may receive ADS-B on one link and ADS-R on the other link for the same aircraft. In this case, ADS-R may be disregarded. *While it is not prohibited to use ADS-R to update a track, it is not a minimum requirement.*

1.4 Page 8, replace paragraph 1.5.1.8 with:

TIS-B On Airport Surface

As of this revision of the ASAS MOPS, ASSAP requirements and test scenarios do not specifically address spatial correlation between TIS-B surface position reports and other sources (ADS-B, ADS-R) or ownship for the airport surface. The geometric filters used for determining spatial correlation would be unable to function properly in the dense traffic environment that could exist on the surface, potentially resulting in a higher rate of ghosting between ADS-B and TIS-B traffic and possibly ghosting ownship as well.

At airports where TIS-B is supported on the airport surface, the following factors should be considered:

- Reliable correlation of an update from a surface surveillance system (e.g., Multilateration) may only be possible via the 24 bit address available in ADS-B and from the Mode S transponder.

- Likewise, reliable TIS-B/ADS-B correlation may not be possible on ADS-B equipped aircraft with Air Traffic Control Radar Beacon System (ATCRBS) transponders. Users should expect ghost targets or shadows of ownship for aircraft equipped this way.

- On the surface, ASSAP will only correlate a TIS-B track with ADS-B/ADS-R track if it has the same 24 bit address.

At airports with both Secondary Surveillance Radar (SSR) and multilateration systems, the ground infrastructure *may change the TIS-B track ID of a target aircraft as it transitions from a surface service volume (<2000 ft AGL and within 7 NM of the airport reference point) to a terminal service volume.*

1.5 Page 9, replace paragraph 1.5.1.11 with:

1090ES Version*s*

1090ES receiving subsystems supporting *this version of* ASAS will process Version *2 messages formatted per the requirements of DO-260B, as well as Version* 1 messages formatted per the requirements of DO-260A (TSO-C166a*), and* Version 0 messages formatted per the requirements of DO-260, DO-181C (TSO-C112) or ICAO Annex 10 Amendment 77. This MOPS assumes that reports sent to ASSAP will be labeled as to whether they are from *Version 0, 1, or 2* transmitting systems. *Version 0* reports will have Navigation Uncertainty Category (NUC) converted to the Navigation Integrity Category (NIC), Navigation Accuracy Category for position (NACp) and Surveillance Integrity Level (SIL) parameters per Appendix N of DO-*260B. Version 1 reports, where they differ from Version 2, will also be addressed per Appendix N of DO-260B*.

Ownship 1090ES transmitting and receiving subsystems supporting ASAS installations will comply with DO-*260B* or later.

The ground system will suppress TIS-B uplinks for *all qualified ADS-B equipped* aircraft.

The FAA Ground infrastructure implementing ADS-R service does not provide ADS-R or TIS-B of 1090ES version 0 equipped aircraft. There was more than one version 0 implementation, and they were not appropriately validated. In the future, ADS-R of 1090ES and UAT version 1 transmitters may not be provided.

1.6 Page 9, new paragraph 1.5.1.13 reads as follows:

UAT Versions

UAT receiving subsystems supporting this version of ASAS will process Version 2 messages formatted per the requirements of DO-282B, as well as Version 1 messages formatted per the requirements of DO-282A (TSO-C154b). This MOPS assumes that reports sent to ASSAP will be labeled as to whether they are from Version 1 or 2 transmitting systems. Version 1 reports, where they differ from Version 2, will be addressed per Appendix R of DO-282B.

Ownship UAT transmitting and receiving subsystems supporting ASAS installations will comply with TSO-C154b or later.

The ground system will suppress TIS-B uplinks for all qualified ADS-B equipped aircraft.

1.7 Page 14, replace paragraph 2.1.7 with:

Design Assurance

Malfunctions of applications in this document *used to display traffic in aircraft that are airborne or on the ground at groundspeeds greater than 80 knots* are considered to be of *major failure condition* criticality. *Malfunctions of applications used to display traffic while ownship is on the ground and less than 80 knots groundspeed are considered to be of minor failure condition criticality. Loss of function for all applications is considered to be of minor failure condition criticality.* Advisory Circular (AC) 25.1309-1() and AC 23.1309-1() *provide guidance on how the hardware design assurance level and the software level for these criticalities may be met.* The hardware and software **shall** be designed and developed such that the probability of providing misleading information (MI) and the probability of loss of function are *commensurate with these failure condition classifications*. These requirements apply when the equipment is in its installed configuration for the most stringent operation supported. To demonstrate compliance, it will be necessary to conduct a safety assessment to evaluate the system's implementation against known failure conditions. This safety assessment should be based upon the guidance of AC 23.1309-1() for Part 23 aircraft, AC 25.1309-1() for Part 25 aircraft, AC 27-1() for normal category rotorcraft, and AC 29-2() for transport category rotorcraft.

Note: For ASSAP architectures integrating with functions requiring a higher level of design assurance (e.g., TCAS), the system designer can apply a single design assurance level to an entire hardware item (based upon most severe application) or a hardware item may be partitioned to ensure separate functional failure paths (FFPs) in order to accommodate a mix of design assurance levels. The hardware safety assessment may use various qualitative and quantitative assessment methods. These may include fault tree analysis (FTA), common mode analysis, failure modes and effects analysis, and statistical reliability analysis methods for applicable quantitative assessment of random faults.

1.8 Page 14, replace paragraph 2.2.1 with:

Introduction

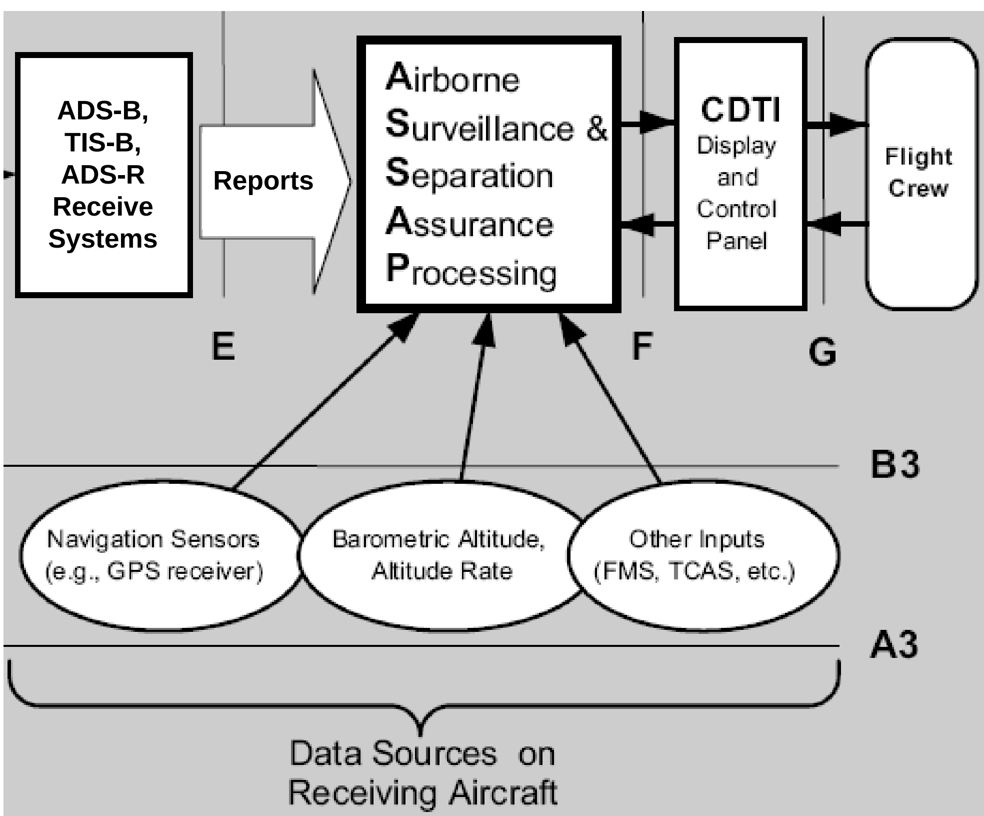
ASSAP is a function that receives surveillance reports on other aircraft/vehicles from multiple sources and derives traffic surveillance and application-specific information for visual and/or aural display to the CDTI for the flight crew. ASSAP receives

ADS-B/ADS-R/TIS-B reports that are assembled by the ADS-B/ADS-R/TIS-B Receive subsystem from corresponding ADS-B/ADS-R/TIS-B messages. ASSAP surveillance processing consists of correlation, and track processing of ADS-B, ADS-R, TIS-B and TCAS (if equipped) traffic reports. ASSAP application processing provides the application-specific processing of all ASA applications.

Note: Future ASAS MOPS that include other applications may also provide guidance information to the CDTI.

It is recognized that manufacturers may implement separate ASSAP and CDTI functions, or a single integrated function that satisfies the requirements of both the ASSAP and CTDI functions. The ASSAP requirements have been written to allow this implementation flexibility. For the purposes of these MOPS and the following sections, the phrase "ASSAP equipment" refers to the equipment providing the ASSAP functionality and does not imply any implementation or design.

This section defines the general requirements for the ASSAP function. The ASSAP subsystem provides the necessary surveillance and application-specific processing of ASA. ASSAP also maintains the interface with the CDTI Display and Control Panel subsystem. The combination of the aircraft data sources on the receiving aircraft, the ADS-B/ADS-R/TIS-B Receive Subsystem and the ASSAP function make up the ASA Receive system. This is illustrated in Figure 2-1.



<u>Figure 2-1</u> Subsystems for ASA Receive Participant

The entire ASA Receive System is responsible for the reception and processing of ownship data as well as the reception of ADS-B, ADS-R and TIS-B messages from other A/Vs and ground systems. This is for the purpose of supporting ASA application processing and providing aural and visual ASA-specific display information to the flight crew. Section 2.2 specifies requirements that apply specifically to the ASSAP functionality occurring between interfaces E and F as illustrated in Figure 2-1.

ASSAP surveillance requirements include track initiation, update, deletion, extrapolation and prediction; track merging and splitting; inter-source correlation (TIS-B & ADS-B/ADS-R; TCAS & others; TIS-B & Ownship) and best selection of data sources. A functional representation of the ASSAP surveillance processing is shown in Figure 2-3.

The ASSAP function may be implemented in stand-alone equipment, integrated with the ADS-B/ADS-R/TIS-B Receive equipment or integrated with other systems. The ASSAP requirements remain applicable when integrated in these alternative implementations.

ASA functional equipment classes are defined by the combination of avionics equipment functionality they provide and the applications they support. These elements that comprise the functional equipment classes are discussed below.

Avionics include the equipment used to process the ADS-B messages and other surveillance information from other aircraft along with the required ownship information. Three types of avionics are defined to address equipment required to support the four ASA applications as defined below:

> *ASSAP is used to process ADS-B, ADS-R, TIS-B, and TCAS (if installed) to surveillance data provide CDTI equipment with consolidated tracks and application specific data.*
>
> *CDTI (Surface Only) is used to control supported applications and graphically display ownship position and the relative positions of aircraft and surface vehicles over a moving map of runways and taxiways for supported airports while ownship is on the ground and less than 80 knots groundspeed.*
>
> *CDTI is used to control supported applications and graphically display ownship position and the relative positions of aircraft and surface vehicles while ownship is airborne or on the surface. This avionics may optionally display over a moving map of runways and taxiways for supported airports.*

ASA functional equipment classes may support one or more of the four current applications as shown in the table below.

Note: ASA functional equipment classes are different from the equipment classes described in ADS-B link MOPS (i.e. DO-260B, DO-282B). The four current applications may be supported with all classes of ADS-B receivers.

Avionics / **Application**	*CDTI (Surface Only) (A)*	*CDTI (B)*	*ASSAP (C)*
Airborne (1)	*Not Permitted*	***CLASS B1***	***CLASS C1***
Surface (2) (Runways Only)	***CLASS A2***	***CLASS B2***	***CLASS C2***
Surface (3) (Runways & Taxiways)	***CLASS A3***	***CLASS B3***	***CLASS C3***
Enhanced Visual Approach (4)	*Not Permitted*	***CLASS B4***	***CLASS C4***

When implementing multiple functional equipment classes, mark all applicable classes. For example, CDTI avionics equipment approved for all ASA applications is marked as CLASS B1, B2, B3, B4.

Although the functional requirements for avionics are based on the current ASA applications, the same avionics may also support future applications of the same or lesser criticality. Designers are expected to carefully consider the use and expandability of the equipment for additional applications and make sufficient provisions for future changes and expansion. Applications in addition to the ones listed above may be implemented in the future.

ASSAP functional equipment must support integration of TCAS source tracks on aircraft equipped with TCAS II.

The remainder of Section 2.2 is organized by: Input/Output, Surveillance Processing, Application Processing and Monitoring.

1.9 Page 21, replace paragraph 2.2.2.3.2 with:

Ownship Quality Data Input Requirements

Ownship quality data is very similar to traffic quality data; however, as the information comes directly from the ownship position source it is not yet categorized into NIC, NAC and SIL values. The following ownship quality data is required for ASSAP.

a. The ASSAP function **shall** (2046) receive the Horizontal Position Uncertainty.

b. The ASSAP function **shall** (2047) receive the Vertical Position Uncertainty.

c. The ASSAP function **shall** (2048) receive the Horizontal Velocity Uncertainty when available. (Note: If the GPS position source does not provide an appropriate horizontal velocity uncertainty, other methods may be necessary to infer the horizontal velocity uncertainty.)

d. The ASSAP function **shall** (2050) receive the Horizontal Position Integrity Containment Region when available.

e. The ASSAP function **shall** (2052) receive the *Source* Integrity Level when available (requirements defined in the RTCA/DO-*260B and DO-282B*).

1.10 Page 23, replace paragraph 2.2.2.5.1.2.2 with:

Traffic Output Priority for TCAS/ASAS Integrated Systems

For TCAS/ASAS integrated systems, the ASSAP function **shall** (2059) provide the highest priority tracks to the CDTI based on the following priority:

1. Resolution Advisory.

2. Traffic Advisory.

3. Airborne Proximate Traffic (when TCAS alerts are present).

4. Coupled Traffic.

5. Selected Traffic.

6. Airborne Proximate Traffic (when no TCAS alerts are present).

7. Other Traffic

The TCAS Proximate Traffic prioritization scheme **shall** (2060) be applied to the integrated group of TCAS and ASAS airborne Proximate Traffic. Thus it is possible for an ASAS Only Proximate Traffic to be a higher priority than a TCAS Proximate Traffic.

Note: Additional tracks should be sent to the CDTI based on existing track prioritization defined in DO-185B or alternative criteria suited to the specific application.

1.11 Page 24, replace paragraph 2.2.2.5.1.4 with:

Traffic Identification

For installations supporting EVApp and/or traffic selection, the ASSAP function **shall** (2064) provide a Flight ID for traffic sent to the CDTI when available.

Note: ICAO terminology is Aircraft ID.

1.12 Page 26, replace paragraph 2.2.2.5.1.10 with:

Traffic Altitude

a. The ASSAP function **shall** (2073) provide Traffic Altitude for airborne traffic sent to the CDTI when available.

b. Traffic Altitude **shall** (2074) be provided as either actual pressure altitude *(i.e., barometric pressure altitude referenced to a standard pressure of 29.92 inches Hg (1013.25 millibars))* or altitude relative to ownship altitude.

Note 1: Traffic Altitude is used for displaying *actual or relative* altitudes for traffic. Ownship pressure correction is also needed for the CDTI to calculate *the* actual altitude *for displayed traffic using the same pressure correction used to display ownship altitude.*

Note 2: The display of actual altitude should be consistent with DO-185B, section 2.2.6.1.2.5.

1.13 Page 28, replace paragraph 2.2.2.5.1.16 with:

Traffic Application Capability

Note: "Traffic Application Capability" is equivalent to the term "Traffic Information Quality" as used in DO-289.

a. The ASSAP function **shall** (2090) provide a Traffic Application Capability for traffic sent to the CDTI.

b. The Traffic Application Capability **shall** (2091) include that the traffic application capability is Invalid or Valid.

c. The Traffic Application Capability **shall** (2092) be provided for all available applications (not just the active applications).

For the EVAcq application, the traffic application capability is one of the following states (EVAcq is for airborne traffic and for surface traffic when not overlaid over an airport map):

Invalid: N/A.

Note: Based on the Best Track Selection requirements, the traffic will be replaced with a correlated TCAS track if available. For an ADS-B, ADS-R, or TIS-B track not correlated with a TCAS track, ASSAP will not send the traffic to the CDTI since it does not meet the performance for the minimum required application (EVAcq).

Valid: Traffic meets *qualified for EVAcq performance criteria per the requirements of paragraph 2.2.4.1.2*.

For the ASSA and FAROA applications, the traffic application capability is one of the following states (ASSA and FAROA are for surface traffic when overlaid over an airport map):

Invalid: Traffic not qualified for ASSA and FAROA.

Valid: Traffic qualified for ASSA and FAROA *per the requirements of paragraph 2.2.4.2.2.*

For the EVApp Application, the traffic application capability is one of the following states:

Invalid: Traffic not qualified for EVApp.

Valid: Traffic qualified for EVApp *per the requirements of paragraph 2.2.4.4.2.*

1.14 Page 35, change title of paragraph 2.2.3.1.3.2 to:

Duplicate Address Processing *for* UAT Systems

1.15 Page 36, new paragraph 2.2.3.1.3.3 reads as follows:

Duplicate Address Processing for 1090 MHz Systems

ADS-B reports from 1090 MHz equipped traffic which do not pass the Report Validity Checks given in Section 2.2.3.1.3.1 **shall** *be subject to further processing to determine if they are the result of a duplicate address as specified below. ADS-B reports from DO-260B compliant receivers will mark reports as duplicate under certain criteria. In cases where the ASAS function is integrated with a DO-260B receiver, there is no need to implement both criteria. A single criteria can meet the minimum requirements of both specifications.*

a. *For reports where no duplicate track exists with a matching participant address and ADS-B source, ASSAP* **shall** *(2117A) begin the track initiation process.*

b. *For each report containing an updated position and/or velocity, and where there is an existing duplicate address track, ASSAP* **shall** *(2118A) update that track with the report only when it passes the Report Validity Tests given in Section 2.2.3.1.3.1.*

c. *All data from the following 1090 MHz Message Type Codes* **shall** *(2118B) be invalidated: Types 1 - 4, 19, and 23 – 31. ADS-B reports from DO-260B compliant receivers are allowed to pass on this data without correlating it when duplicate addresses are detected.*

Note: The Enhanced Visual Approach application will be unavailable for a duplicate address track because horizontal velocity will not be available for this traffic.

1.16 Pages 42 and 43, replace Table 2-2 with:

Table 2-2 Traffic Vehicle Application Specific Requirements Summary

Requirement Category	**Requirement**	**Applicable Subsystem Interfaces (See Figure 1-1)**	**(Airborne) EVAcq**	**(Surface) ASSA/FAROA**	**(Enhanced Visual Approach) EVApp**
State Data	Horizontal Position Uncertainty (95%)	A1→B1	0.5 NM (NACp ≥ 5)	30 meter (m) (NACp ≥ 9) *(Note 6)*	0.3 NM (NACp ≥ 6)
	Horizontal Velocity Uncertainty (95%)	A1→B1	N/A	< 3 m/s (Note 1)	< 10 m/s (Note 1)
	Vertical Position Uncertainty (95%)	A1→B1	Valid Pressure or Geometric (Note 4)	On Ground or Valid Pressure or Geometric [Note 4 & 5]	Valid Pressure or Geometric (Note 4)
	Vertical Velocity Uncertainty (95%)	A1→B1	N/A	N/A	N/A
State Data Integrity	*Source* Integrity Level	A1→B1	N/A	N/A	10e-5/hr (SIL ≥ 2)
	Navigation Integrity Category	A1→B1	N/A	N/A	0.6 NM (NIC ≥ 6)
	System Design Assurance (Note 3)	*A1→D*	*1*	*1*	*2*
State Data Timing	Maximum Latency	A1→A4	0.5 s	0.5 s	0.5 s
		A4→G	4.5 s	4.5 s	4.5 s
		A4→B1	0.4 s	0.4 s	0.4 s
		B1→D	1.1 s	1.1 s	1.1 s
		D→E	0.5 s	0.5 s	0.5 s
		E→F	2 s	2 s	2 s

Requirement Category	Requirement	Applicable Subsystem Interfaces (See Figure 1-1)	(Airborne) EVAcq	(Surface) ASSA/FAROA	(Enhanced Visual Approach) EVApp
		F→G	0.5 s	0.5 s	0.5 s
	Maximum Data Age until Dropped	at E	25 s	11 s (moving) 25 s (static)	15 s
ID/Status Information	Maximum Latency	A1→G	30 s	30 s	30 s

Notes:

1. *Many Version 0 and 1 implementations report NACv as "unavailable" despite reporting velocity that meets the Horizontal Velocity Uncertainty requirement. Derived velocity may be used to validate the reported velocity is meeting the performance requirement in lieu of reported velocity quality.*

2. *NOTE REMOVED.*

3. *System Design Assurance (SDA) is defined in Version 2 equipment or later. SIL values from Version 1 equipment may be used to derive SDA using the backward compatibility provisions of DO-260B (Appendix N) or DO-282B (Appendix R). Version 0 equipment, may be assumed to have an SDA of 1.*

4. *For Version 1 reports, if valid baro is unavailable, geometric altitude may be used when NACp ≥ 9. NACp categories less than 9 do not constrain the accuracy of geometric altitude. For Version 2 reports, if valid baro is unavailable, geometric altitude may be used when the value for Geometric Vertical Accuracy (GVA) > 1.*

5. *Traffic vehicle vertical requirements for ASSA/FAROA are described in 2.2.4.2.2.*

6. *The ASSA/FAROA horizontal position uncertainty requirement for airborne traffic is 50 meters (95%) (NACp ≥9) for use with parallel runways with centerline-to-centerline spacing of less than 676 meters (2218 feet) and 185.2 meters (95%) (NACp ≥7) for all other runway geometry.*

1.17 Page 44, replace Table 2-3 with:

Table 2-3 Ownship Application Specific Requirements Summary

Requirement Category	Requirement	Applicable Subsystem Interfaces (See Figure 2-1)	(Airborne) EVAcq	(Surface) ASSA/FAROA	(Enhanced Visual Approach) EVApp
State Data Uncertainty	Max Horizontal Position Uncertainty (95%)	A3→B3	0.5 NM	50 m (Note 1)	0.3 NM
	Maximum Horizontal Velocity Uncertainty (95%)	A3→B3	N/A	N/A	< 10 m/s
	Vertical Position Uncertainty (95%)	A3→B3	Valid Pressure Altitude (Note 3)	On Ground Status (while on surface) or Valid Pressure (while airborne) [Note 3]	Valid Pressure Altitude (Note 3)
	Vertical Velocity Uncertainty (95%)	A3→B3	N/A	N/A	N/A
State Data Integrity	Surveillance Integrity Risk	A3→B3	N/A	N/A	10e-3/hr (SIL ≥ 1)
	Horizontal Position Integrity Containment Region	A3→B3	N/A	N/A	0.6 NM

Notes:

1. *These constraints are based on a total system error (TSE) budget derived from RTCA/DO-272A and RTCA/DO-257A (Aerodrome Moving Map Display (AMMD)), using more restrictive allocations for runway and taxiway database accuracies. GNSS sensors that assume Selective Availability ON are known to report very conservative accuracy metrics and mitigations are provided in paragraph 2.2.4.2.1 to assure the 50 meter (95%) accuracy requirement is met..*
2. *It is assumed that vertical rate derived from barometric altimetry measurements will be sufficient to support this application. Geometric altitude rate based on GPS (with SA off), or a baro /geo rate are considered better than baro only.*

3. If valid pressure altitude is unavailable, geometric altitude may be used when VFOM < 45m.

1.18 Page 45, replace paragraph 2.2.4.1.2 with:

Traffic Vehicle Requirements for EVAcq (*Airborne*)

All existing versions of the 1090ES and UAT ADS-B links are capable of producing EVAcq traffic data (e.g., DO-260 Version 0), and all future versions are expected to be developed to be capable of producing EVAcq traffic data.

An EVAcq traffic **shall** (2139) be derived from a track with valid horizontal position. A traffic track with NACp less than 5 **shall** (2140) not be provided to the CDTI interface.

An EVAcq traffic may not be reporting barometric altitude. This condition is known as non-altitude reporting or NAR. *In this case relative geometric altitude may be computed. In order to compute relative geometric altitude, the following* ***shall*** *(2141) apply*:

a. For Version 0 or 1 traffic, NACp must be 9 or greater.

b. For Version 2 traffic, GVA must be 2 or greater.

c. Ownship geometric altitude uncertainty (95%) must be less than 45m.

EVAcq traffic with an SDA less than 1 ***shall*** *(2141A) not be provided to the CDTI interface*.

If an EVAcq track's data age exceeds 25 seconds, ASSAP **shall** (2142) remove the traffic from the CDTI interface. This is the maximum data age allowed based on an enroute SSR TIS-B update.

Note: The initial application safety assessment determined the integrity requirement of this application to be 10^{-2}. This is the same order of magnitude as the accuracy parameter. As a result, RTCA Special Committee 186 (SC-186) has decided that the accuracy parameter was sufficient to determine validity for this application.

1.19 Page 46, replace paragraph 2.2.4.2.1 with:

Ownship Requirements for ASSA/FAROA (*Surface)*

ASSAP may perform the ASSA/FAROA application as follows when Ownship horizontal position and vertical position is valid and of sufficient quality.

When airborne, Ownship data must meet the following criteria or ASSAP **shall** (2143) signal that ASSA/FAROA is inoperative via the CDTI interface:

- A valid Horizontal Position with a horizontal uncertainty (95%) less than *50* meters AND pressure altitude is valid.

OR

- A valid Horizontal and Vertical Position (Geometric Altitude) with a horizontal uncertainty (95%) less than *50* meters and vertical uncertainty (95%) less than 45 meters.

When on ground, Ownship data must meet the following criteria or ASSAP **shall** (2144) signal that ASSA/FAROA is inoperative via the CDTI interface:

- A valid Horizontal Position with a reported horizontal uncertainty (95%) less than *50* meters.

AND

- For Class A functional equipment (i.e., Class A2, A3), ownship horizontal velocity is less than 80 knots

If a Runway database is not available for depiction of the Runway Surfaces and Extended Centerline, or Final Approach Course, ASSAP **shall** (2145) signal that FAROA is Unavailable (fail) via the CDTI interface.

If an Airport Surface database is not available for depiction of the Runway Surfaces, Extended Centerline or Final Approach Course, Taxiways, and Movement Surfaces, ASSAP **shall** (2146) signal that ASSA is Unavailable (fail) via the CDTI interface.

Note: The requirements for determining the availability of databases is written within the context of the functional separation of responsibility between ASSAP and CDTI as defined by DO-289. It does not imply a requirement on the allocation of functions to hardware. It is fully expected that the determination of the availability of data for display will likely reside in a multi-function display that is implementing CDTI and moving map functionality. In that case, the Multi-Function Display (MFD) is implementing a piece of the ASSAP function.

1.20 Page 47, replace paragraph 2.2.4.2.2 with:

Traffic Vehicle Requirements for ASSA/FAROA *(Surface)*

All versions of the 1090ES and UAT ADS-B links are capable of producing ASSA/FAROA traffic data (e.g., DO-260 Version 0), and all future versions are expected to be developed to be capable of producing ASSA/FAROA traffic data.

When AIRBORNE traffic meets the following criteria, ASSAP **shall** (2147) mark the traffic valid for ASSA/FAROA on the CDTI interface:

Horizontal Position

- Traffic is reporting valid Horizontal Position with *185.2 meters (95%) (e.g., NACp ≥7) or greater accuracy when runway geometry does not include parallel runways with centerline-to-centerline spacing less than 676 meters (2218 feet).*

OR

- *Traffic is reporting valid Horizontal Position with 50 meters (95%) (e.g., NACp ≥9) or greater accuracy when runway geometry includes parallel runways with centerline-to-centerline spacing less than 676 meters (2218 feet).*

AND

Pressure Altitude or Geometric Altitude

- Traffic is reporting valid pressure altitude OR valid geometric altitude with a NACp of 9 or greater *(Version 0 or 1) OR valid geometric altitude with a GVA of 2 or greater (Version 2)*.

AND

Message Reception

- Traffic position message has been received within the last 11 seconds.

AND

Horizontal Velocity

- *Traffic is reporting valid horizontal velocity with 3 m/s (95%) or greater accuracy.*

System Design Assurance

- *Traffic is reporting a system design assurance (or equivalent) of 1 or greater.*

When ON GROUND traffic meets the following criteria, ASSAP **shall** (2148) mark the traffic valid for ASSA FAROA on the CDTI interface:

- Traffic is reporting valid horizontal position with 30 meters (95%) or greater *accuracy.*

AND

- Traffic is in motion and a position message has been received within the last 11 seconds, OR traffic is not in motion and a position message has been received within the last 25 seconds.

AND

- *Traffic is reporting valid horizontal velocity with 3 m/s (95%) or greater accuracy.*

AND

- *Traffic is reporting a system design assurance (or equivalent) of 1 or greater.*

1.21 Page 50, replace paragraph 2.2.4.4.1 with:

***Ownship* Requirements**

ASSAP may perform the Enhanced Visual Approach application when own aircraft horizontal and vertical positions are valid and of sufficient quality.

Vertical position is satisfied by geometric altitude or pressure altitude. When own aircraft horizontal or vertical position is invalid, ASSAP **shall** (2165) signal that EVApp is Unavailable (fail) via the CDTI interface. When own aircraft horizontal position uncertainty (95%) is greater than 0.3 NM (556 m), ASSAP **shall** (2166) signal that EVApp is Unavailable (fail) via the CDTI interface. When geometric altitude is used for vertical position and own aircraft vertical position uncertainty (95%) is greater than 45 m, ASSAP **shall** (2167) signal that EVApp is Unavailable (fail) via the CDTI interface.

ASSAP may perform the Enhanced Visual Approach application when own aircraft horizontal velocity is of sufficient quality. When own aircraft horizontal velocity uncertainty (95%) is greater than or equal to 10 m/s, ASSAP **shall** (2168) signal that EVApp is Unavailable (fail) via the CDTI interface.

When the ownship SIL is zero or the horizontal position *integrity* is greater than *0.6* NM, ASSAP **shall** (2169) signal that EVApp is Unavailable (fail) via the CDTI interface.

1.22 Page 50, replace paragraph 2.2.4.4.2 with:

Traffic Vehicle Requirements

a. An EVApp traffic **shall** (2170) be derived from traffic with valid horizontal and vertical position. Vertical position is satisfied by pressure altitude or geometric altitude. When pressure altitude is used for vertical position, traffic **shall** (2171) have a NACp of 6 or greater to be marked as a valid EVApp traffic. When geometric altitude is used for vertical position, *Version 0 or 1* traffic **shall** (2172) have a NACp of 9 or greater to be marked as a valid EVApp traffic. *When geometric altitude is used for* *vertical position, Version 2 traffic* ***shall*** *(2172A) have a GVA of 2 or greater to be marked as a valid EVApp traffic.*

b. Traffic **shall** (2173) have a NACv of 1 or greater to be marked as a valid EVApp traffic.

Note: Most current implementations report NACv as "unavailable" despite reporting velocity that meets the requirement. Other methods may be used to infer the velocity uncertainty in the near term.

c. Traffic track **shall** (2174) have a SIL of 1 or greater and a NIC of 6 or greater to be marked as a valid EVApp traffic.

Note: <u>Validation of horizontal position integrity for version 0 and version 1 traffic is not required for this application, but may be required for future applications.</u>

d. If EVApp traffic is not updated within the maximum data age of 15 seconds, ASSAP **shall** (2175) mark the traffic as invalid for the EVApp application.

e. EVApp traffic with a SDA less than 2 ***shall*** *(2175A) be marked as invalid for the EVApp application.*

1.23 Page 51, replace paragraph 2.3.1 with:

General CDTI Requirements

The CDTI is defined as *the displays and controls necessary to support the applications included in this document. At a minimum, CDTI includes* a graphical plan-view (top down) traffic display. The CDTI is required (in Section 2.3.4.1) to indicate ownship position and (in Section 2.3.1.2) to show the positions, relative to the ownship, of traffic.

The basic (minimal) application of the CDTI is enhanced traffic situational awareness. At a minimum, enhanced traffic situational awareness is provided by the EVAcq application within the visual range described for that application. The same requirements apply for enhanced traffic situational awareness beyond the EVAcq visual range. CDTI **shall** (3000) support the EVAcq *(Airborne)* requirements.

Additionally, the CDTI may support these applications:

1. Airport Surface Situational Awareness/Final Approach and Runway Occupancy Awareness (ASSA/FAROA) *(Surface (Runways and Taxiways))*.
2. *Final Approach and Runway Occupancy Awareness (FAROA) (Surface (Runways Only))*.
3. Enhanced Visual Approach (EVApp) *(Enhanced Visual Approach)*.

The minimum CDTI requirements specified in this version of these MOPS are based on these operational applications that are described in DO-289, *and applications subsequently approved by RTCA SC-186.* For each application that is implemented, all of the application's requirements must be met.

ASA functional equipment classes are defined by the combination of avionics equipment functionality they provide and the applications they support. These elements that comprise the functional equipment classes are discussed below.

Avionics include the equipment used to process the ADS-B messages and other surveillance information from other aircraft along with the required ownship information. Three types of avionics are defined to address equipment required to support the four ASA applications as defined below:

> *ASSAP is used to process ADS-B, ADS-R, TIS-B, and TCAS (if installed) surveillance data to provide CDTI equipment with consolidated tracks and application specific data.*
>
> *CDTI (Surface Only) is used to control supported applications and graphically display ownship, the relative positions of aircraft and surface vehicles, over a moving map of runways and taxiways or runways only for supported airports while ownship is on the ground and less than 80 knots groundspeed.*
>
> *CDTI is used to control supported applications and graphically display ownship position and the relative positions of aircraft and surface vehicles while ownship is airborne or on the surface. This avionics may optionally display over a moving map of runways and taxiways or runways only for supported airports.*

ASA functional equipment classes may support one or more of the four current applications as shown in Table 1 – ASA Functional Equipment Classes in the TSO Requirements paragraph 3. A total ADS-B ASA system will include one or more CDTIs and ASSAP that supporting at least one of the applications.

When implementing multiple functional equipment classes, mark all applicable classes. For example, CDTI avionics equipment approved for all ASA applications is marked as CLASS B1, B2, B3, B4.

Although the functional requirements for avionics are based on the current ASA applications, the same avionics may also support future applications of the same or lesser criticality. Designers are expected to carefully consider the use and expandability of the equipment for additional applications and make sufficient provisions for future changes and expansion.

CDTI ***shall*** *(3000A)* also support integration *of TCAS source tracks into ASAS on aircraft equipped with TCAS II.*

1.24 Page 64, replace paragraph 2.3.4.2.3.2.6 with:

Alerts

The following requirements apply generally to CDTI alerts based on both ASAS and TCAS systems. Additional TCAS-specific alert symbol requirements are provided in section 2.3.4.2.3.3.

Traffic that triggers an alert **shall** (3040) be indicated on the traffic display with a symbol variation. The following requirements only apply to the alerted traffic symbol:

a. If traffic directionality is valid, directionality information **shall** (3041) be displayed during alerts.

b. The traffic symbol **shall** (3042) change to amber/yellow for caution level alerts.

c. The traffic symbol **shall** (3043) change to red for warning level alerts.

d. For traffic without valid directionality:

- If traffic has a caution level alert, the traffic symbol may be modified by changing the shape to a circle.
- If traffic has a warning level alert, the traffic symbol may be modified by changing the shape to a square.

e. For traffic with valid directionality:

- If traffic has a caution level alert, the traffic symbol may be modified by changing the shape to a circle with a directional inlay.
- If traffic has a warning level alert, the traffic symbol may be modified by changing the shape to a square with a directional inlay.

Note: Caution and Warning level alerts may use the same traffic symbology as TCAS Traffic Alerts and Resolution Advisories, respectively. (See sections 2.3.4.2.3.3.1 and 2.3.4.2.3.3.2)

*f. For airborne applications, a*lerting traffic that lies outside the configured traffic display range should be positioned at the measured relative bearing, and at the configured display maximum range (i.e., edge of display), and with a symbol shape modification that indicates that the traffic is off-scale.

Note: A half-symbol at the display edge is one acceptable indication method. Automatic scaling to position alerting traffic within the configured traffic display range is another acceptable method

Note: *Future applications with alerts on the surface may need to develop an alternate indication method in order to accommodate the need for determining off-scale position information relative to airport surface features such as runways.*

1.25 Page 68, replace paragraph 2.3.4.3 with:

Number of Traffic Element

A traffic element is an aircraft or vehicle.

a. The CDTI **shall** (3051) be capable of displaying at least 16 traffic elements.

Note: *The limit of 16 is considered as a display capability, so that future applications may make use of it (e.g.,. computation limits). A setting to another limit (e.g., 8) is an acceptable way to proceed, and it is not required that the number of traffic to display is modifiable by the pilots in real time.*

b. The CDTI should provide an indication when the number of traffic elements meeting the traffic display criteria exceeds the maximum number of traffic elements that can be displayed.

Note: *Traffic will be displayed based on the Traffic Display Criteria (see section 2.3.1.1). Traffic of interest to the flight crew may not be included within the first 16 traffic in this list. For example, an aircraft at the other end of the runway may be of interest while 16 aircraft are closer to ownship. A higher limit of traffic elements may be appropriate.*

1.26 Page 72, replace paragraph 2.3.5.5.2 with:

Traffic Actual Altitude

Actual Altitude is the traffic's reported altitude instead of the relative altitude between ownship and traffic. *If the actual altitude is to be shown on a continuous basis after selection by the flight crew, it **shall** (3072) be corrected for the local barometric pressure using the same correction used by the flight crew.* The following requirements apply if the Actual Altitude feature is implemented.

A clear and unambiguous indication **shall** (3069) be provided on the display that the actual altitude mode has been selected. Actual altitude tags **shall** (3070) be positioned above or below the traffic symbol in a manner consistent with relative altitude data tags.

Actual altitude **shall** (3071) be displayed as a 3-digit number representing hundreds of feet above MSL. (e.g., “007” represents 700 feet MSL and “250” represents 25,000 feet MSL.)

1.27 Page 73, replace paragraph 2.3.5.7 with:

Traffic Identification

Traffic identification may also be referred to as flight identification or flight ID (e.g., the aircraft flight number or the tail number). The following requirements apply *for traffic identification:*

Note: Traffic identification may not be available for all traffic.

Note: ICAO terminology for Traffic Identification is Aircraft Identification.

a. The CDTI **shall** (3076) be capable of displaying eight alphanumeric characters for the traffic identification.

   Note: The ICAO standard for aircraft identification is a maximum of eight alphanumeric characters.

b. The location of traffic identification field with respect to the traffic symbol ***shall (3076A)*** be consistent for all displayed traffic.

1.28 Page 84, replace paragraph 2.3.9.2 with:

ASSA/FAROA (*Surface*)

For installations that support the ASSA/FAROA applications (reference ASA MASPS Appendices E and F):

a. The CDTI **shall** (3134) be capable of indicating the directionality of traffic for which directional information is available.

b. The CDTI should provide this additional information:

   - Traffic ID.

c. (Deleted)

d. Ownship and traffic vehicle position symbology **shall** (3136) correspond to the underlying airport map, when displayed. Aircraft positions **shall** (3137) not be adjusted to snap to runways or taxiways. (i.e., They should reflect the received position.)

e. The CDTI **shall** (3138) be adjustable to a range of 1.0 NM or less in the direction of ownship travel as measured from the ownship position to the edge of the viewable screen.

f. When the ASSA application is active, a graphical depiction of the airport surface including taxiways and runways **shall** (3139) be present as an underlay. *If an Airport Surface database is not available for depiction of the runways and taxiways (as they are defined in DO-257A), CDTI* ***shall*** *(2146) indicate that ASSA (Surface – Runways and Taxiways) is Unavailable by the absence of an Airport Moving Map display or some other acceptable means (e.g., display message or crew alert message).*

Note: *It is expected that the determination of the availability of data for display will reside in a multi-function display that is implementing CDTI and moving map functionality.*

g. When the FAROA application is active, a graphical depiction of the airport surface including runways **shall** (3140) be present as an underlay. *If a Runway database is not available for depiction of the runways (as they are defined in DO-257A), CDTI* ***shall*** *(3140A) indicate that FAROA (Surface – Runways Only) is Unavailable by the absence of an Airport Moving Map display or some other acceptable means (e.g., display message or crew alert message). .*

Note: *It is expected that the determination of the availability of data for display will reside in a multi-function display that is implementing CDTI and moving map functionality.*

1.29 Page 88, replace paragraph 2.4 with:

Equipment Performance – Environmental Conditions

The environmental tests and performance requirements described in this section are intended to provide a laboratory means of determining the overall performance characteristics of the equipment under conditions representative of those that may be encountered in actual aeronautical operation.

Unless otherwise specified, the test procedures applicable to a determination of equipment performance under environmental test conditions are contained in RTCA Document *DO-160* Environmental Conditions and Test Procedures for Airborne Equipment. General information on the use of *RTCA/DO-160* is contained in sections 1 through 3 of that document. Also, a method of identifying which environmental tests were conducted and other amplifying information on the conduct of the tests is contained in Appendix A of *RTCA/DO-160*.

Some of the performance requirements in sections §2.2 and §2.3 are not required to be tested to all of the conditions contained in *RTCA/DO-160*. Judgment and experience have indicated that these particular parameters are not susceptible to certain environmental conditions and that the level of performance specified in sections §2.2 and §2.3 will not be measurably degraded by exposure to these conditions.

Review of the requirements provided in sections §2.2 and §2.3 indicates that such requirements will be satisfied through software implementations which are not normally affected by environmental conditions. Therefore, the environmental test procedures of Table 2-7 are established in order to verify only the various interface functions of the Airborne Surveillance Application Processing function under environmental conditions. These test procedures are to be performed only for non-integrated Airborne Surveillance Application Processing implementations. When the ASAS implementation is integrated with a TCAS receiver the environmental tests specified in DO-185B are sufficient to validate the environmental performance of ASAS.

1.30 Page 92, replace paragraph 2.5.2.1.1 with:

Verification of Traffic State Vector Report Input Requirements (§2.2.2.1.1)

Test Tool Requirements:

It will be necessary to be able to modify the injected scenarios used in this section to conduct negative tests to exercise data field values outside the expected values (e.g.) reserved values, to ensure that such data field values are properly handled by ASSAP as data not available.

Test Procedure:

Step 1: Inject Scenario 1-1 from section 2.5.7.1 as stimulus to ASSAP, but without the TCAS source. Use 1090ES or UAT report format as appropriate for the installation. Ensure ASSAP is configured to provide all available data to the CDTI interface.

Verify that the track appears on the CDTI interface and the extrapolation of that track is consistent with the truth data. Verify that all applicable State Vector Report data for the track appears on the CDTI interface.

Repeat this step with a modified version of Scenario 1-1 where each data field that has reserved values has one of the reserved values set in a given ADS-B/ADS-R/TIS-B report in order to exercise each data field for those data fields that have reserved values. Verify that ASSAP treats any data field with a reported value outside the normal expected values as data not available at the CDTI interface.

Step 2: Inject Scenario 1-2 from section 2.5.7.1 as stimulus to ASSAP, but without the TCAS source. Use 1090ES or UAT report format as appropriate for the installation. Ensure ASSAP is configured to provide all available data to the CDTI interface.

Verify that the appropriate tracks appear on the CDTI interface and the extrapolation of that track is consistent with the truth data. Verify that all applicable State Vector Report data for the track appears on the CDTI interface.

Repeat this step with a modified version of Scenario 1-2 where each data field that has reserved values has one of the reserved values set in a given ADS-B/ADS-R/TIS-B report in order to exercise each data field for those data fields that have reserved values. Verify that ASSAP treats any data field with a reported value outside the normal expected values as data not available at the CDTI interface.

Step 3: Inject Scenario 1-3 from section 2.5.7.1 as stimulus to ASSAP, but without the TCAS source. Use 1090ES or UAT report format as appropriate for the installation. Ensure ASSAP is configured to provide all available data to the CDTI interface.

Verify that the appropriate tracks appear on the CDTI interface and the extrapolation of that track is consistent with the truth data. Verify that appropriate State Vector Report data for the track appears on the CDTI interface.

Repeat this step with a modified version of Scenario 1-3 where each data field that has reserved values has one of the reserved values set in a given ADS-B/ADS-R/TIS-B report in order to exercise each data field for those data fields that have reserved values. Verify that ASSAP treats any data field with a reported value outside the normal expected values as data not available at the CDTI interface.

1.31 Page 93, replace paragraph 2.5.2.1.2 with:

Verification of Traffic ID/Status Data Report Input Requirements (§2.2.2.1.2)

Test Tool Requirements:

It will be necessary to be able to modify the injected scenarios used in this section to conduct negative tests to exercise data field values outside the expected values (e.g.) reserved values, to ensure that such data field values are properly handled by ASSAP as data not available.

Test Procedure:

Step 1: Inject Scenario 1-1 from section 2.5.7.1 as stimulus to ASSAP, but without the TCAS source. Use 1090ES or UAT report format as appropriate for the installation. Ensure ASSAP is configured to provide all available data to the CDTI interface.

Verify that the track appears on the CDTI interface and the extrapolation of that track is consistent with the truth data. Verify that the Traffic ID/Status Report data for the track appears on the CDTI interface.

Repeat this step with a modified version of Scenario 1-1 where each data field that has reserved values has one of the reserved values set in a given ADS-B/ADS-R/TIS-B report in order to exercise each data field for those data fields that have reserved values. Verify that ASSAP treats any data field with a reported value outside the normal expected values as data not available on the CDTI interface.

Step 2: Inject Scenario 1-2 from section 2.5.7.1 as stimulus to ASSAP, but without the TCAS source. Use 1090ES or UAT report format as appropriate for the installation. Ensure ASSAP is configured to provide all available data to the CDTI interface.

Verify that the appropriate tracks appear on the CDTI interface and the extrapolation of that track is consistent with the truth data. Verify that the Traffic ID/Status Report data for the track appears on the CDTI interface.

Repeat this step with a modified version of Scenario 1-2 where each data field that has reserved values has one of the reserved values set in a given ADS-B/ADS-R/TIS-B report in order to exercise each data field for those data fields that have reserved values. Verify that ASSAP treats any data field with a reported value outside the normal expected values as data not available.

Step 3: Inject Scenario 1-3 from section 2.5.7.1 as stimulus to ASSAP, but without the TCAS source. Use 1090ES or UAT report format as appropriate for the installation. Ensure ASSAP is configured to provide all available data to the CDTI interface.

Verify that the appropriate tracks appear on the CDTI interface and the extrapolation of that track is consistent with the truth data. Verify that the Traffic ID/Status Report data for the track appears on the CDTI interface.

Repeat this step with a modified version of Scenario 1-3 where each data field that has reserved values has one of the reserved values set in a given ADS-B/ADS-R/TIS-B report in order to exercise each data field for those data fields that have reserved values. Verify that ASSAP treats any data field with a reported value outside the normal expected values as data not available on the CDTI interface.

1.32 Page 99, replace paragraph 2.5.2.5.1.7 with:

Verification of Traffic Horizontal Position (§2.2.2.5.1.7)

Generate a scenario including airborne and surface target elements that include Traffic Horizontal Position information as latitude/longitude, for some of the traffic elements, and as relative range and bearing referenced from ownship position for other traffic elements in the scenario.

Verify at the CTDI interface that those elements with a latitude/longitude were received with the latitude/longitude information included.

Verify at the CTDI interface that those elements with a relative range and bearing referenced from ownship position were received with the relative range and bearing information included and *calculated based on the ownship horizontal position source* defined in Section 2.2.2.3.1 of this document.

1.33 Page 99, replace paragraph 2.5.2.5.1.8 with:

Verification of Traffic Ground Speed (§2.2.2.5.1.8)

Generate a scenario including surface target elements with Ground Speed information included.

Verify at the *CDTI* interface that those elements with a Ground Speed were received with the Ground Speed information included.

For designs that validate the reported horizontal velocity uncertainty in lieu of a reported NACv, generate scenarios that cause the velocity quality validation to fail. Verify that those traffic elements are marked as invalid. If the approach and surface applications are implemented, generate scenarios for both the 3 m/s validation and 10 m/s validation.

1.34 Page 101, replace paragraph 2.5.2.5.1.16 with:

Verification of Traffic Application Capability (§2.2.2.5.1.16)

Generate a scenario including target elements that include Traffic Application Capability information as valid, for some of the traffic elements, and as invalid for other traffic elements in the scenario. Be sure to include at least one valid and one invalid traffic element for each available application whether active or not.

Verify at the CTDI interface that those elements with a valid indication were received with the Traffic Application Capability information marked as valid as appropriate for the application definitions defined in Section 2.2.2.5.1.16 of this document.

Verify at the CTDI interface that those elements with an invalid indication were received with the Traffic Application Capability information marked as invalid as appropriate for the application definitions defined in Section 2.2.2.5.1.16 of this document.

1.35 Page 106, change title of paragraph 2.5.3.1.3.2 to:

Verification of Duplicate Address *Processing for UAT Systems* (§2.2.3.1.3.2)

1.36 Page 106, new paragraph 2.5.3.1.3.3 reads as follows:

Verification of Duplicate Address Processing for 1090 MHz Systems (§2.2.3.1.3.3)

Step 1: Inject Scenario 2-5 from Section 2.5.7.2.

Verify that the duplicate addresses result in a new track within 2 updates for 1090.

Step 2: Inject Scenario 3-5 from Section 2.5.7.2.

Verify that the duplicate addresses result in a new track within 2 updates for 1090.

1.37 Page 106, replace paragraph 2.5.4.1.2 with:

Verification of Traffic Vehicle Requirements for EVAcq (§2.2.4.1.2)

Test Tool Requirements:

This test will require the generation of multiple traffic scenarios as a prerequisite.

Test Procedure:

Case 1: Generate a scenario with a track that initially has NACp greater than or equal to 5. Have the NACp value drop below 5. Verify that the track is dropped from the CDTI at this time.

Case 2*a*: *For Version 1 traffic, g*enerate a scenario with a track that initially has NACp greater than or equal to 9 but without barometric altitude information. Use relative Geometric altitude. Verify that the track is marked valid on the CDTI and displays the correct relative altitude.

Case 2b: For Version 2 traffic, generate a scenario with a track that initially has GVA greater than or equal to 2, but without barometric altitude information. Use relative Geometric altitude. Verify that the track is marked valid on the CDTI and displays the correct relative altitude.

Case 3: Generate a scenario with a track that initially has NACp less than 9 but without altitude information. Verify that the relative altitude tag is dropped from the track.

Case 4: Generate a scenario with a track that initially has NACp greater than or equal to 5. Update this track in 24 seconds and verify that the track remains on the CDTI. Update the track again in 26 seconds and verify that the track was dropped prior to the second update.

Case 5: Generate a scenario with a track that has an SDA of 0. Verify that the track is not displayed on the CDTI. Change the SDA for this track to a value greater than or equal to 1. Verify the track is displayed on the CDTI.

1.38 Page 113, replace paragraph 2.5.4.2.1 with:

Verification of Ownship Requirements for ASSA/FAROA (§2.2.4.2.1)

Test Procedure:

<u>Step 1:</u>

Generate an airborne scenario with ownship having a valid Horizontal Position with a horizontal uncertainty < 50m and with a valid pressure altitude.

Verify that ASSA/FAROA was operative at the CDTI interface.

Generate an airborne scenario with ownship having a valid Horizontal Position with a horizontal uncertainty > 50m and with a valid pressure altitude.

Verify that ASSA/FAROA was inoperative at the CDTI interface.

Generate an airborne scenario with ownship having a valid Horizontal Position with a horizontal uncertainty < 50m and a valid Vertical Position (Geometric Altitude) with a reported vertical position uncertainty < 45m.

Verify that ASSA/FAROA was operative at the CDTI interface.

Generate an airborne scenario with ownship having a valid Horizontal Position with a horizontal uncertainty > 50m with a valid pressure altitude and a reported vertical position uncertainty > 45m.

Verify that ASSA/FAROA was inoperative at the CDTI interface.

Generate an airborne scenario with ownship having a valid Horizontal Position with a horizontal uncertainty < 50m and a reported vertical position uncertainty > 45m.

Verify that ASSA/FAROA was inoperative at the CDTI interface.

Generate a surface scenario with ownship having a valid Horizontal Position with a horizontal uncertainty < 50m.

Verify that ASSA/FAROA was operative at the CDTI interface.

Generate a surface scenario with ownship having a valid Horizontal Position with a horizontal uncertainty > 50m.

Verify that ASSA/FAROA was inoperative at the CDTI interface.

(For Class A functional equipment) Generate a surface scenario with ownship on ground having a valid Horizontal Position with a horizontal uncertainty < 50m and a valid Horizontal Velocity < 80 knots.

Verify that ASSA/FAROA was operative at the CDTI interface.

(For Class A functional equipment) Generate a surface scenario with ownship on ground having a valid Horizontal Position with a horizontal uncertainty < 50m and a valid Horizontal Velocity > 80 knots.

Verify that ASSA/FAROA was inoperative at the CDTI interface.

Step 2: Generate Ownship data with the Runway database not available for the depiction of Runway Surfaces and Extended Centerline or Final Approach Course. Verify that ASSAP signals that FAROA is unavailable via the CDTI interface.

Step 3: Generate Ownship data with the Runway database not available for the depiction of Runway Surfaces and Extended Centerline or Final Approach Course, Taxiways and Movement Surfaces. Verify that ASSAP signals that ASSA is unavailable via the CDTI interface.

1.39 Page 115, replace paragraph 2.5.4.2.2 with:

Verification of Traffic Vehicle Requirements for ASSA/FAROA (§2.2.4.2.2)

Test Procedure:

Step 1: Generate an airborne scenario where a traffic element is reporting valid horizontal position and geometric altitude with a NACp *7* and is reporting a *valid horizontal velocity with 3 m/s or greater accuracy and* valid pressure altitude and where the traffic position message has been received within the last 11 seconds.

Verify that the traffic is marked as valid for ASSA/FAROA on the CDTI interface.

Step 2: Repeat Step 1, but change the update rate to greater than 11 seconds and verify that the traffic is marked as invalid for ASSA/FAROA on the CDTI interface.

Step 3a: Repeat Step 1, but remove the pressure altitude and verify that the traffic is marked as invalid for ASSA/FAROA on the CDTI interface.

Step 3b: Repeat Step 1, but change the horizontal velocity accuracy to greater than 3 m/s and verify that the traffic is marked as invalid for ASSA/FAROA on the CDTI interface.

Step 4*a*: Repeat Step 1 *for Version 0 and 1 traffic*, but remove the pressure altitude and change the target NACp to 9. Verify that the traffic is marked as valid for ASSA/FAROA on the CDTI interface.

Step 4b: Repeat Step 1 for Version 2 traffic, but remove the pressure altitude and set the GVA to 2 or greater. Verify that the traffic is marked as valid for ASSA/FAROA on the CDTI interface.

Step 5: Repeat Step 1, but change NACp to *6* and verify that the traffic is marked as invalid for ASSA/FAROA on the CDTI interface.

Step 6: (For functional equipment intended for use with runway geometry that includes parallel runways with centerline-to-centerline spacing less than 676 meters (2218 feet) Repeat Step 1, but change NACp to 8 and verify that the traffic is marked as invalid for ASSA/FAROA on the CDTI interface

Step 7: Generate a surface scenario where the *on ground* traffic is reporting valid horizontal position with a NACp *9, a valid horizontal velocity with 3 m/s or greater accuracy* and is in motion with a position message not having been received within the last *11* seconds.

Verify that the traffic is marked as *valid* for ASSA/FAROA on the CDTI interface.

Step 8: Repeat Step 7, but change the NACp to 8 and verify that the traffic is marked as invalid for ASSA/FAROA on the CDTI interface.

Step 9: Repeat Step 7, but change the horizontal velocity accuracy to greater than 3 m/s and verify that the traffic is marked as invalid for ASSA/FAROA on the CDTI interface.

Step 10: Repeat Step 7, but change the on ground traffic to no longer be in motion with a position message not having been received within the last 25 seconds and verify that the traffic is marked as invalid for ASSA/FAROA on the CDTI interface.

Step 11: Generate an airborne scenario where the traffic has an SDA of 0. Verify that the traffic is marked as invalid for ASSA/FAROA on the CDTI. Change the SDA for this traffic to a value greater than or equal to 1. Verify the traffic is marked as valid for ASSA/FAROA on the CDTI interface.

Step 12: Generate a surface scenario where the traffic has an SDA of 0. Verify that the traffic is marked as invalid for ASSA/FAROA on the CDTI. Change the SDA for this traffic to a value greater than or equal to 1. Verify the traffic is marked as valid for ASSA/FAROA on the CDTI interface.

1.40 Page 117, replace paragraph 2.5.4.4.1 with:

Verification of Ownship Requirements for EVApp (§2.2.4.4.1)

Test Tool Requirements:

This test will require a source for the generation of Ownship data.

Test Procedure:

Case 1: Generate Ownship data with the Ownship horizontal position invalid and verify that ASSAP signals that EVApp is inoperative via the CDTI interface.

Case 2: Generate Ownship data, in an airborne state, with the Ownship vertical position invalid and verify that ASSAP signals that EVApp is inoperative via the CDTI interface.

Case 3: Generate Ownship data with the Ownship horizontal position uncertainty set greater than 0.3 NM and verify that ASSAP signals that EVApp is inoperative via the CDTI interface.

Case 4: Generate Ownship data, in the airborne state using geometric altitude for vertical position where the vertical position uncertainty is set greater than 45m, and verify that ASSAP signals that EVApp is inoperative via the CDTI interface.

Case 5: Generate Ownship data with the Ownship horizontal velocity uncertainty set greater than 10m/s and verify that ASSAP signals that EVApp is inoperative via the CDTI interface.

Case 6: Generate Ownship data with the Ownship R_C greater than 0.*6* NM and verify that ASSAP signals that EVApp is inoperative via the CDTI interface.

1.41 Page 118, replace paragraph 2.5.4.4.2 with:

Verification of Traffic Vehicle Requirements for EVApp (§2.2.4.4.2)

Test Tool Requirements:

This test will require the generation of traffic tracks.

Test Procedure:

Case 1: Generate traffic data with a valid horizontal and vertical position and verify that ASSAP signals that a EVApp traffic is derived via the CDTI interface.

Case 2: Generate traffic data with a pressure source for altitude and a NACp value set to 5, NACv set to 1, SIL set to 1 and NIC set to 6 and verify that ASSAP signals that the track is marked as invalid for EVApp.

Case 3: Generate traffic data with a pressure source for altitude and a NACp value set to 6, NACv set to 1, SIL set to 1 and NIC set to 6 and verify that ASSAP signals that a EVApp traffic element is derived via the CDTI interface. Repeat this case with NACv set to 0 and verify that ASSAP signals that the track is marked as invalid for EVApp. Repeat this case with SIL set to 0 and verify that ASSAP signals that EVApp is inoperative via the CDTI interface. Repeat this case with NIC set to 5 and verify that ASSAP signals that EVApp is inoperative via the CDTI interface. *Repeat this case for Version 2 traffic data with SDA set to 0 and verify that ASSAP signals that EVApp is inoperative via the CDTI interface.*

Case 4*a*: Generate *Version 1* traffic data with a geometric altitude source for altitude and a NACp value set to 8, NACv set to 1, SIL set to 1 and NIC set to 6 and verify that ASSAP signals that the track is marked as invalid for EVApp.

Case 4b: Generate Version 2 traffic data with a geometric altitude source for altitude and a GVA value set to 1, NACp set to 6, NACv set to 1, SIL set to 1, SDA set to 2 and NIC set to 6 and verify that ASSAP signals that the track is marked as invalid for EVApp.

Case 5*a*: Generate *Version 0 and 1* traffic data with a geometric altitude source for altitude and a NACp value set to 9, NACv set to 1, SIL set to 1 and NIC set to 6 and verify that ASSAP signals that an EVApp traffic element is derived via the CDTI interface. Repeat this case with NACv set to 0 and verify that ASSAP signals that the track is marked as invalid for EVApp. Repeat this case with SIL set to 0 and verify that ASSAP signals that the track is marked as invalid for EVApp. Repeat this case with NIC set to 5 and verify that ASSAP signals that the track is marked as invalid for EVApp.

Case 5b: Generate Version 2 traffic data with a geometric altitude source for altitude and a GVA value set to 2, NACp value set to 6, NACv set to 1, SIL set to 1, SDA set to 2 and NIC set to 6 and verify that ASSAP signals that an EVApp traffic element is derived via the CDTI interface. Repeat this case with NACv set to 0 and verify that ASSAP signals that the track is marked as invalid for EVApp. Repeat this case with SIL set to 0 and verify that ASSAP signals that the track is marked as invalid for EVApp. Repeat this case with NIC set to 5 and verify that ASSAP signals that the track is marked as invalid for EVApp. Repeat this case with SDA set to 1 and verify that ASSAP signals that the track is marked as invalid for EVApp.

Case 6: Generate traffic data with a valid horizontal and vertical position and verify that ASSAP signals that EVApp traffic is derived via the CDTI interface. Allow more than 15 seconds to pass without an update. Verify that ASSAP signals that the traffic is invalid for the EVApp application.

1.42 Page 131, replace paragraph 2.6.1 entries for requirement paragraph 2.3.1 and 2.3.9.2 in Table 2-10 with:

2.3.1 (3000) & (3000A)	2.6.2.1, 2.6.2.3 & 2.6.2.4	D	The system meets the requirements for the EVAcq application.

2.3.9.2 (3135)	Deleted		

1.43 Page 168, replace paragraph 2.6.2.18 with:

Verification – ASSA/FAROA

If the installation supports the ASSA/FAROA application, then using CDTI Test Setups #1, #2, and #10 as specified in 2.6.3.1, 2.6.3.2, and 2.6.3.10 respectively verify compliance to the following requirements.

Provide valid Ownship and sufficient traffic information (valid and invalid directionality, good, invalid traffic data quality, and a valid surface map.

Verify all traffic with valid directionality is displayed with directionality.

Cycle through the full set of selectable ranges and verify compliance with the following:

1. Verify that the display is adjustable to 1 NM or less in the direction of ownship travel as measured from the ownship position to the edge of the viewable screen.

2. Verify that the display is adjustable to 40 NM or greater in the direction of ownship travel as measured from the ownship position to the edge of the viewable screen.

Simulate an airport surface map and display on the CDTI display.

3. Verify the displayed traffic corresponds to the underlying surface map.

4. Verify the displayed traffic are displayed at their actual received positions.

1.44 Page C-4, replace paragraph C.3.1.1.1 with:

Track Generation (1090ES Implementation)

Upon reception of a state vector report, ASSAP searches for a track of the same type (ADS-B, ADS-R, TIS-B) and with the same 24-bit address as the report. If no match is found, ASSAP generates a new track containing the following parameters:

a. System time (track time of applicability).

b. Position time of applicability.

c. Velocity time of applicability.

d. Track type (ADS-B, ADS-R, TIS-B).

e. 24-bit address.

f. Position (latitude, longitude, altitude).

g. Velocity (East/West velocity, North/South velocity, altitude rate).

h. NIC.

i. [1]NACp = 5

j. [1]NACv = 1

k. [1]SIL = 0

l. [1]GVA = 1 (Version 2)

m. [2]State covariance matrices.

Note:

1. *Track quality parameters are initially set to the minimum values allowed by the Enhanced Visual Acquisition application (with the exception that NACv is set to 1 in order to make the velocity uncertainty a known value and, for Version 2 reports, GVA is set to 1 to make the geometric vertical accuracy a known value). Reception of these parameters in subsequent Mode Status reports will overwrite this data.*

2. *State covariance matrices are derived from estimated position and velocity uncertainties in the local East/North/Up (ENU) coordinate frame:*

Initial covariance matrix for the x-dimension

$$\begin{pmatrix} \sigma_x^2 & \sigma_{x\dot{x}} \\ \sigma_{x\dot{x}} & \sigma_{\dot{x}}^2 \end{pmatrix} = \begin{pmatrix} \sigma_{epu}^2 & \sigma_{epu}\sigma_{hva} \\ \sigma_{epu}\sigma_{hva} & \sigma_{hva}^2 \end{pmatrix}$$

Initial covariance matrix for the y-dimension

$$\begin{pmatrix} \sigma_y^2 & \sigma_{y\dot{y}} \\ \sigma_{y\dot{y}} & \sigma_{\dot{y}}^2 \end{pmatrix} = \begin{pmatrix} \sigma_{epu}^2 & \sigma_{epu}\sigma_{hva} \\ \sigma_{epu}\sigma_{hva} & \sigma_{hva}^2 \end{pmatrix}$$

where

σ_{epu} (standard deviation of estimated position uncertainty) is derived from NACp (described in Table C-1A).

σ_{hva} (standard deviation of horizontal velocity accuracy) is derived from NACv (described in Table C-2).

Initial covariance matrix for the z-dimension

$$\begin{pmatrix} \sigma_z^2 & \sigma_{z\dot{z}} \\ \sigma_{z\dot{z}} & \sigma_{\dot{z}}^2 \end{pmatrix} = \begin{pmatrix} \sigma_{vepu}^2 & \sigma_{vepu}\sigma_{vva} \\ \sigma_{vepu}\sigma_{vva} & \sigma_{vva}^2 \end{pmatrix}$$

where

σ_{vepu} (standard deviation of vertical estimated position uncertainty) is derived from NACp if geometric altitude is used and NACp ≥ 9 *(Version 1), from the reported geometric vertical accuracy (Version 2),* or an assumed value *for pressure altitude uncertainty (e.g., 100 ft)* otherwise.

σ_{vva} (standard deviation of vertical velocity accuracy) is derived from NACv if geometric altitude rate is used, or an assumed value *for pressure altitude rate uncertainty (e.g., 25 ft/s)* otherwise.

Table C-1*A* Navigation Accuracy Categories for Position (NACp) *(Version 1)*

NAC_P	95% Horizontal and Vertical Accuracy Bounds (EPU and VEPU)
0	EPU ≥ 18.52 km (10 NM)
1	EPU < 18.52 km (10 NM)
2	EPU < 7.408 km (4 NM)
3	EPU < 3.704 km (2 NM)
4	EPU < 1852 m (1NM)
5	EPU < 926 m (0.5 NM)
6	EPU < 555.6 m (0.3 NM)
7	EPU < 185.2 m (0.1 NM)
8	EPU < 92.6 m (0.05 NM)
9	EPU < 30 m and VEPU < 45 m
10	EPU < 10 m and VEPU < 15 m
11	EPU < 3 m and VEPU < 4 m

Note: NACp accuracy bounds for Version 2 are the same except Version 2 does not have VEPU.

***Table C-1B* Geometric Vertical Accuracy (GVA) (Version 2)**

GVA	*Vertical Figure of Merit (VFOM) from GNSS Position Source*

0	*Unknown or > 150 meters*
1	*≤ 150 meters*
2	*≤ 45 meters*
3	*Reserved – may be decoded as < 45 meters*

Note: Where σ_{epu} and σ_{vepu} (if applicable) are derived from 95% values assumed to correspond to a Gaussian distribution. For example, a NACp of 5 equates to an EPU of 926 meters, where σ_{epu} = EPU/1.96 = 472.449 meters.

Table C-2 Navigation Accuracy Categories for Velocity (NACv)

Navigation Accuracy Category for Velocity	
NACv	**Horizontal Velocity Error**
0	**Unknown or ≥ 50 feet (15.24 m) per second**
1	**< 50 feet (15.24 m) per second**
2	**< 15 feet (4.57 m) per second**
3	**< 5 feet (1.52 m) per second**
4	**< 1.5 feet (0.46 m) per second**

Note: Where σ_{hva} and σ_{vva} (if applicable) are derived from 95% values assumed to correspond to a Gaussian distribution. For example, a NACv of 1 equates to an HVA of 10 m/s, where σ_{hva} = HVA/1.96 = 5.102 m/s.

1.45 Page C-9, replace paragraph C.3.1.1.2.1.1 with:

State Assembly With Position Updates

Equations (1), (2), and (3) are used to convert a position update from WGS84 to local ENU coordinates. Measurement position variances are derived from the NACp value stored in the candidate track. It is important to note that this is the technique used to link state vector and mode status reports. It is possible that a mode status report updated NACp and NACv in the track milliseconds before the arrival of the state vector update. First, the residual (or innovation) variances are calculated with extrapolated track position variances and estimated measurement position variances (based on most current NACp):

$$\sigma_{v_x}^2 = \sigma_{\hat{x}}^2 + \sigma_{epu}^2$$
$$\sigma_{v_y}^2 = \sigma_{\hat{y}}^2 + \sigma_{epu}^2$$
$$\sigma_{v_z}^2 = \sigma_{\hat{z}}^2 + \sigma_{vepu}^2 \quad (6)$$

where

$\left(\sigma_{\hat{x}}^2, \sigma_{\hat{y}}^2, \sigma_{\hat{z}}^2\right)$ are extrapolated track position variances

$\left(\sigma_{epu}^2, \sigma_{vepu}^2\right)$ are estimated measurement position variances derived from NACp *(Version 1), from the reported geometric vertical accuracy (Version 2),* or an assumed value for vertical pressure altitude uncertainty *(e.g., 100 ft).*

Gain vectors are then calculated with extrapolated track and residual variances:

$$k_{0_x} = \frac{\sigma_{\hat{x}}^2}{\sigma_{v_x}^2}, \; k_{1_x} = \frac{\sigma_{\hat{x}\hat{\dot{x}}}}{\sigma_{v_x}^2}$$
$$k_{0_y} = \frac{\sigma_{\hat{y}}^2}{\sigma_{v_y}^2}, \; k_{1_y} = \frac{\sigma_{\hat{y}\hat{\dot{y}}}}{\sigma_{v_y}^2} \quad (7)$$
$$k_{0_z} = \frac{\sigma_{\hat{z}}^2}{\sigma_{v_z}^2}, \; k_{1_z} = \frac{\sigma_{\hat{z}\hat{\dot{z}}}}{\sigma_{v_z}^2}$$

The assembled state is generated as follows:

$$x_a = \hat{x} + k_{0x}(x_m - \hat{x})$$
$$y_a = \hat{y} + k_{0_y}(y_m - \hat{y})$$
$$z_a = \hat{z} + k_{0z}(z_m - \hat{z})$$
$$\dot{x}_a = \hat{\dot{x}} + k_{1x}(x_m - \hat{x}) \quad (8)$$
$$\dot{y}_a = \hat{\dot{y}} + k_{1y}(y_m - \hat{y})$$
$$\dot{z}_a = \hat{\dot{z}} + k_{1z}(z_m - \hat{z})$$

where

(x_m, y_m, z_m) are measurement positions in local ENU

It is important to note that in cases where altitude is measured with a barometric sensor, the error characteristics associated with the original measurement (i.e., assumed pressure altitude uncertainty) are used to filter the calculated relative geometric altitude, as these characteristics have not changed.

The assembled state covariance matrices are calculated as follows:

$$
\begin{aligned}
\sigma_{x_a}^2 &= (1-k_{0_x})\sigma_{\hat{x}}^2 \\
\sigma_{x\dot{x}a} &= (1-k_{0_x})\sigma_{\hat{x}\hat{\dot{x}}} \\
\sigma_{\dot{x}_a}^2 &= \sigma_{\hat{\dot{x}}}^2 - k_{1_x}\sigma_{\hat{x}\hat{\dot{x}}} \\
\\
\sigma_{y_a}^2 &= (1-k_{0_y})\sigma_{\hat{y}}^2 \\
\sigma_{y\dot{y}a} &= (1-k_{0_y})\sigma_{\hat{y}\hat{\dot{y}}} \\
\sigma_{\dot{y}_a}^2 &= \sigma_{\hat{\dot{y}}}^2 - k_{1_y}\sigma_{\hat{y}\hat{\dot{y}}} \\
\\
\sigma_{z_a}^2 &= (1-k_{0_z})\sigma_{\hat{z}}^2 \\
\sigma_{z\dot{z}a} &= (1-k_{0_z})\sigma_{\hat{z}\hat{\dot{z}}} \\
\sigma_{\dot{z}_a}^2 &= \sigma_{\hat{\dot{z}}}^2 - k_{1_z}\sigma_{\hat{z}\hat{\dot{z}}}
\end{aligned}
\qquad (9)
$$

The assembled state and track state (both in local ENU coordinates) are then sent to the correlation window function.

1.46 Page C-13, replace paragraph C.3.1.1.2.2 with:

Correlation Window

The correlation window is used to perform a final check that ensures the received state vector report truly corresponds to the candidate track. The correlation window is an estimated maximum distance between two reported positions, based on the concepts shown in Figure C-3.

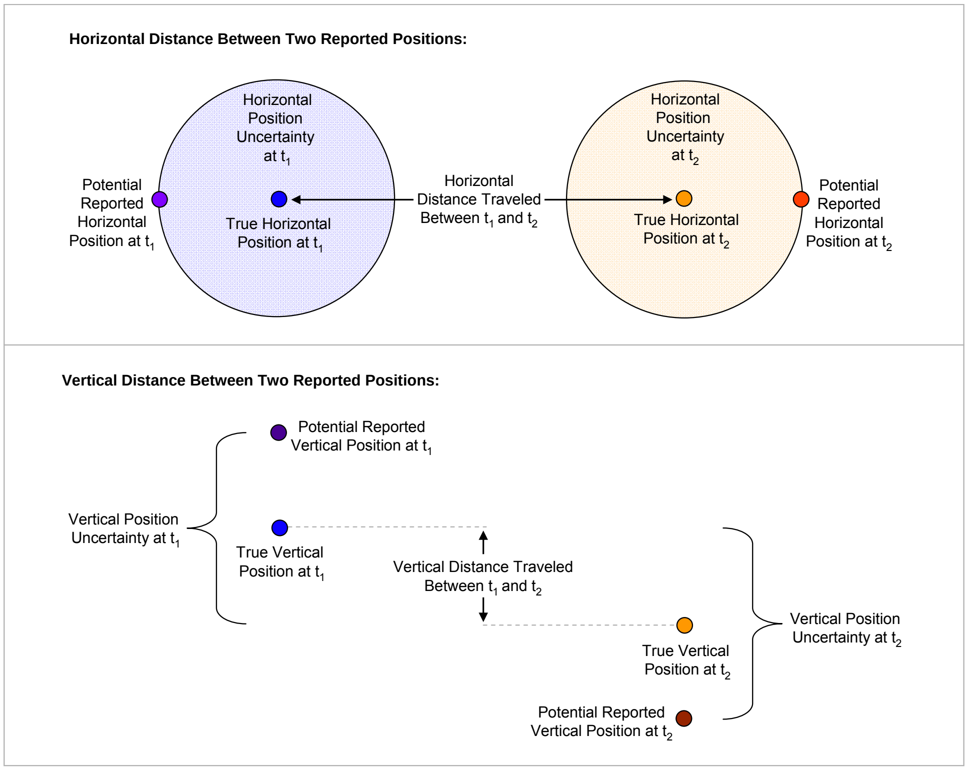


Figure C-3 Estimated Maximum Horizontal and Vertical Distances Between Two Reported Positions

The correlation window is calculated as follows:

$$r_h = \sqrt{\dot{x}_a^2 + \dot{y}_a^2}(dt) + 2(6\sigma'_{epu})$$
$$r_v = |\dot{z}_a| dt + 2(6\sigma'_{vepu}) \quad (14)$$

where

σ'_{epu} , σ'_{vepu} are derived from degrading NACp to NACp – 1 *(Version 1), from degrading GVA to GVA-1(Version 2),* or an assumed value is used for vertical pressure altitude uncertainty *(e.g., 100 ft)*.

r_h is an estimated maximum horizontal distance between the assembled and track positions.

r_v is estimated maximum vertical distance between the assembled and track positions.

Note: These estimates assume linear dynamics (no acceleration).

Next, differences between assembled and track positions are calculated:

$$d_h = \sqrt{(x_a - x)^2 + (y_a - y)^2}$$
$$d_v = |z_a - z| \qquad (15)$$

where

d_h is the difference between assembled/filtered and track horizontal positions.

d_v is the difference between assembled/filtered and track vertical positions.

If $d_h \le r_h$ and $d_v \le r_v$, spatial correlation occurs.

1.47 Page C-30, replace paragraph C.3.2.2.2 with:

Non-Mode S Address (or Unmatched Mode S Address) TCAS Track Processing

For all ADS-B/ADS-R/TIS-B tracks in the track file database that have not been previously labeled as invalid for correlation with the TCAS track (i.e., *track(i).TCAS_IDs(j)= current TCAS track ID* and *track(i).TCAS_correlation_status(j)* has not been set equal to -1), track position is converted to local ENU coordinates with equations (1), (2), and (3). Relative geometric altitude (‘*z*’) is replaced with relative pressure altitude using (21). The track ENU position is then predicted to the time of applicability of the TCAS track with equation (4). Each ADS-B/ADS-R/TIS-B track is compared to the TCAS track with a dynamic correlation window that changes size to account for a number of error sources. The dynamic window consists of horizontal (core and buffer) and vertical components. The horizontal window’s core (depicted in Figure C-10) is a trapezoid based on potential range and bearing error in the TCAS track and error in the calculation of two-dimensional range.

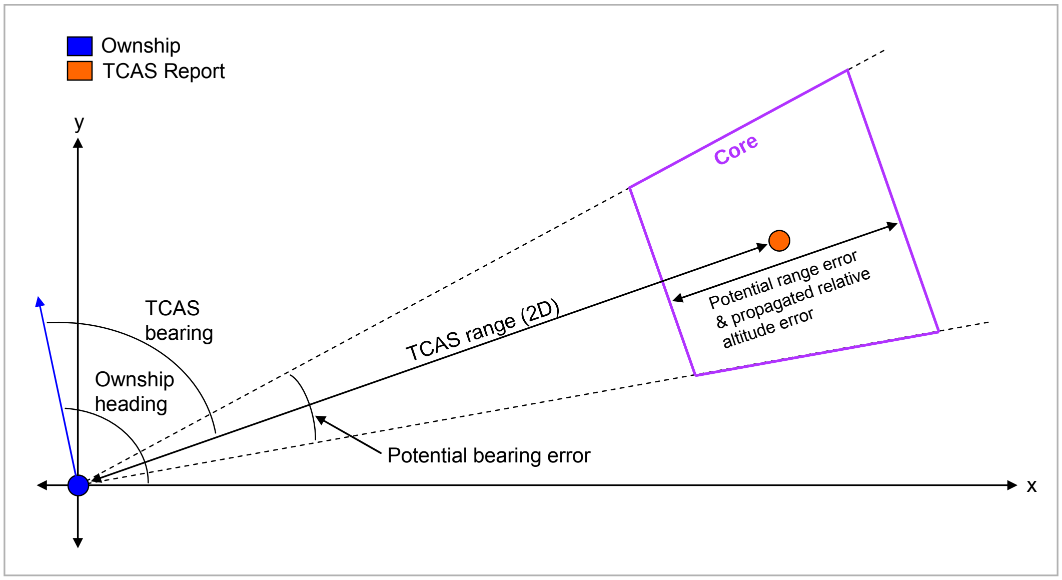


Figure C- 10 Dynamic TCAS Correlation Window – Horizontal Core

The horizontal core of the dynamic TCAS window is defined as follows:

$$L = 2s_l(6\sigma_r)$$

$$\beta = s_b(6\sigma_b)$$

$$p_1 = \left[\left(r_{xy} - \frac{L}{2}\right)\cos\alpha + \left(r_{xy} - \frac{L}{2}\right)\tan\beta\cos\left(\alpha + \frac{\pi}{2}\right), \left(r_{xy} - \frac{L}{2}\right)\sin\alpha + \left(r_{xy} - \frac{L}{2}\right)\tan\beta\sin\left(\alpha + \frac{\pi}{2}\right)\right] \quad (25)$$

$$p_2 = \left[\left(r_{xy} + \frac{L}{2}\right)\cos\alpha + \left(r_{xy} + \frac{L}{2}\right)\tan\beta\cos\left(\alpha + \frac{\pi}{2}\right), \left(r_{xy} + \frac{L}{2}\right)\sin\alpha + \left(r_{xy} + \frac{L}{2}\right)\tan\beta\sin\left(\alpha + \frac{\pi}{2}\right)\right]$$

$$p_3 = \left[\left(r_{xy} + \frac{L}{2}\right)\cos\alpha + \left(r_{xy} + \frac{L}{2}\right)\tan\beta\cos\left(\alpha + \frac{3\pi}{2}\right), \left(r_{xy} + \frac{L}{2}\right)\sin\alpha + \left(r_{xy} + \frac{L}{2}\right)\tan\beta\sin\left(\alpha + \frac{3\pi}{2}\right)\right]$$

$$p_4 = \left[\left(r_{xy} - \frac{L}{2}\right)\cos\alpha + \left(r_{xy} - \frac{L}{2}\right)\tan\beta\cos\left(\alpha + \frac{3\pi}{2}\right), \left(r_{xy} - \frac{L}{2}\right)\sin\alpha + \left(r_{xy} - \frac{L}{2}\right)\tan\beta\sin\left(\alpha + \frac{3\pi}{2}\right)\right]$$

where

s_l = adaptable length scalar.

s_b = adaptable width (bearing) scalar.

[1]σ_b = assumed standard deviation of bearing error = 6.67 degrees = 0.1164 radians.

p_1, p_2, p_3, p_4 = points that define the horizontal core (as illustrated by Figure C-11).

Note: The bearing error standard deviation of 6.67 degrees was empirically arrived at to balance false and correct correlations

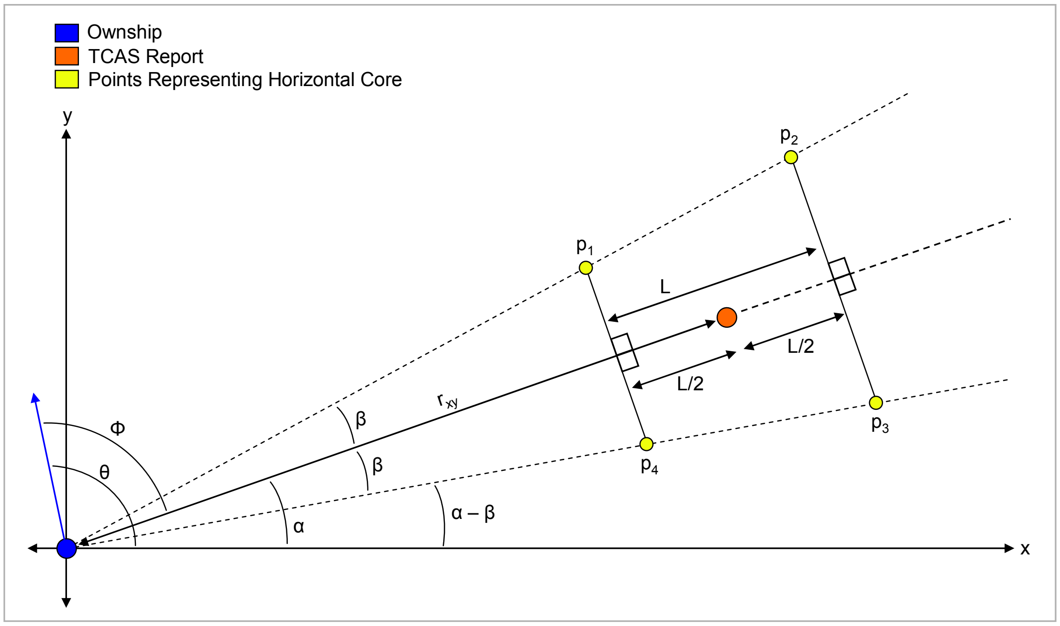


Figure C- 11 Dynamic TCAS Correlation Window – Points Representing the Horizontal Core

Table C-5 contains optimal values for s_l and s_b identified through intensive simulation testing with operational and synthesized data.

Table C- 5 Optimal Length Scalar for the Dynamic TCAS Correlation Window

Scalar	Optimal Value
s_l	41.000
s_b	1.0833

Note: *In the case where address matching is not possible, it is important to note that the word optimal does not imply perfection. Large length and width scalars (and hence a large window) will increase the probability of correlation; however, they also increase the potential for miscorrelation. Therefore the window should be large enough to achieve a high correlation rate, but small enough to minimize the probability of miscorrelation. The values listed in Table C-5 produced a very high association rate with operational flight test data involving few aircraft and stressful dynamics, yet these values also produced no miscorrelations with synthesized (dense) terminal traffic data.*

It is extremely important to note that a special case exists in which the dynamic TCAS window will warp if a small algorithm change is not performed. If the TCAS target is within close proximity of ownship (i.e., 1 NM or less), then the origin in the ENU coordinate frame (ownship position) is within the TCAS window – this causes significant warping that will negatively impact performance. This case can be detected when r_{xy} –

L/2 < 0. If this case is detected, the core points p_1 and p_4 are both set to (0,0) and the width scalar s_b is slightly increased to 1.625, resulting in a triangular core.

The horizontal window's buffer (depicted in Figure C-12) is a 12-sided polygon based on track horizontal position error and prediction error introduced when tracks are extrapolated to the TOA of the TCAS report. The buffer is an estimate of the shape that would be formed when a circle representing track position uncertainty is moved completely around the core, with the center of the circle remaining on the border of the trapezoid. Buffer widths can change dramatically depending on the track being examined.

For tracks with poor NACp values (e.g., 4), the buffer will be large due to potential position error. If the time difference between the TCAS update and track update is significant (e.g,, 10 seconds), the buffer will be large due to potential prediction error.

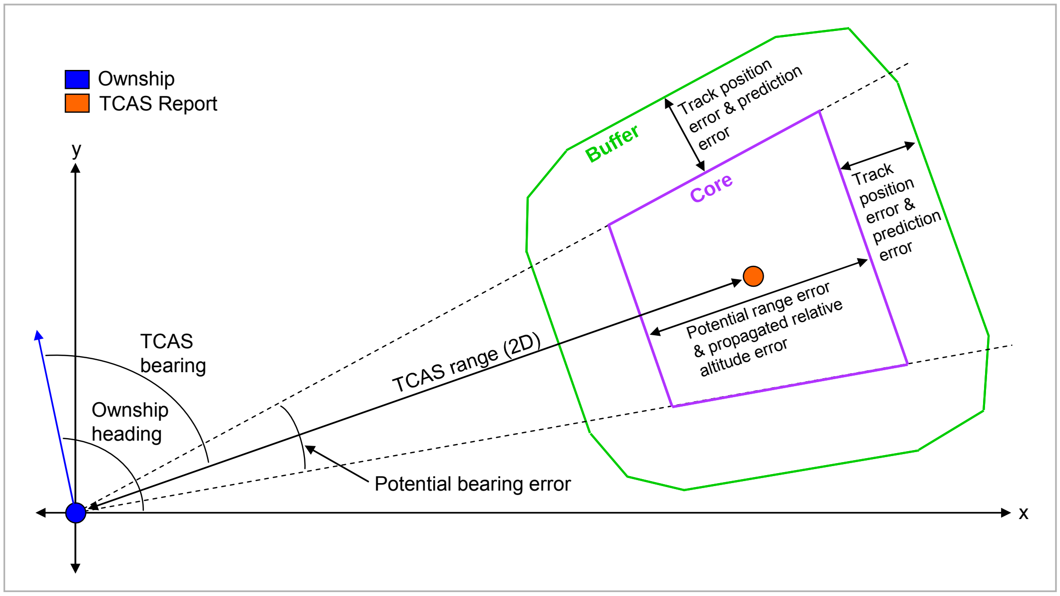


Figure C- 12 Dynamic TCAS Correlation Window – Horizontal Buffer

First, the width of the buffer is defined as follows:

$$w = 3\sigma_{epu} + v(dt) \qquad (26)$$

where

σ_{epu} = is the standard deviation of track position uncertainty (derived from NACp).

v = track speed (along-track horizontal velocity).

dt = time difference between the TCAS track TOA and track file TOA.

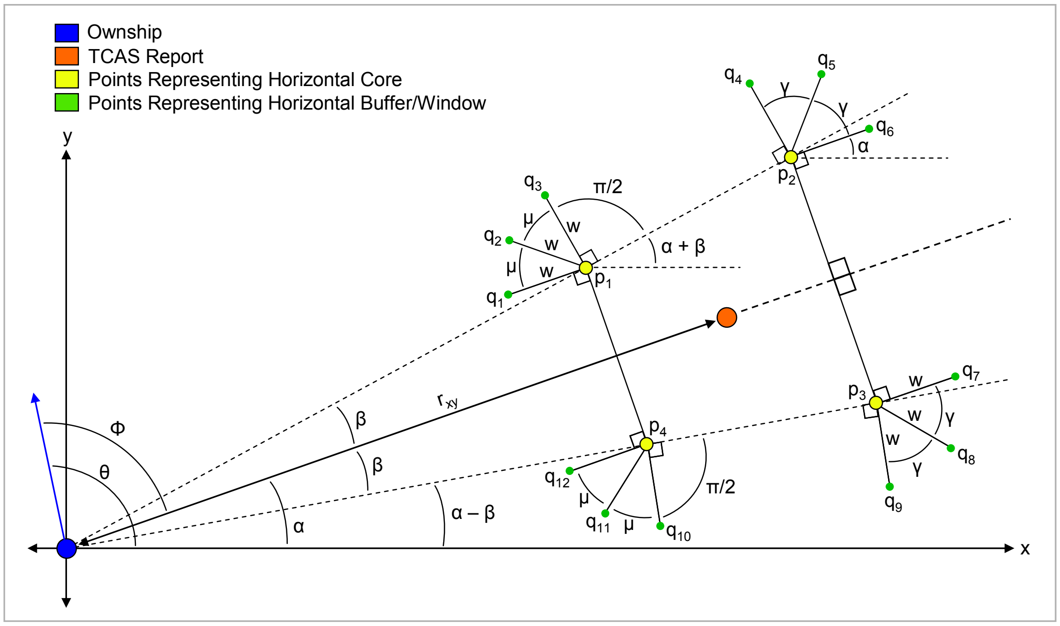
The buffer (and hence the horizontal window) is then defined by rotating radii (equal to the buffer width) about the points that make up the core:

$$\mu = \frac{\pi - 2\beta}{4}$$
$$\gamma = \frac{\pi + 2\beta}{4}$$
$$q_1 = p_1 + \left[w\cos\left(\alpha + \beta + \frac{\pi}{2} + 2\mu \right), w\sin\left(\alpha + \beta + \frac{\pi}{2} + 2\mu \right) \right]$$
$$q_2 = p_1 + \left[w\cos\left(\alpha + \beta + \frac{\pi}{2} + \mu \right), w\sin\left(\alpha + \beta + \frac{\pi}{2} + \mu \right) \right]$$
$$q_3 = p_1 + \left[w\cos\left(\alpha + \beta + \frac{\pi}{2} \right), w\sin\left(\alpha + \beta + \frac{\pi}{2} \right) \right]$$
$$q_4 = p_2 + \left[w\cos(\alpha + 2\gamma), w\sin(\alpha + 2\gamma) \right]$$
$$q_5 = p_2 + \left[w\cos(\alpha + \gamma), w\sin(\alpha + \gamma) \right]$$
$$q_6 = p_2 + \left[w\cos\alpha , w\sin\alpha \right]$$
$$q_7 = p_3 + \left[w\cos\left(\alpha - \beta - \frac{\pi}{2} + 2\gamma \right), w\sin\left(\alpha - \beta - \frac{\pi}{2} + 2\gamma \right) \right]$$
$$q_8 = p_3 + \left[w\cos\left(\alpha - \beta - \frac{\pi}{2} + \gamma \right), w\sin\left(\alpha - \beta - \frac{\pi}{2} + \gamma \right) \right]$$
$$q_9 = p_3 + \left[w\cos\left(\alpha - \beta - \frac{\pi}{2} \right), w\sin\left(\alpha - \beta - \frac{\pi}{2} \right) \right]$$
$$q_{10} = p_4 + \left[w\cos\left(\alpha - \beta - \frac{\pi}{2} \right), w\sin\left(\alpha - \beta - \frac{\pi}{2} \right) \right]$$
$$q_{11} = p_4 + \left[w\cos\left(\alpha - \beta - \frac{\pi}{2} - \mu \right), w\sin\left(\alpha - \beta - \frac{\pi}{2} - \mu \right) \right]$$
$$q_{12} = p_4 + \left[w\cos\left(\alpha - \beta - \frac{\pi}{2} - 2\mu \right), w\sin\left(\alpha - \beta - \frac{\pi}{2} - 2\mu \right) \right] \quad (27)$$

where

μ , γ = angles used to rotate radii (buffer width) about points that make up core.

$q_1, q_2, \ldots q_{12}$ = points that define the horizontal buffer and horizontal window (as illustrated by Figure C-13).



<u>Figure C- 13</u> Dynamic TCAS Correlation Window – Points Representing the Horizontal Buffer/Window

The vertical component of the dynamic TCAS window is based upon estimated TCAS altitude error, track vertical estimated position uncertainty, and a height scalar:

$$h = s_h\left(3\sigma_z + 3\sigma_{vepu}\right) \tag{28}$$

where

> σ_z *= assumed standard deviation of TCAS altitude error = 3.889 meters.*
>
> σ_{vepu} *= standard deviation of track vertical position uncertainty (derived from NACp if the original altitude measurement was geometric and NACp ≥ 9 <u>(Version 1), from the reported geometric vertical accuracy (Version 2)</u>, or an assumed value <u>for pressure altitude uncertainty (e.g., 100 ft) otherwise</u>.*
>
> s_h *= height scalar, optimal value = 6.359.*

If the predicted horizontal track position ($\hat{x}, \hat{y}$) falls within the horizontal window ($q_1, q_2, \ldots q_{12}$) and predicted track vertical position ($\hat{z}$) falls within the range *[z – h, z + h]*, where *z* is *the* previously computed TCAS relative altitude, *then* spatial correlation succeeds. Otherwise, spatial correlation fails.

The data storage and success/failure criteria for full TCAS correlation are very similar to that used for the ownship shadow detection described previously. Upon a failed TCAS correlation window test, a "0" is added to the end of a 6-bit FIFO queue stored in the ADS-B/ADS-R/TIS-B track file (i.e., *track(i).TCAS_correlation_patterns(j)*), removing any value that may exist in the first index if the queue is full. TCAS correlation patterns are initialized when an ADS-B/ADS-R/TIS-B track is generated and grow to a maximum of six bits. For example, if a newly generated i-th ADS-B/ADS-R/TIS-B track failed the correlation window test upon track initiation and five subsequent updates with the j-th

TCAS track, the correlation pattern *track(i).TCAS_correlation_patterns(j)* in the track file would transition as follows: [0], [00],…,[000000].

If the TCAS correlation window succeeds, a "1" is added to the appropriate correlation pattern in the track file. Upon three consecutive full correlations (i.e., *track(i).TCAS_correlation_patterns(j) = [111] or track(i).TCAS_correlation_patterns(j) = [100111]*) the TCAS track is determined to be fully correlated with the ADS-B/ADS-R/TIS-B track if the following *two* conditions are met:

> *1)* The ADS-B/ADS-R/TIS-B track is not already fully correlated with another TCAS track (reflected in correlation status and TCAS ID fields in the track file).
>
> *2* The TCAS track is not already fully correlated with a different ADS-B/ADS-R/TIS-B track (reflected in correlation status and TCAS ID fields in a different track file).

If these conditions are met, the track file is marked appropriately (i.e., *track(i).TCAS_correlation_status(j) = 1, track(i).TCAS_correlation_tag = 1*). Otherwise, only the correlation pattern is updated. This "monogamous correlation" approach ensures that rampant miscorrelations are not transferred to the CDTI. If a TCAS track is erroneously correlated with the incorrect ADS-B/ADS-R/TIS-B track file, "tentative decorrelation" must occur before full correlation with a different track file can be obtained.

Tentative decorrelation occurs after three consecutive correlation window failures (i.e., *track(i).TCAS_correlation_patterns(j) = [111000], track(i).TCAS_correlation_status(j) = 0*) . Note that in this case, the ADS-B/ADS-R/TIS-B track is still valid for future correlation with this TCAS track*;* however, it is also valid for correlation attempts with other TCAS tracks. However, upon six consecutive correlation window failures (*track(i). TCAS_correlation_patterns(j) = [000000]*), the ADS-B/ADS-R/TIS-B track is invalidated from future comparisons with this TCAS track (i.e., *track(i).TCAS_correlation_status(j) = -1*).

Once full correlation occurs, the inter-source correlation function will no longer send the TCAS track to the traffic state file generator (and on to the CDTI), unless one of the following conditions occurs:

> *1)* Tentative decorrelation occurs (i.e., *track(i).TCAS_correlation_patterns(j) = [111000] and* track*(i).TCAS_correlation_status(j) = 0*). Note that this is typically a precursor for full decorrelation.
>
> *2)* TCAS is determined to be the best surveillance source for the target when the ADS-B/ADS-R/TIS-B track quality parameters fall below the minimum acceptable values for the Enhanced Visual Acquisition application. In this case, a field in the track file (i.e., *track(i).suppress*) is set so that the traffic state file generator does not forward the track to the CDTI.

1.48 Page C-38, replace paragraph C.3.2.3.1 with:

ICAO Address TIS-B Track Processing

If the TIS-B track has an ICAO address, ASSAP searches the track file database for an ADS-B/ADS-R track which 1) has the same ICAO address as the TIS-B track, and 2) has not been previously labeled as invalid for correlation (i.e., *track(i).TISB_IDs(j)= current TIS-B track ID* and *track(i).TISB_correlation_status(j)* has not been set equal to -1). If the ADS-B/ADS-R track has an ICAO address which does not match that of the TIS-B track (i.e., *track(i).address ≠ current TIS-B track ID*), the ADS-B/ADS-R track is determined to be not correlated with the TIS-B track and invalidated from future comparisons with this TIS-B track (i.e., *track(i).TISB_IDs(j)= current TIS-B track ID* and *track(i).TISB_correlation_status(j)* = -1).

If the above conditions are satisfied (i.e., an ICAO address match is obtained with an ADS-B/ADS-R track that is valid for correlation), the ADS-B/ADS-R track position is converted to local ENU coordinates with equations (1), (2) and (3), then predicted to the time of applicability of the TIS-B track with equation (4).

The candidate ADS-B/ADS-R track is then compared to the TIS-B track using a correlation window based on the position accuracies of the tracks. In this case, horizontal range between the two targets is computed *as*:

$$
\begin{aligned}
dx &= x - \hat{x} \\
dy &= y - \hat{y} \\
hr &= \sqrt{dx^2 + dy^2} \\
hr_{threshold} &= s_h\left(3\sigma_{epu_{TISB}} + 3\sigma_{epu_{ADS}}\right)
\end{aligned}
\qquad (29)
$$

where

(x, y) = *horizontal ENU coordinates of TIS-B track.*

$(\hat{x}, \hat{y})$ = *predicted horizontal ENU coordinates of ADS track.*

$\sigma_{epu_{TISB}}$ = *standard deviation of TIS-B track position uncertainty (derived from NACp).*

$\sigma_{epu_{ADS}}$ = *standard deviation of ADS track position uncertainty (derived from NACp).*

The horizontal range threshold ($hr_{threshold}$) is derived from the estimated position uncertainties of TIS-B and ADS tracks and a scalar (s_h) that compensates for prediction error (with optimal values of 1.92 and 1.40 for 1090ES and UAT implementations, respectively).

If $hr \leq hr_{threshold}$, horizontal spatial correlation succeeds. The vertical correlation technique is slightly different and is defined as follows:

$$vr_{TISB} = \lfloor z - 3s_v\sigma_{vepu_{TISB}}, z + 3s_v\sigma_{vepu_{TISB}} \rfloor$$
$$vr_{ADS} = \lfloor \hat{z} - 3s_v\sigma_{vepu_{ADS}}, \hat{z} + 3s_v\sigma_{vepu_{ADS}} \rfloor \quad (30)$$

where

z = vertical ENU position of TIS-B track.

$\hat{z}$ = predicted vertical ENU position of ADS track.

$\sigma_{vepu_{TISB}}$ = standard deviation of TIS-B track vertical position uncertainty (derived from NACp if the original altitude measurement was geometric and NACp ≥ 9(Version 1), from the reported geometric vertical accuracy (Version 2), or an assumed value for pressure altitude uncertainty (e.g., 100 ft) otherwise.

$\sigma_{vepu_{ADS}}$ = standard deviation of ADS track vertical position uncertainty (derived from NACp if the original altitude measurement was geometric and NACp ≥ 9 (Version 1), from the reported geometric vertical accuracy (Version 2), or an assumed value for pressure altitude uncertainty (e.g., 100 ft) otherwise.

The vertical range threshold scalar (s_v) compensates for prediction error (with optimal values of 0.91 and 0.20 for 1090ES and UAT implementations, respectively).

If the vertical ranges overlap *overlap* (i.e., $z_i \in vr_{TISB}$ and $z_i \in vr_{ADS}$), vertical spatial correlation succeeds. If both horizontal and vertical correlation succeed, full spatial correlation occurs; otherwise, full spatial correlation fails. If full spatial correlation occurs, the ADS track is tagged as having a correlated TIS-B target (i.e., *track(i).TISB_correlation_tag = 1*) , the correlation status in the track file is modified (*track(i).TISB_correlation_status(j) = 1*), and a six bit FIFO queue detection pattern is updated (i.e., *track(i).TISB_correlation_patterns(j) = [1]*) upon the first comparison and successful correlation).

If a matching ICAO address cannot be found in the ADS-B/ADS-R track file database, ASSAP attempts to correlate the TIS-B track with any ADS-B/ADS-R targets that have not been marked invalid for correlation as described in the next section. Since all non-matching ICAO address ADS-B/ADS-R tracks will have been marked invalid for correlation, only ADS-B/ADS-R tracks which do not have an ICAO address will be examined further.

1.49 Page L-1, replace Table L-1 with:

<u>Table L-1</u> ADS-B *Ownship* Data Lifetime Requirements

	Input Data Elements	Date Lifetime (Seconds)
1	ICAO 24-bit Address	n/a
2	Address Selection (ICAO vs. Temporary)	60
3	Latitude	2
4	Longitude	2
5	Altitude Type Selection (Barometric vs. Geometric)	60
6	Barometric Pressure Altitude	2
7	Geometric Altitude	2
8	NIC	2
9	Automatic Airborne / On-Ground Indication	2
10	North Velocity	2
11	East Velocity	2
12	Ground Speed	2
13	Track Angle	2
14	Heading	2
15	Barometric Vertical Rate	2
16	Geometric Vertical Rate	2
17	A/V Length and Width, *with GPS Antenna Offset and Position Offset Applied by Sensor Indication*	n/a
19	Emitter Category	n/a
20	Call Sign	60
21	Emergency / Priority Status Selection	60
22	SIL	60
23	NAC_P	2
24	NAC_V	2
25	NIC_{BARO}	2
26	TCAS Installed and Operational	60
27	TCAS/ACAS Resolution Advisory Flag	18
28	“True/Magnetic Indicator” Flag	60
29	*Geometric Vertical Accuracy*	*60*
30	*System Design Assurance*	*60*
31	*SIL Supplement*	*60*
32	*NIC Supplement*	*2*

APPENDIX 2. TSO REQUIREMENTS FOR FUNCTIONAL CLASSES OF ASA AVIONICS BY APPLICATION

The following table identifies the performance requirements for each application that is supported by one of the three classes (i.e., CDTI (Surface Only), CDTI, ASSAP) of ASAS avionics identified in this TSO. All requirements in a given paragraph and all underlying subparagraphs apply unless the subparagraphs are listed separately or an exception is noted.

ASAS avionics that integrate ASSAP and CDTI classes may allocate the requirements to either class of avionics.

If an optional information or display element (as described in DO-317) is implemented, then those performance requirements and verification sections would apply. For example, if the traffic horizontal velocity vector is implemented, then the CDTI should meet the requirements of 2.3.5.11 and be verified using the guidance in 2.6.2.4.8.

Avionics / Application	CDTI (Surface Only) (A)	CDTI (B)	ASSAP (C)
Requirements Common to All Applications	2.1; 2.3.1; 2.3.2 (except 2.3.2.4.2 and 2.3.2.4.4); 2.3.3; 2.3.4 (except 2.3.4.2.3.2.9); 2.3.5.2; 2.3.5.3; 2.3.5.5; 2.3.5.6; 2.3.5.7 2.3.5.12; 2.3.5.13; 2.3.6.2; 2.3.6.3; 2.3.6.4; 2.3.7; 2.3.8; 2.3.10; 2.3.11; 2.4; 2.6 (only); All of 2.6.1 except the following: {Table 2-10 requirements for 2.3.2.4.2; 2.3.2.4.4; 2.3.4.2.3.2.9; 2.3.5.4}; All of 2.6.2 except the following: {2.6.2.4.6 for 2.3.5.8; 2.6.2.4.8 for 2.3.5.11; 2.6.2.4.9 for 2.3.5.9; 2.6.2.5 for 2.3.5.4; 2.6.2.6 & 2.6.2.7 for 2.3.9.3(a) (3141); 2.6.2.7 and 2.6.2.7.1 for 2.3.4.2.3.2.9; 2.6.2.8 for 2.3.2.4.2, 2.3.2.4.4 and 2.3.9.1; 2.6.2.16 for 2.3.6.5; 2.6.2.17 for 2.3.9.1; 2.6.2.18 and 2.6.2.22 for 2.3.9.2;	2.1; 2.3.1; 2.3.2 (except 2.3.2.4.2 and 2.3.2.4.4); 2.3.3; 2.3.4 except 2.3.4.2.3.9); 2.3.5.2; 2.3.5.3; 2.3.5.5; 2.3.5.6; 2.3.5.7 2.3.5.12; 2.3.5.13; 2.3.6.2; 2.3.6.3; 2.3.6.4; 2.3.7; 2.3.8; 2.3.10; 2.3.11; 2.4; 2.6 (only); All of 2.6.1 except the following: {Table 2-10 requirements for 2.3.2.4.2; 2.3.2.4.4; 2.3.4.2.3.2.9; 2.3.5.4}; All of 2.6.2 except the following: {2.6.2.4.6 for 2.3.5.8; 2.6.2.4.8 for 2.3.5.11; 2.6.2.4.9 for 2.3.5.9; 2.6.2.5 for 2.3.5.4; 2.6.2.6 & 2.6.2.7 for 2.3.9.3(a) (3141); 2.6.2.7 and 2.6.2.7.1 for 2.3.4.2.3.2.9; 2.6.2.8 for 2.3.2.4.2, 2.3.2.4.4 and 2.3.9.1; 2.6.2.16 for 2.3.6.5; 2.6.2.17 for 2.3.9.1; 2.6.2.18 and 2.6.2.22 for 2.3.9.2;	2.1; 2.2.1; 2.2.2.1; 2.2.2.2; 2.2.2.3; 2.2.2.3.1(a)-(d), (f)-(i), (k)-(m); 2.2.2.3.2; 2.2.2.4; 2.2.2.5(only); 2.2.2.5.1 (except 17.1); 2.2.2.5.2 (except 2.2.2.5.2.2); 2.2.2.5.3; 2.2.2.5.4; 2.2.2.6; 2.2.3 (except 2.2.3.1.2(b) and 2.2.3.1.3.3); 2.2.5; 2.2.6; 2.4; All of 2.5 except the following: {2.5.2.3.1 for 2.2.2.3.1(e), (j), (n); 2.5.2.3.3; 2.2.2.5.1.17.1; 2.5.2.5.2.2; 2.5.3.1.2 for 2.2.3.1.2(b)};

Avionics / Application	CDTI (Surface Only) (A)	CDTI (B)	ASSAP (C)
Unique ASAS Requirements for Airborne Application	Not Permitted	2.3.9 (excluding subparagraphs)	2.2.4.1; 2.5.4.1;
Unique ASAS Requirements for Surface (Runways Only) Application	2.3.9.2 (except c and f); 2.6.2.18 for 2.3.9.2 except for 2.3.9.2(c) (3135); 2.6.2.22 for 2.3.9.2(g) (3140);	2.3.9.2 (except c and f); 2.6.2.18 for 2.3.9.2 except for 2.3.9.2(c) (3135); 2.6.2.22 for 2.3.9.2(g) (3140);	2.2.2.3.1(e), (j); 2.2.2.3.3; 2.2.4.2; 2.5.2.3.1 for 2.2.2.3.1(e), (j); 2.5.2.3.3; 2.5.4.2;
Unique ASAS Requirements for Surface (Runways & Taxiways) Application	2.3.9.2 (except c and g); 2.6.2.18 for 2.3.9.2 except for {2.3.9.2(c) (3135); 2.6.22 for 2.3.9.2(f) (3139);	2.3.9.2 (except c and g); 2.6.2.18 for 2.3.9.2 except for {2.3.9.2(c) (3135); 2.6.22 for 2.3.9.2(f) (3139);	2.2.2.3.1(e), (j), (n); 2.2.2.3.3; 2.2.4.2; 2.5.2.3.1 for 2.2.2.3.1(e), (j), (n); 2.5.2.3.3; 2.5.4.2;
Unique ASAS Requirements for Enhanced Visual Approach Application	Not Permitted	2.3.2.4.2; 2.3.4.2.3.2.9; 2.3.9.3(a); 2.6.2.7 & 2.6.2.6 for 2.3.9.3(a);	2.2.2.5.1.4; 2.2.2.5.1.5, 2.2.2.5.1.8; 2.2.2.5.1.9; 2.2.2.5.2.2; 2.2.4.4; 2.5.2.5.1.4; 2.5.2.5.1.5; 2.5.2.5.1.8; 2.5.2.5.1.9; 2.5.2.5.2.2; 2.5.4.4;

Table 1: Requirements for Functional Classes of ASA Avionics by Application