U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

Subject: Airworthiness Approval for ADS-B In Systems and Applications

Date: 2/28/11

AC No: 20-172

Initiated by: AIR-130

This advisory circular (AC) provides guidance for the initial and follow-on installations of Automatic Dependent Surveillance – Broadcast (ADS-B) In systems supporting ground and airborne traffic display applications. These applications are defined in TSO-C195, *Avionics Supporting Automatic Dependent Surveillance – Broadcast (ADS-B) Aircraft Surveillance Applications (ASA)*. The display applications discussed in this AC are designed to support basic situational awareness only. As more advanced applications mature, this AC will be updated to reflect those added to TSO-C195.

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

Table of Contents

Paragraph *Page*

List of Tables

List of Figures

Chapter 1. General Information.

1-1. Purpose.

a. This advisory circular (AC) provides guidance material for the installation of ADS-B In technology in aircraft. ADS-B In includes reception of ADS-B, Traffic Information Services – Broadcast (TIS-B) and Automatic Dependent Surveillance – Rebroadcast (ADS-R) messages, but does not include reception of Flight Information Service – Broadcast (FIS-B) messages.

b. The installation of ADS-B In avionics provides the pilot(s) with supplemental information. No existing responsibility is changed by virtue of installation of this equipment and application(s). The situational awareness applications defined in TSO-C195 supplement, but do not replace, a pilot's see and avoid responsibility, as required by Title 14 of the Code of Federal Regulations (14 CFR) § 91.113(b)).

c. This AC is not mandatory and does not constitute a regulation. This AC describes an acceptable means, but not the only means, to install ADS-B In equipment that is compliant with applicable 14 CFR part 91 requirements. However, if you use the means described in this AC, you must follow it entirely. The term "must" is used to indicate mandatory requirements when following the guidance in this AC. The terms "should" and "recommend" are used when following the guidance is recommended but not required to comply with this AC. A list of definitions and acronyms relevant to this AC can be found in appendix 3.

d. This AC provides guidance information intended for new approvals. This AC is not intended to modify, change or cancel existing equipment design or airworthiness approvals. Equipment with existing approvals can continue to be installed within the provisions of their original design and airworthiness certification.

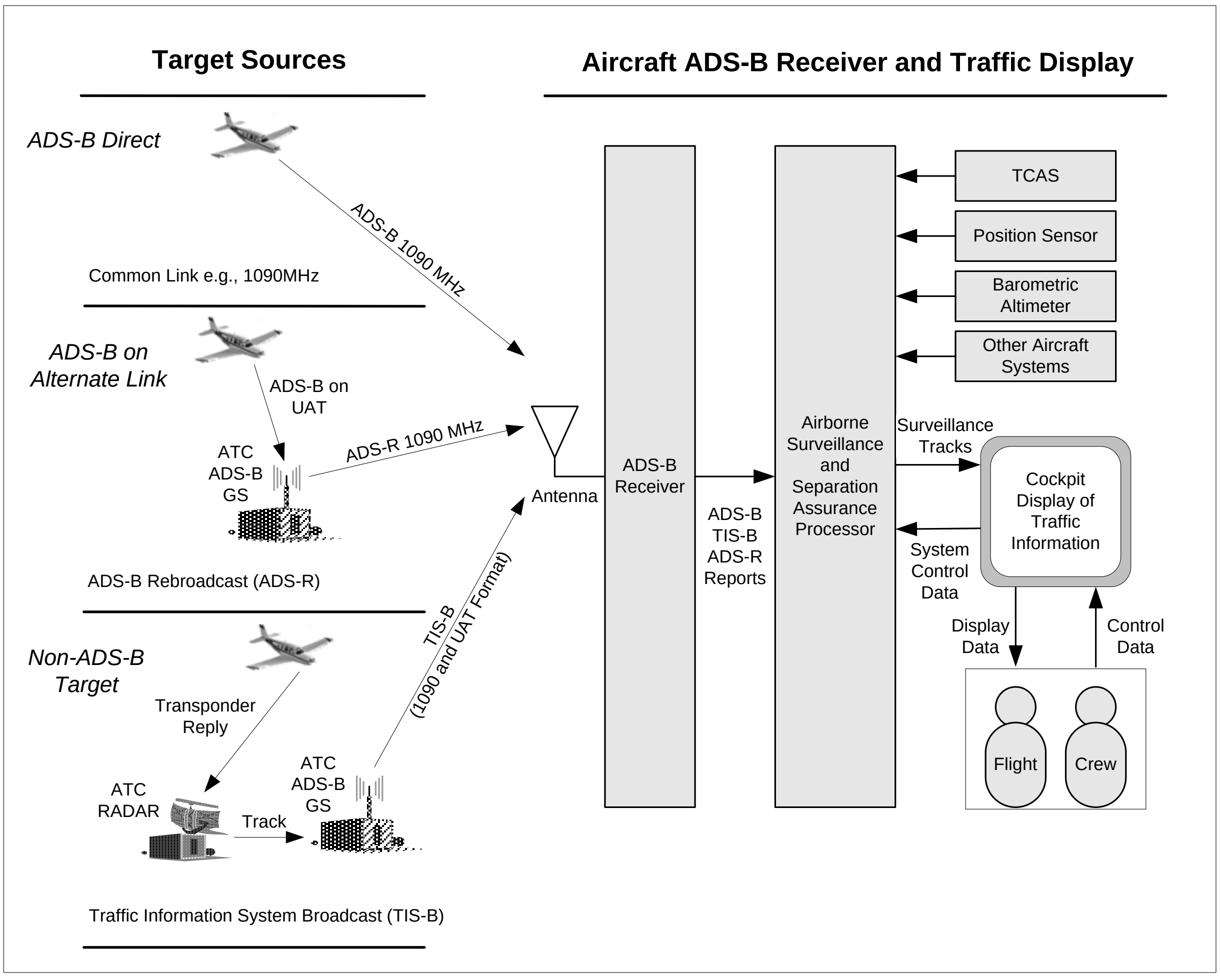
1-2. Audience. This AC is for installers of ADS-B In equipment, and can assist in obtaining design approval for installation. The installed design can be approved under a type certificate (TC), supplemental type certificate (STC), including AML-STC, or an amended type certificate.

1-3. Scope. This AC addresses initial and follow-on installations of ADS-B In systems that comply with TSO-C195, *Avionics Supporting Automatic Dependent Surveillance – Broadcast (ADS-B) Aircraft Surveillance Applications (ASA).* Data from a previously approved installation design may be reused to fulfill some of the data requirements for a follow-on installation design as appropriate. For example, the latency analysis between a GPS position source and the ADS-B equipment may be reused on a follow-on installation provided that the part numbers for both units are identical. All installations of ADS-B In should also provide ADS-B Out. Installation guidance for ADS-B Out can be found in AC 20-165, *Airworthiness Approval of Automatic Dependent Surveillance - Broadcast (ADS-B) Out Systems*. Installation guidance for flight information service-broadcast (FIS-B) applications that make use of the Surveillance and Broadcast Services (SBS) ground system will be covered in a future AC. Installation guidance for other FIS-B equipment can be found in AC 20-149, *Safety and Interoperability Requirements for Initial Domestic Flight Information Service–Broadcast*. A list of related documents can be found in appendix 4 of this AC.

1-4. Background.

a. The ADS-B system, shown in figure 1, is a next generation surveillance technology, incorporating both air and ground aspects that provide air traffic control (ATC) with a more accurate picture of the aircraft's three-dimensional position in the en route, terminal, and surface environments. The aircraft provides broadcast messages of its identification, position, altitude, velocity, and other information. The ground portion is comprised of ADS-B ground stations, which receive these broadcasts and direct them to ATC automation systems for presentation on a controller's display. In addition, aircraft equipped with ADS-B In capability can also "see" these broadcasts from other ADS-B equipped aircraft and display them to improve the pilot's situational awareness of other traffic, both airborne and on the ground. Suitably equipped surface vehicles may also be visible to ADS-B In capable aircraft.

Figure 1. ADS-B In System Overview



b. ADS-B Out refers to an appropriately equipped aircraft broadcasting own-ship information. ADS-B In refers to an appropriately equipped aircraft's ability to receive and display other aircraft's ADS-B information and ground station broadcast information, such as traffic information service - broadcast (TIS-B) and automatic dependent surveillance - rebroadcast (ADS-R). The TIS-B service provides traffic based on ground surveillance of transponder-equipped aircraft. The ADS-R service provides traffic from aircraft equipped with an alternate ADS-B link.

c. There are two ADS-B link options: 1090 extended squitter (1090ES) and universal access transceiver (UAT). The 1090ES equipment operates on 1090 MHz and has performance requirements specified in TSO-C166b, *Extended Squitter Automatic Dependent Surveillance - Broadcast (ADS-B) and Traffic Information Service - Broadcast (TIS-B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz)*. The UAT operates on 978 MHz and has performance requirements specified in TSO-C154c, *Universal Access Transceiver (UAT) Automatic Dependent Surveillance – Broadcast (ADS-B) Equipment Operating on Frequency of 978 MHz*.

Chapter 2. ADS-B In System Installation Guidance.

2-1. System Overview. ADS-B In refers to an appropriately equipped aircraft's ability to receive and display other aircraft's ADS-B information and ground station broadcast information, such as TIS-B and ADS-R. The information can be received by an appropriately equipped aircraft on either of two radio frequency (RF) links: 1090 ES or UAT. The received information is processed by onboard avionics and presented to the flight crew on a display. In this AC, guidance is provided for the display of traffic information while on the airport surface and while airborne. This information supports the four initial applications defined in TSO-C195. This AC will be updated to add appropriate guidance for additional applications as they mature.

2-2. Equipment Classes. TSO-C195 defines minimum performance standards that provide a basis for installation of ADS-B In equipment in aircraft. The TSO defines three avionics equipment classes: (A) cockpit display of traffic information (CDTI) (surface only); (B) CDTI; and (C) airborne surveillance and separation assurance processing (ASSAP). Class A equipment is intended to support the display of ADS-B traffic while own-ship is on the surface and moving slower than 80 knots. Class A equipment must deactivate the CDTI when In-Air or at speeds greater than 80 knots. Class B equipment supports the display of ADS-B traffic without restriction. Class C equipment processes ADS-B messages to generate traffic data for a CDTI. Table 1 shows which applications are supported by the three equipment classes. An installation requires both the CDTI and ASSAP functions, which are explained in paragraphs 2-4 and 2-5 of this AC, respectively.

Table 1. ADS-B In Equipment Classes

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**

2-3. ADS-B Applications.

a. ADS-B In avionics for traffic situational awareness enable four aircraft surveillance applications: airborne; enhanced visual approach; surface (with runways and taxiways); and surface (with runways only). Refer to table 1 to see which applications are supported by the three equipment classes found in TSO-C195.

b. The airborne application displays ADS-B traffic on a plan view (bird's eye view) relative to own-ship. Each aircraft symbol displayed conveys position, direction, and altitude information. Optionally, additional information, like identity, may be displayed. The traffic information assists the flight crew in visually acquiring traffic while airborne. The CDTI display may be used to help acquire traffic visually or as a supplement to an ATC traffic advisory. This application improves both safety and efficiency by providing the flight crew with an enhanced traffic awareness. Installations that provide in flight moving map displays in addition to traffic should comply with TSO-C165, *Electronic Map Display Equipment for Graphical Depiction of Aircraft Position*.

c. The enhanced visual approach application builds upon the airborne application. It allows the pilot to select an aircraft to follow on approach. Additional information about the selected aircraft, including range and ground speed, is displayed to enhance the pilot’s situational awareness. The CDTI display is used to assist the flight crew in acquiring and maintaining visual contact during a visual approach. The application improves both the safety and the performance of visual approach operations. The enhanced visual approach application should not be confused with creating a new approach operation. No operational responsibility is changed when using the enhanced visual approach application.

d. The surface application with runways and taxiways displays ADS-B traffic on a plan view (bird's eye view) relative to own-ship, superimposed on a map of the airport surface. This map consists of all airport runways and includes taxiways when the data is available. Aircraft on-ground and in-air are differentiated by symbols to aid the pilot in visual acquisition. The surface application improves flight crew situational awareness during taxi, takeoff, and landing phases of flight. This application reduces the possibility of runway incursion and collision. These installations should also comply with TSO-C165 for airport moving map displays.

e. The surface application with runways is similar to the previous application, but does not include display of taxiways. These installations should also comply with TSO-C165 for airport moving map displays as applied to display of runways.

f. The displayed ADS-B information addressed by this AC is not intended for maneuvering based solely on presence or absence of traffic on the display. As future applications are fielded, we expect that certain maneuvers may be found to be safe and acceptable. The analysis and safety studies to justify such procedures are not yet completed. When those activities are concluded and the maneuvers are shown to be safe and acceptable in the national airspace system (NAS), appropriate maneuvers are expected to be allowed based in part on the displayed ADS-B In information. We will revise this guidance accordingly at that time.

2-4. CDTI.

a. Displays. The ADS-B In system includes at least one flight deck traffic display (i.e., CDTI) depicting the relative position and related information of ADS-B equipped aircraft in a plan view (bird's eye view). The CDTI display may be presented on a dedicated display or integrated into and presented on an existing display (e.g., electronic flight information system (EFIS), multi-function display (MFD), or electronic flight bag (EFB)). CDTI equipment should be compliant with the Class A or Class B requirements of TSO-C195. Class A equipment supports only the Basic Surface application. CDTI equipment should be installed in accordance with manufacturer instructions. Installation in the forward field of view (14 CFR § 23.1321 and § 25.1321) will provide the best situational awareness and support subsequent upgrades to other ADS-B applications. Side-mounted displays are acceptable for the basic situational awareness applications, but have limited potential to support more advanced applications. The display must be installed such that the crew has an unobstructed view of the display when seated in the normal position. For general installation guidance on displays, refer to AC 25-11A and AC 23.1311-1B.

b. Traffic Symbols. The FAA worked closely with the industry to standardize the ADS-B In symbols and features. The resulting symbols are provided in appendix 2. The traffic display should depict the symbols, features, and information defined in the appendix. To use alternate symbols or features, a human factors analysis must demonstrate that a clear and substantial benefit can be derived. Applicants electing to use different symbols must compare the differences with appendix 2 and address any potential negative impact to pilots who are familiar with the standard symbols.

c. Required Controls. The CDTI control panel may be a dedicated control panel or it may be incorporated into another control, such as a multifunction control display unit (MCDU) or EFB. CDTI controls must be readily accessible from the normal seated position. Pilot controls for the ADS-B In equipment must be provided as follows:

(1) A means to adjust the display range between the minimum and maximum values.

(2) A means to adjust the altitude band between the minimum and maximum values.

(3) A means to adjust the brightness of the display.

d. Optional Controls. The following optional controls may be provided:

(1) A means to select between display of relative and actual altitude.

(2) A means to select at least one traffic element.

(3) A means to select alternate display criteria (e.g., filters and vertical views).

(4) A means to declutter, which removes optional traffic information when display of the information is not desired. If decluttering is implemented,

(a) A means must be provided for the flight crew to control the decluttering.

(b) The flight crew must be able to perform the declutter operation by a simple action.

(c) The flight crew should be able to return to the previous state by a simple action.

(d) If automatic decluttering is implemented, a means should be provided for the flight crew to control the automated decluttering function.

(e) An indication that decluttering is active must be provided.

(5) A means to pan the view. If panning is implemented:

(a) There must be a means to control panning.

(b) There must be a means to return to the original view with a simple action.

(6) A means to designate traffic for an application. For example, equipment may allow a selected aircraft to be designated for the enhanced visual approach application.

2-5. Airborne Surveillance and Separation Assurance Processing (ASSAP). The ASSAP subsystem accepts ADS-B reports, TIS-B reports, ADS-R reports, and traffic alert and collision avoidance system (TCAS) tracks (if installed). ASSAP correlates sources, generates tracks, and performs application-specific processing. Surveillance tracks and application-specific alerts or guidance are output by ASSAP to the CDTI function. The ASSAP equipment must be compliant with the Class C requirements of TSO-C195 and should be installed in accordance with manufacturer instructions. TCAS processors track transponder-equipped aircraft. Therefore, TSO-C195 equipment requires installations with TCAS to provide these tracks to the ASSAP equipment to complete the traffic picture. TCAS in this AC is meant to apply to all versions of certified traffic advisory system (TAS) or TCAS compliant with TSO-C147, TSO-C118, or TSO-C119. Hybrid surveillance TCAS are included. For aircraft installations without TCAS, the TIS-B service provides tracks of transponder-equipped aircraft.

2-6. ADS-B In Receiver and Antenna. The installation should include a UAT (per TSO-C154c) or a 1090 ES (per TSO-C166b) receiver. Ideally, installation of a dual-band receiver would allow for dual-link interoperability where ADS-R coverage is not provided. The ASSAP equipment may interface with the ADS-B receiver equipment or it may be integrated. If TCAS is installed, the ADS-B In equipment must contain or interface with the TCAS equipment so that the TCAS tracks may be used. Guidance material concerning the installation of the UAT or 1090ES equipment, and associated antenna(s), is provided in AC 20-165.

2-7. Integration Considerations.

a. System Definition. ADS-B In installations include the ADS-B In receiver, antennas, traffic processor, control panels, and display components. All of these component part numbers must be identified as part of the integrated system. Any change to any of the components' hardware or software requires evaluation of the potential impact to the ADS-B In function.

b. Equipment Compatibility Requirements. A critical component of the ADS-B In system is the positioning sensor. Compatibility between the sensor and the surveillance processor must be established by the equipment manufacturer(s) and detailed in an installation manual or supplement. Position source compatibility should consider the position source requirements in AC 20-165. Compatibility between all other system components should be documented in an installation manual or supplement.

c. Aircraft Integration with ADS-B In System.

(1) Provide electrical power and grounding in accordance with the manufacturer's installation manual. Conduct an electrical load analysis to verify that there is adequate power capacity for the ADS-B In equipment.

(2) Ensure that the total latency to receive, process, and display traffic data is less than three seconds. Ensure that traffic time of applicability is within 1 second of the time of display. Ensure the total latency of own-ship position at the display is less than 3.5 seconds. Ensure that the own-ship time of applicability is within 1 second of the time of display. Perform a latency analysis in accordance with appendix 1 to demonstrate compliance. The total latency figures here are to be interpreted to mean when an ADS-B message is received. They do not address data age issues while the system is waiting to receive the next position report for an existing track. Data age and timeout requirements are handled separately for each application in TSO-C195 compliant equipment.

(3) The same position source used to provide own ship data for transmission on ADS-B Out should be used to provide position to the ASSAP equipment. Position sources interfaced to the ASSAP equipment must meet the criteria in AC 20-165. Future applications may require that ASSAP and the ADS-B Out equipment use the same position source. Aircraft manufacturers should plan accordingly to prevent extensive redesign. An alternate position source may be used to provide own ship position to the CDTI display, but the accuracy, latency, and display time of applicability requirements still apply (refer to appendix 1). Provide connections in accordance with the manufacturer's installation manual.

(4) Follow manufacturer's instructions for strapping and/or programming of configurable aircraft parameters. Manufacturers are highly encouraged to provide instructions to installers for setting the global navigation satellite system (GNSS) antenna offset parameter during installation. The GNSS antenna offset information can be extremely valuable for ADS-B In surface situation awareness and future surface collision alerting applications on large aircraft with GNSS antenna far from the nose.

(5) Verify that the equipments' environmental qualifications (e.g., DO-160 environmental categories) are suitable for the aircraft type and equipment location.

(6) Any limitations associated with use of the ADS-B In equipment must be recorded in the Aircraft Flight Manual.

d. System Safety Analysis. Unannunciated failures and hazardously misleading data must be improbable/remote for Class B and C equipment; but can be probable for Class A equipment. Loss of function can be probable for all Classes. This can be shown using the methods described in AC 25.1309-1(), *System Design and Analysis*, or in AC 23-1309-1(), *System Safety Analysis and Assessment for Part 23 Airplanes*, as appropriate.

Chapter 3. Test and Evaluation.

3-1. General. Installation of an ADS-B In system should be accomplished on an aircraft with an ADS-B Out system. ADS-R and TIS-B services are only provided to aircraft that indicate, in their ADS-B Out messages, that they are an ADS-B In aircraft. This chapter assumes that the ADS-B Out system complies with AC 20-165, and defines additional tests for the installed system.

3-2. Ground Tests.

a. Ground tests should be conducted on each aircraft installation. Ground tests should include the verification that ADS-B Out, ADS-R, and TIS-B message elements can be accurately received and processed. If ADS-B In equipment is integrated with TCAS, then TIS-B reception is not required for airborne traffic. However if the surface applications are implemented, TIS-B surface targets must be processed even by an installation that includes TCAS. Ground tests should include verification of the integration with a position sensor, since own-ship state data is used to generate the displayed data. In addition, any message elements that are presented on the CDTI display should be verified for accuracy. See AC 20-165 for a list and detailed explanation of each of the message elements. Ground test equipment should be capable of generating all of the different types of messages, including ADS-B Out, ADS-R, and TIS-B messages. If targets of opportunity are available to validate the ADS-B In functionality, they may be used in lieu of dedicated test equipment. Verify that the system receives and displays the following traffic information when stimulated appropriately:

(1) Relative horizontal position.

(2) Ground speed of surface traffic (if implemented).

(3) Directionality (Heading or Track Angle).

(4) Pressure altitude of airborne traffic relative to own-ship.

(5) Vertical trend of airborne traffic.

Note: ASSAP must indicate a climb/descent when traffic vertical velocity exceeds 500 feet per minute (fpm). Indication of vertical trend is allowed to occur at smaller vertical rates.

(6) Air/Ground status of other aircraft.

(7) Flight ID (if implemented).

(8) TIS-B/ADS-R service status (when not installed with TCAS).

(9) Differential ground speed (if implemented).

b. TCAS-equipped aircraft provide inputs to ASSAP. Verify that the system receives and displays the following information when stimulated appropriately:

(1) Traffic range.

(2) Traffic bearing.

(3) Traffic pressure altitude.

(4) Traffic vertical trend.

(5) Traffic TCAS alert status (i.e., no threat, proximity traffic, traffic advisory, or resolution advisory).

c. If the ADS-B In system supports the surface application, verify that the airport runways are depicted accurately. If taxiway data is available, verify that the airport taxiways are depicted accurately.

d. Evaluate simulated failures of the aircraft sensors integrated with the ADS-B In equipment to determine that the resulting system failure state agrees with the predicted results.

e. Observe all of the electronic systems on the flight deck to determine that the ADS-B equipment is not a source of interference (conducted or radiated) to previously installed systems or equipment, and that operation of the ADS-B In equipment is not adversely affected by the previously installed systems and equipment.

f. Evaluate the general arrangement and operation of controls, displays, circuit breakers, indicators, and placards of the ADS-B In and CDTI equipment.

(1) Evaluate the ADS-B In system controls to determine that they are appropriately designed and located to prevent inadvertent actuation. Pay close attention to line select keys, touch screens, or cursor-controlled trackballs, as these can be susceptible to unintended mode selection resulting from their location in the flight deck (for example, proximity to a foot rest or adjacent to a temporary stowage area).

(2) Evaluate the CDTI display to ensure that all information is, at a minimum, legible, unambiguous, and attention-getting (as applicable).

(3) Evaluate the traffic symbols presented on the CDTI display for compliance with the standard recommended symbols from RTCA/DO-317, which are summarized in appendix 2 of this AC.

g. Evaluate the ADS-B In self-test features.

h. If possible, verify the dynamic performance of displayed traffic by observing any available ADS-B Out, ADS-R, TCAS (if installed), or TIS-B traffic in the area.

i. Evaluate the overall CDTI system installation for satisfactory accessibility and visibility under all lighting conditions.

3-3. Flight Tests.

a. Flight tests must be conducted for each initial installation of a unique configuration of ADS-B In receiver, position sensor, ASSAP, and CDTI equipment. Flight test data from a different aircraft may be used to establish suitability in follow-on installations. Flight testing must be conducted in the range of a cooperative ADS-B Out-equipped aircraft. Flight testing should be conducted within TIS-B and ADS-R coverage. The flight test should verify the following:

(1) The other aircraft flight identification (if implemented).

(2) The ability to select a desired target aircraft (if implemented).

(3) The ability to display ground speed of the selected target aircraft (if implemented).

(4) The bearing from own-ship to the other aircraft.

(5) The distance from own-ship to the other aircraft.

(6) The relative altitude of the other aircraft.

(7) The direction of the other aircraft.

(8) The ground speed of the other aircraft (if implemented).

(9) The targets are appropriately displayed during maneuvers throughout the normal flight envelope.

(a) Movement of displayed target information should not result in objectionable jitter, jerkiness, or ratcheting effects.

(b) Movement of displayed target information should not blur, shimmer, or produce unintended dynamic effects such that the information becomes distracting or difficult to interpret.

(c) Filtering or coasting of data intended to smooth the movement of CDTI-displayed target information should not introduce significant positioning errors or create system lag that makes it difficult to perform the intended task.

(d) False or redundant tracks should not occur regularly during the flight. This would indicate that the track correlation is not performing properly. This could indicate that the TCAS antenna bearing is performing poorly, as an example.

b. If implemented, verify that the information provided on the CDTI display is suitable for the surface application. Depending upon which surface class has been installed, either runways only will be depicted or both runways and taxiways will be depicted.

Appendix 1. Latency Analysis

1. Purpose. The purpose of this appendix is to provide guidelines on accomplishing a latency analysis of your ADS-B In system to demonstrate that it complies with the end-to-end budget for ADS-B applications. It is important to minimize latency and the uncertainty of latency (i.e., how the latency differs between updates) at the system integration level. The easiest way to ensure this design goal is met is to provide a direct connection between the position source and the ADS-B equipment. Any other system blocks between them will increase latency and uncertainty. In some cases, an increase in uncertainty can have a more detrimental effect than the latency itself. Refer to RTCA/DO-317 appendix J for additional information on the interfaces described below.

2. Analysis. For ADS-B In installations, the latency analysis consists of two parts; the traffic latency analysis and the own-ship position latency analysis. Together, these analyses must show:

a. That the total latency allowance is not exceeded and,

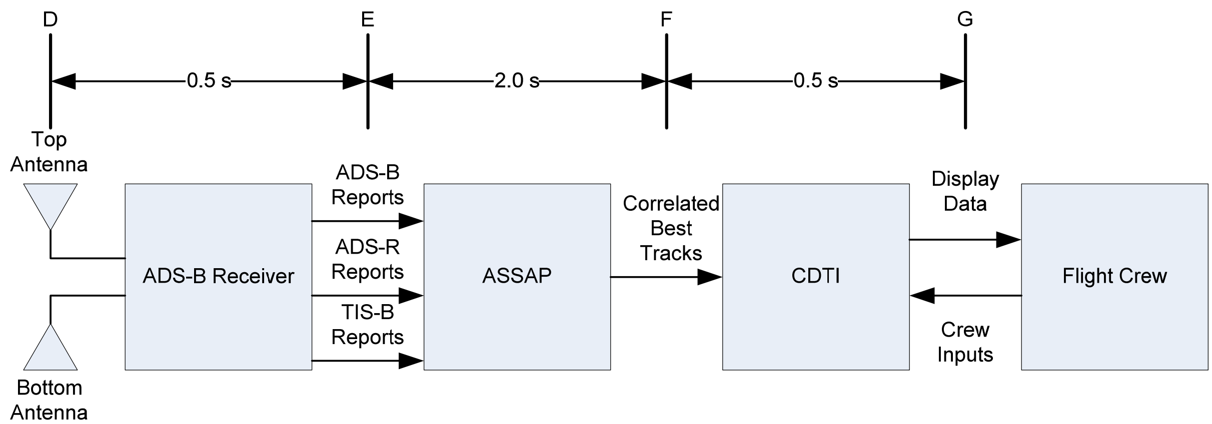
b. The own-ship position and traffic positions are estimated to a time of applicability within 1 second of the time of display.

> **Note:** Manufacturers should ensure installation instructions adequately address latency to assist the installer.

3. Traffic Latency Analysis. Figure 2 depicts a block diagram of the ADS-B In system and the recommended latency budget allocated to each block. To demonstrate that the system does not exceed the total latency budget, determine the applicable latencies for each component and total all of the individual component latencies. You must include all sources of latency, including, but not limited to: the ADS-B receiver, the ASSAP equipment, the CDTI equipment, and any intermediary devices. The total for your system between interface D and interface G must not exceed three seconds. It is acceptable for a manufacturer to allocate the total budget among their system components as needed. However, this design choice will limit the flexibility of pairing their equipment with other manufacturers. In calculating worst case latency, the traffic latency analysis must assume the simultaneous processing of the maximum number of traffic symbols the system is designed to support.

4. Traffic Time of Applicability Analysis. Demonstrate by analysis that the traffic displayed to the flight crew has been estimated forward to be within 1 second of the time of display. For instance, if the latency analysis in the previous paragraph comes to 2.6 seconds, the traffic must be estimated forward 2.6 seconds +/- 1 second by the system prior to displaying that traffic. The actual estimate for each individual piece of traffic will vary as the received ADS-B messages arrive asynchronously. The analysis must demonstrate that this variation is handled appropriately. The analysis must also demonstrate that any variation in the latency due to processes within the equipment chain does not cause the time of applicability to violate the 1 second tolerance. If different vendors' equipment are paired together to create a complete system, latency performance data for each system component must originate with the component manufacturer. Reverse engineering another vendor's latency performance is not an acceptable means of compliance. Manufacturers are encouraged to include their individual component latency performance in an installation manual to facilitate proper ADS-B system integrations.

Figure 2. Traffic Latency Block Diagram



5. Own-Ship Position Latency Analysis. Figure 3 and Figure 4 depict block diagrams of two potential implementations of ADS-B In system architectures with recommended latency budgets allocated to each block. For either architecture, the ASSAP equipment must receive the own-ship position data with less than 600 ms of compensation error and less than 1 second of total latency. For this portion of the analysis, total latency starts at the time of measurement of the position source (A3) and ends when ASSAP has received the complete position update (B3). Own-ship total latency at the time of display (G) must not exceed 3.5 seconds.

6. Own-Ship Position Time of Applicability. Demonstrate by analysis that the own-ship position displayed to the flight crew has been estimated forward to be within 1 second of the time of display. The 1 second tolerance must include any compensation error present in the system. Determine the total latency from the position source time of measurement (A3) to the time of display (G). This latency will depend on the path of own-ship position data and vary by system architecture. Refer to Figure 3 and Figure 4 for examples of two potential architectures. The analysis must demonstrate that any variation in the latency due to processes within the equipment chain does not cause the time of applicability to violate the 1 second tolerance. If different vendors' equipment are paired together to create a complete system, data for each system component must originate with the component manufacturer. Reverse engineering another vendor's latency performance is not an acceptable means of compliance. Manufacturers are encouraged to include their individual component latency performance in an installation manual to facilitate proper ADS-B system integrations.

Figure 3. Own-Ship Latency Block Diagram Simple Architecture

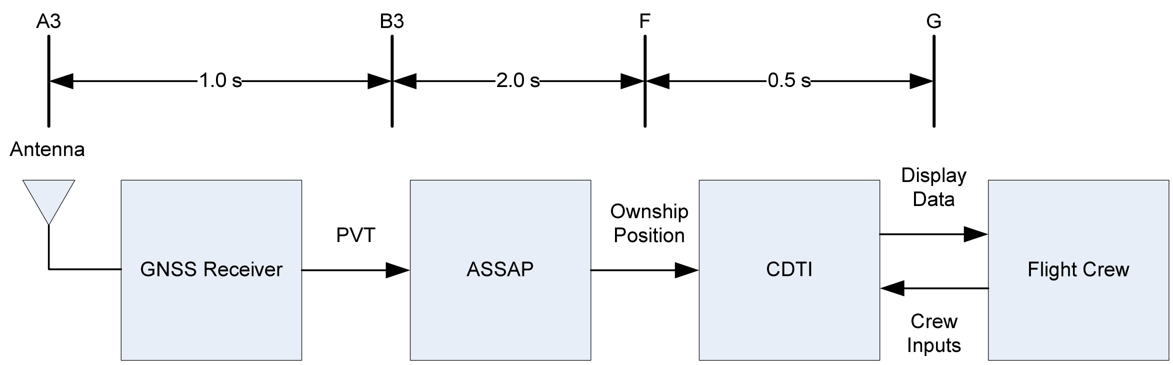
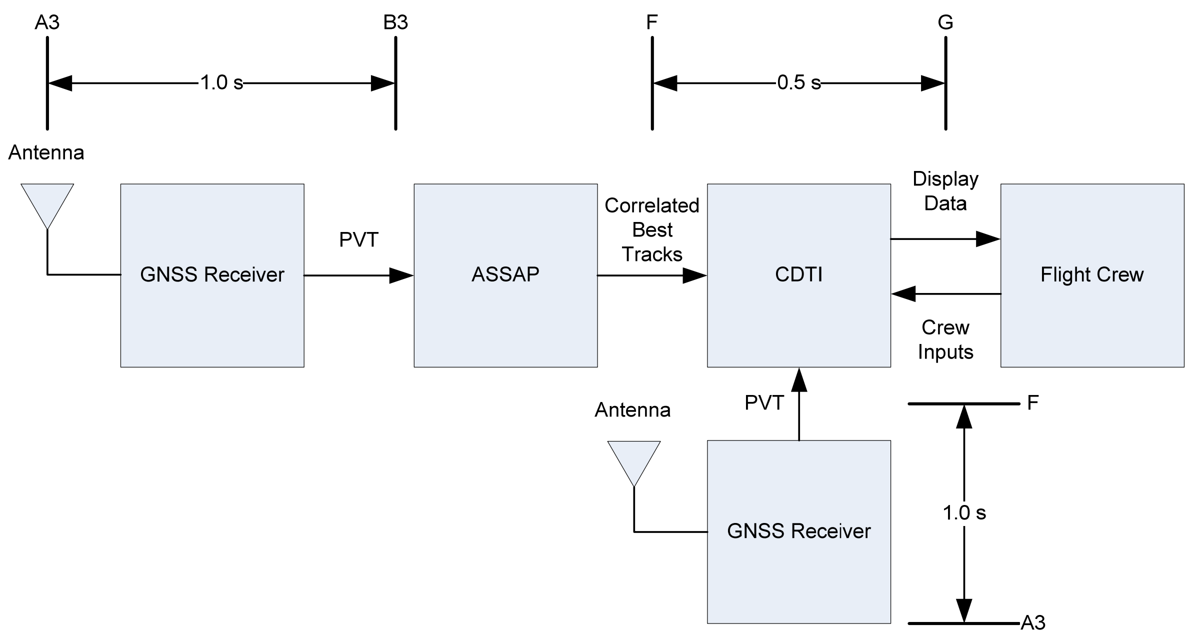


Figure 4. Own-Ship Latency Block Diagram Alternate Architecture



Appendix 2. Symbol Requirements for the CDTI

1. Traffic Symbols and Variations. The "basic" traffic symbol is used to depict airborne traffic. Traffic symbols can be modified from the basic symbol to provide special status information, such as on-ground, selected, coupled, and alerted. The symbols depicted are examples. The line width, physical size, and hue of the figures are not requirements. The requirements are stated in the associated text.

a. Basic Directional (see Figure 5).

(1) If directionality is valid, the basic directional traffic symbol must be depicted with an arrowhead shape.

(2) The color must be cyan or white.

(3) The color must be the same color as the basic non-directional symbol.

(4) The color should not be the same color as the own-ship symbol.

(5) For displays that do not integrate aircraft surveillance applications system **(**ASAS) with TCAS, the symbol may be filled or unfilled.

(6) For TCAS/ASAS-integrated systems, the symbol must be unfilled.

Figure 5. Basic Directional Symbol

b. Basic Non-Directional (see Figure 6).

(1) If directionality is invalid, the basic non-directional traffic symbol must be depicted with a diamond shape.

(2) The color must be cyan or white.

(3) The color must be the same color as the basic directional symbol.

(4) The color should not be the same color as the own-ship symbol.

(5) For displays that do not integrate ASAS with TCAS, the symbol may be filled or unfilled.

(6) For TCAS/ASAS-integrated systems, the symbol must be unfilled.

Figure 6. Basic Non-Directional Symbol

c. Traffic Directionality. If the traffic symbol indicates directionality, the directionality of the traffic symbol must be displayed relative to the display orientation.

> **Note:** The traffic directionality in air is based on traffic ground track angle, and not necessarily traffic heading. This is important for monitoring traffic such as helicopters that can fly backwards and to account for winds.

d. Traffic Application Capability. The traffic symbol may provide an indication of traffic application capability.

> **Note 1:** Traffic information that does not meet the minimum requirements for enhanced visual acquisition (EVAcq) should not be sent to the CDTI display from ASSAP.

> **Note 2:** ASSAP may provide TCAS-only data that does not support EVAcq. TCAS data will still be displayed.

e. Traffic On-Ground Status (see Figure 7).

(1) If traffic is on-ground, the basic traffic symbol must be modified by changing the color.

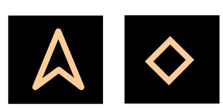
(2) The color may be brown/tan.

(3) The size of on-ground traffic symbols may be decreased for additional encoding, and/or to reduce clutter.

(4) The symbol may be filled or unfilled.

> **Note:** Additionally, altitude information is removed from the data tag.

Figure 7. Traffic On-Ground Symbol



2. Alerts. The following requirements, per TSO-C195, apply generally to CDTI-displayed alerts based on both ASAS and TCAS systems. Additional TCAS-specific alert symbol requirements are provided in RTCA/DO-317, section 2.3.4.2.3.3.

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

(1) If traffic directionality is valid, directionality information must be displayed during alerts.

(2) The traffic symbol must change to amber/yellow for caution level alerts.

(3) The traffic symbol must change to red for warning level alerts.

(4) For traffic without valid directionality:

(a) If traffic has a caution level alert, the traffic symbol may be modified by changing the shape to a circle.

(b) If traffic has a warning level alert, the traffic symbol may be modified by changing the shape to a square.

(5) For traffic with valid directionality:

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

(b) 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 symbols as TCAS traffic advisories and resolution advisories, respectively. (See RTCA/DO-317, sections 2.3.4.2.3.3.1 and 2.3.4.2.3.3.2.)

(6) For airborne applications, alerting 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 1: 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 2: 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.

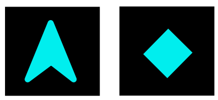
b. Proximate Traffic (see Figure 8).

(1) For TCAS/ASAS integrated systems, the traffic symbol must indicate airborne proximate status.

(2) If proximate traffic is displayed, the basic traffic symbol must be displayed as filled.

Note: This requirement is to be consistent with TCAS symbol convention.

Figure 8. Proximate Traffic Symbol



c. Selected Traffic.

(1) Selected traffic is traffic that is selected by the flight crew. Traffic selection results in display of additional traffic information beyond what is presented in the minimum data tag, and may enable other functions (e.g., coupling).

(2) If traffic selection is implemented:

(a) There must be some means of distinguishing the selected traffic from other traffic.

(b) A border must not be used to indicate selected traffic.

Note 1: A border is a discernable line that surrounds an existing symbol. Border types include fixed-shape or conformal.

Note 2: Borders are reserved for depicting coupled traffic (see Figure 9).

(3) When traffic is selected, additional information on that traffic must be displayed in a data block or a data tag.

d. Coupled Traffic (see Figure 9).

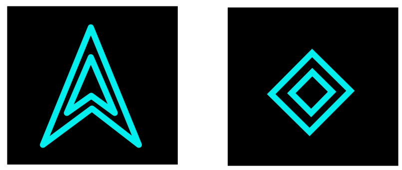
(1) Coupled traffic is traffic upon which a coupled application is to be performed. For example, in enhanced visual approach (EVApp), the traffic to be followed is "coupled" so that the application and the flight crew both know the specific traffic upon which to act.

(2) If traffic coupling is implemented:

(a) There must be some means of distinguishing the coupled traffic from other traffic.

(b) If traffic is coupled, the basic traffic symbol should be modified by adding a shape-conforming border.

Figure 9. Coupled Traffic Symbols



(c) There must be an indication of off-scale coupled traffic.

> **Note:** A coupled half-symbol at the display edge and appropriate bearing is one acceptable method of indication.

(d) The loss of "coupled" status (e.g., due to signal loss or invalid data) must be indicated to the flight crew.

3. TCAS Alert Symbology for TCAS/ASAS-Integrated Systems.

a. If traffic directionality is valid, directionality information must not be removed during a TCAS traffic advisory or resolution advisory.

> **Note 1:** Directionality information, if available, may assist the flight crew in visual search and identification of the alerted traffic.

> **Note 2:** Appendix G of RTCA/DO-317 describes TCAS/ADS-B symbol integration issues.

b. Traffic Advisories (see Figure 10).

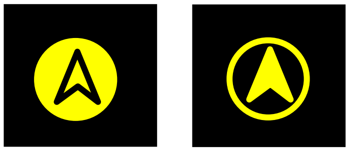
(1) If traffic has a TA, the traffic symbol must be modified by changing the color to amber/yellow, and changing the shape to a circle.

(2) Traffic with valid directionality must include a directional inlay.

(3) The size of TA traffic symbols may be increased to accommodate the shape modification.

(4) Line widths and fill may be changed to improve color interpretation and saliency.

Figure 10. Traffic Advisory Symbols



c. Resolution Advisories (RAs) (see Figure 11).

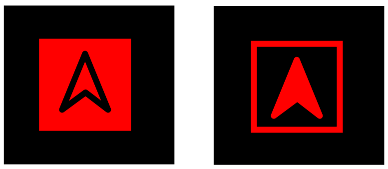
(1) If traffic has an RA, the traffic symbol must be modified by changing the color to red, and changing the shape to a square.

(2) Traffic with valid directionality must include a directional inlay.

(3) The size of RA traffic symbols may be increased to accommodate the shape modification.

(4) Line widths and fill may be changed to improve color interpretation and saliency.

Figure 11. Resolution Advisory Symbols



Appendix 3. Definitions and Acronyms

1. Definitions. The following are definitions of terms used in this document.

a. 24-bit Address. Address assigned to each aircraft transponder or ADS-B transmitter. For aircraft equipped with Mode S transponders, their replies to TCAS interrogations and their ADS-B transmissions should use the same 24-bit address, allowing correlation by ASSAP.

b. Advisory. The level or category of alert for conditions that require flight crew awareness and may require subsequent flight crew response.

c. Aircraft Surveillance Applications System (ASAS). An aircraft system based on airborne surveillance that provides assistance to the flight crew supporting the separation of their aircraft from other aircraft.

d. Airborne Separation Assistance Application. An equipment function of an Aircraft Surveillance Applications System that provides data to support an operational procedure for controllers and flight crews to meet a defined operational goal.

e. Alert. A general term that applies to all advisories, cautions, and warning information; can include visual, aural, tactile, or other attention-getting methods.

f. Application. The function(s) for which the ASA system is used.

g. Aircraft Surveillance Application (ASA). An application that uses aircraft surveillance data to provide benefits to the flight crew.

h. Antenna Offset Parameter. The distance from the nose of the aircraft to the GPS antenna. For large aircraft, this offset can be significant when placing the aircraft symbol on the airport map properly.

i. Automatic Dependent Surveillance-Broadcast (ADS-B). A function on an aircraft or surface vehicle operating within the surface movement area that periodically broadcasts its state vector (horizontal and vertical position, horizontal and vertical velocity) and other information. ADS-B is automatic because no external stimulus is required to elicit a transmission. It is dependent because it relies on on-board navigation sources and on-board broadcast transmission systems to provide surveillance information to other users.

j. Automatic Dependent Surveillance-Rebroadcast (ADS-R). A service of the ground system that rebroadcasts ADS-B messages from one link technology onto another. For example, the SBS ground system provides ADS-R service to rebroadcast UAT messages on 1090 MHz and vice versa.

k. Availability. An indication of the ability of a system or subsystem to provide usable service. Availability is expressed in terms of the probability of the system or subsystem being available at the beginning of an intended operation.

l. Background Application. An application that applies to all traffic of operational interest. One or more background applications may be in use in some or all airspace (or on the ground), but without flight crew input or automated input to select specific traffic. Background applications include: airborne, surface (runways and taxiways) and surface (runways only).

m. Caution. The level or category of alert for conditions that require immediate flight crew awareness and subsequent flight crew response.

n. Coast Interval. The elapsed time since a report from any source has been correlated with the track.

o. Cockpit Display of Traffic Information (CDTI). The pilot interface portion of a surveillance system. This interface includes the traffic display and all the controls that interact with such a display. The CDTI is defined as a graphical plan-view (top-down) traffic display. The CDTI receives position information of traffic and own-ship from the airborne surveillance and separation assurance processing (ASSAP) function. The ASSAP receives such information from the surveillance sensors and own-ship position sensors.

p. Compensated Latency. Latency can be compensated by extrapolating position using the last known position measurement, the elapsed time, and the last known velocity measurement. The elapsed time used to extrapolate is called compensated latency.

q. Conformal. A desirable property of map projections. A map projection (a function that associate points on the surface of an ellipsoid or sphere representing the earth to points on a flat surface such as the CDTI display) is said to be conformal if the angle between any two curves on the first surface is preserved in magnitude and sensed by the angle between the corresponding curves on the other surface.

r. Correlation. The process of determining that a new measurement belongs to an existing track.

s. Coupled Application. An application that operates only on specifically-chosen (either by the flight crew or automation) traffic. They generally operate only for a specific flight operation. Coupled applications include: enhanced visual approach.

t. Coupled Traffic. Traffic upon which a coupled application is to be conducted.

u. Data Block. A block of information about selected traffic that is displayed somewhere around the edge of the CDTI display, rather than mixed in with the symbols representing traffic in the main part of the display.

v. Data Tag. A block of information that is displayed next to the traffic symbol in the main part of the CDTI display.

w. Desirable. The capability denoted as desirable is not required to perform the procedure, but would increase the utility of the operation.

x. Differential Ground Speed. Calculated by taking the difference between the magnitude of the own ship ground speed and the designated traffic ground speed. The assumption is that own ship is following the designated traffic approach path over the ground. Positive values indicate closure on the designated traffic.

y. Display Range. The maximum distance from own-ship that is represented on the CDTI display. If the CDTI display is regarded as a map, then longer display ranges correspond to smaller map scales, and short display ranges correspond to larger map scales.

z. Domain. Divisions in the current airspace structure that tie separation standards to the surveillance and automation capabilities available in the ground infrastructure. Generally there are five domains: surface, terminal, en route, oceanic/remote and uncontrolled. For example, terminal airspace, in most cases comprises airspace within 30 miles and 10,000 feet AGL of airports with a terminal automation system and radar capability. Terminal Instrument Flight Rules (IFR) separation standards are normally 3 miles horizontally and 1000 feet vertically.

aa. Enhanced Visual Acquisition (EVAcq). This application is an enhancement for the out-the-window visual acquisition of aircraft traffic and potentially ground vehicles.

bb. Enhanced Visual Approach (EVApp). This application aids the pilot in identifying and maintaining separation from a lead aircraft when performing a visual approach operation.

cc. Estimation. The process of determining a track's state based on new measurement information.

dd. Extended Runway Center Line. An extension outwards of the center line of a runway, from one or both ends of that runway.

ee. Extended Squitter. A long (112 bit) Mode S transmission that is spontaneously produced by the radio as opposed to a response to a Mode S Interrogation. Extended Squitter is the mechanism used to provide ADS-B messages from a Mode S transponder.

ff. Extrapolation. The process of predicting a track's state forward in time based on the track's last kinematic state.

gg. Field of View. The field of view of a CDTI is the geographical region within which the CDTI shows traffic. Some documents call this the field of regard.

hh. Flight Crew. One or more cockpit crew members required for the operation of the aircraft.

ii. Geometric Altitude. Provided as height above ellipsoid and referenced to WGS-84 reference datum.

jj. GNSS Sensor Integrity Risk. The probability of an undetected failure that results in navigation system error (NSE) that significantly jeopardizes the total system error (TSE) exceeding the containment limit.

kk. Ground Speed. The magnitude of the horizontal velocity vector (see velocity). In these minimum operational performance standards (MOPS) it is always expressed relative to a frame of reference that is fixed with respect to the earth's surface such as the WGS-84 ellipsoid.

ll. Ground Track Angle. The direction of the horizontal velocity vector (see velocity) relative to the ground as noted in ground speed.

mm. Hazard Classification. Refer to AC 25-1309-1(), System Design and Analysis, or AC 23.1309-1(), System Safety Analysis and Assessment for Part 23 Airplanes, as applicable.

nn. Horizontal Velocity. The component of velocity in a local horizontal plane. For Global Positioning System (GPS) sensors, that plane is tangent to the WGS-84 ellipsoid and is vertically displaced such that it contains the navigation sensors's reference point. For inertial navigation system (INS) equipment, the local plane is tangent to the local gravity vector.

oo. Height Above Ellipsoid. Height above the WGS-84 reference ellipsoid.

pp. Integrity Containment Risk (ICR). The per-flight-hour probability that a parameter will exceed its containment bound without being detected and reported within the required time to alert. (See also integrity and surveillance integrity level.)

qq. International Civil Aviation Organization (ICAO). A United Nations organization that is responsible for developing international standards, and recommending practices, and procedures covering a variety of technical fields of aviation.

rr. Latency. The time incurred between two particular interfaces. Total latency is the delay between the time of a measurement and the time that the measurement is reported at a particular interface (the latter minus the former). Components of the total latency are elements of the total latency allocated between different interfaces. Each latency component will be specified by naming the interfaces between which it applies.

ss. Mixed Equipage. An environment where all aircraft do not have the same set of avionics capabilities. For example, some aircraft may transmit ADS-B and others may not, which could have implications for ATC and pilots. A mixed equipage environment will exist until all aircraft operating in a system have the same set of avionics capabilities.

tt. Multilateration. A surveillance system that uses the time of receipt of transponder transmissions to determine the position of the aircraft.

uu. Nautical Mile (NM). A unit of length used in the fields of air and marine navigation. In this document, a nautical mile is always the international nautical mile of 1852 m exactly.

vv. Navigation Accuracy Category Position (NAC_P). The NACp parameter describes the accuracy region about the reported position within which the true position of the surveillance position reference point is assured to lie with a 95% probability at the reported time of applicability.

ww. Navigation Accuracy Category Velocity (NAC_V). The NACv parameter describes the accuracy about the reported velocity vector within which the true velocity vector is assured to be with a 95% probability at the reported time of applicability.

xx. Navigation Integrity Category (NIC). The NIC parameter describes an integrity containment region about the reported position, within which the true position of the surveillance position reference point is assured to lie at the reported time of applicability. For the conditions and probability of assurance associated with the integrity containment region, see the source integrity level (SIL) parameter.

yy. Navigation Sensor Availability. An indication of the ability of the guidance function to provide usable service within the specified coverage area, and is defined as the portion of time during which the sensor information is to be used for navigation, during which reliable navigation information is presented to the crew, autopilot, or other system managing the movement of the aircraft. Navigation sensor availability is specified in terms of the probability of the sensor information being available at the beginning of the intended operation.

zz. Navigation Sensor Continuity. The capability of the sensor (comprising all elements generating the signal in space and airborne reception) to perform the guidance function without non-scheduled interruption during the intended operation.

aaa. Navigation Sensor Continuity Risk. The probability that the sensor information will be interrupted and not provide navigation information over the period of the intended operation.

bbb. Navigation System Integrity. This relates to the trust that can be placed in the correctness of the navigation information supplied. Integrity includes the ability to provide timely and valid warnings to the user when the navigation system must not be used for navigation.

ccc. Own-ship. From the perspective of a flight crew, or of the ASSAP and CDTI functions used by that flight crew, the own-ship is the ASA participant (aircraft or vehicle) that carries that flight crew and those ASSAP and CDTI functions.

ddd. Persistent Error. An error that occurs continuously once it begins. Such an error may be the absence of data or the presentation of data that is false or misleading. An unknown measurement bias may, for example, cause a persistent error.

eee. Positional Uncertainty. A measure of the potential inaccuracy of an aircraft's position-fixing system and, therefore, of ADS-B-based surveillance. Use of the Global Positioning System (GPS) reduces positional inaccuracy to small values, especially when the system is augmented by either space-based or ground-based subsystems.

fff. Pressure Altitude. Altitude reported by a barometric pressure altimeter without corrections for local pressure settings.

ggg. Primary Surveillance Radar (PSR). A radar sensor that listens to the echoes of pulses that it transmits to illuminate aircraft targets. PSR sensors, in contrast to secondary surveillance radar (SSR) sensors, do not depend on the carriage of transponders on board the aircraft targets.

hhh. Range Reference. The CDTI feature of displaying range rings or other range markings at specified radii from the own-ship symbol.

iii. Secondary Surveillance Radar (SSR). A radar sensor that listens to replies sent by transponders carried on board airborne targets. SSR sensors, in contrast to primary surveillance radar (PSR) sensors, require the aircraft under surveillance to carry a transponder.

jjj. Selected Traffic. Traffic for which additional information is requested by the flight crew.

kkk. Sensor. A measurement device. An air data sensor measures atmospheric pressure and temperature, to estimate pressure altitude, and pressure altitude rate, airspeed, etc. A primary surveillance radar sensor measures its antenna direction and the times of returns of echoes of pulses that it transmits to determine the ranges and bearings of airborne targets. A secondary surveillance radar sensor measures its antenna direction and the times of returns of replies from airborne transponders to estimate the ranges and bearings of airborne targets carrying those transponders.

lll. Separation. The minimum distance between aircraft/vehicles allowed by regulations. Separation requirements vary by factors such as radar coverage (none, single, composite), flight regime (terminal, en route, oceanic), and flight rules (instrument or visual).

mmm. Separation Violation. Violation of appropriate separation requirements.

nnn. Simple Action. A flight crew action that may be performed within a short period of time and without requiring significant concentration that would distract from the main aviation tasks (e.g., a button press).

ooo. Spacing. A distance maintained from another aircraft for specific operations.

ppp. Subsystem Availability Risk. The probability, per flight hour, that an ASA subsystem is not available, that is, that it is not meeting its functional and performance requirements.

qqq. Source Integrity Level (SIL). The SIL field defines the probability of the reported horizontal position exceeding the radius of containment defined by the NIC, without alerting, assuming no avionics faults. Although the SIL assumes there are no un-annunciated faults in the avionics system, the SIL must consider the effects of a faulted signal-in-space (SIS), if a signal-in-space is used by the position source.

rrr. State Vector. An aircraft's current horizontal position, vertical position, horizontal velocity, vertical velocity, and navigational accuracy and integrity.

sss. Traffic Selection. Manual process of flight crew selecting a traffic element.

ttt. TCAS Potential Threat. Traffic detected by TCAS equipment on board the own-ship, that has passed the Potential Threat classification criteria for a TCAS TA and does not meet the Threat Classification criteria for a TCAS RA (RTCA/DO-185B § 1.8). If the ASAS own-ship CDTI display is also used as a TCAS TA display, then information about TCAS potential threats will be conveyed to the CDTI via the ASSAP function.

uuu. TCAS Proximate Traffic. Traffic, detected by TCAS equipment on board the own-ship, that is within 1200 feet and 6 NM of the own-ship (RTCA/DO-185B § 1.8). If the ASAS own-ship CDTI display is also used as a TCAS display, then information about TCAS proximate traffic will be conveyed to the CDTI, possibly via the ASSAP function.

vvv. TCAS-Only Traffic. A traffic element about which TCAS has provided surveillance information, but which the ASSAP function has not correlated with traffic from other surveillance sources such as ADS-B, ADS-R, or TIS-B.

www. Time of Applicability. The time that a particular measurement or parameter is (or was) relevant.

xxx. Track. (1) A sequence of reports from the ASSAP function that all pertain to the same traffic target. (2) Within the ASSAP function, a sequence of estimates of traffic target state that all pertain to the same traffic element.

yyy. Track Angle. See Ground Track Angle.

zzz. Track State. See State Vector.

aaaa. Traffic Conflict. Predicted converging of aircraft in space and time, which constitutes a violation of a given set of separation minima.

bbbb. Traffic. All aircraft/vehicles that are within the operational vicinity of own-ship.

cccc. Traffic Element. An aircraft or vehicle.

dddd. Traffic Information Service – Broadcast (TIS-B). A surveillance service that broadcasts traffic information derived from one or more ground surveillance sources to suitably equipped aircraft or surface vehicles, with the intention of supporting ASA applications.

eeee. Traffic Symbol. A depiction on the CDTI display of an aircraft or vehicle other than the own-ship.

ffff. Transponder. A piece of equipment carried on board an aircraft to support the surveillance of that aircraft by secondary surveillance radar sensors. A transponder receives on the 1030 MHz and replies on the 1090 MHz downlink frequency.

gggg. Uncompensated Latency. Latency can be compensated by extrapolating position using the last known position measurement, the elapsed time, and the last known velocity measurement. The remaining time between the present and the elapsed time the equipment has compensated for is called uncompensated latency.

hhhh. Velocity. The rate of change of position. Horizontal velocity is the horizontal component of velocity and vertical velocity is the vertical component of velocity.

iiii. Warning. The level or category of alert for conditions that require immediate flight crew awareness and immediate flight crew response.

2. Acronyms:

AC	Advisory Circular (FAA)
ACL	ASA Capability Level
ACM	Airborne Conflict Management
ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-R	Automatic Dependent Surveillance – Rebroadcast
AGL	Above Ground Level
AMMD	Aerodrome Moving Map Display (an acronym from [DO-257A])
ANSD	Assured Normal Separation Distance
ASA	Aircraft Surveillance Applications
ASAS	Aircraft Surveillance Applications System
ASSA	Airport Surface Situation awareness
ASSAP	Airborne Surveillance and Separation Assurance Processing
ATC	Air Traffic Control
ATCRBS	Air Traffic Control Radar Beacon System
CDTI	Cockpit Display of Traffic Information
CFR	Code of Federal Regulations
CNS	Communications, Navigation, Surveillance
CPA	Closest Point of Approach
EFB	Electronic Flight Bag
EFIS	Electronic Flight Instrument System
EHSI	Electronic Horizontal Situation Indicator
EPU	Estimated Position Uncertainty
EUROCAE	European Organization for Civil Aviation Equipment
FAA	Federal Aviation Administration
FAROA	Final Approach and Runway Occupancy Awareness
FMS	Flight Management System
Fpm	Feet Per Minute
Ft	Feet
GA	General Aviation
GNSS	Global Navigation Satellite System

GPS	Global Positioning System
HAE	Height Above Ellipsoid
HMI	Hazardously Misleading Information
ICAO	International Civil Aviation Organization
ICR	Integrity Containment Risk
ID	Identification
IFR	Instrument Flight Rules
Kts	Knots
M	meter (or "metre"), the SI metric system base unit for length
MCDU	Mult-Function Control and Display Unit
MFD	Multi-Function Display
MHz	Mega Hertz
MOPS	Minimum Operation Performance Standards (RTCA documents)
N/A	Not Applicable or No Change
NAC	Navigation Accuracy Category (sub "p" is for position and sub "v" is for velocity)
NAS	National Airspace System
NIC	Navigation Integrity Category
NM	Nautical Mile
NUC	Navigation Uncertainty Category
OEM	Original Equipment Manufacturer
PSCP	Project Specific Certification Plan
PVT	Position, Velocity, and Time
RA	Resolution Advisory (TCAS II)
RC	Radius of Containment
RFG	Requirements Focus Group
RMS	Root Mean Square
RNAV	Area Navigation
RNP	Required Navigation Performance
s	second, the SI metric system base unit for time or time interval
SA	Situation Awareness
SAE	Society of Automotive Engineers

SBS	Surveillance and Broadcast Services
SC	Special Committee
SIL	Surveillance Integrity Level (sub BARO is for barometric altitude)
SSR	Secondary Surveillance Radar
STP	Surveillance Transmit Processing
SV	State Vector
TA	Traffic Advisory (TCAS II)
TCAS	Traffic Alert and Collision Avoidance System
TCAS I	TCAS system that does not provide resolution advisories
TCAS II	TCAS system that provides resolution advisories
TDC	Traffic Display Criteria
TIS-B	Traffic Information Service – Broadcast
TMC	Traffic Management Coordinator
TOA	Time of Applicability
TSE	Total System Error
TSO	Technical Standard Order
UAT	Universal Access Transceiver
UTC	Universal Time, Coordinated, formerly Greenwich Mean Time
VDL-4	Very High Frequency Data Link Mode 4
VEPU	Vertical Estimated Position Uncertainty
WGS-84	World Geodetic System-1984

Appendix 4. Related Documents

1. FAA Documents.

AC 20-131( ), *Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II) and Mode S Transponders*.

AC 20-138( ), *Airworthiness Approval of Global Navigation Satellite System (GNSS) Equipment*.

AC 20-151( ), *Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II) Version 7.0 & 7.1 and Associated Mode S Transponders.*

AC 20-153( ), *Acceptance of Data Processes and Associated Navigation Databases*.

AC 20-159( ), *Obtaining Design and Production Approval of Airport Moving Map Display Applications Intended For Electronic Flight Bag Systems*.

AC 21-40( ), *Guide for Obtaining a Supplemental Type Certificate*.

AC 23.1309-1( ), *System Safety Analysis and Assessment for Part 23 Airplanes*.

AC 25-1309-1( ), *System Design and Analysis*.

AC 27-1( ), *Certification of Normal Category Rotorcraft.*

AC 29-2( ), *Certification of Transport Category Rotorcraft*.

AC 43-6( ), *Altitude Reporting Equipment and Transponder System Maintenance and Inspection Practices.*

AC 120-76( ), *Guidelines For The Certification, Airworthiness, and Operational Approval of Electronic Flight Bag Computing Devices.*

TSO-C5, *Direction Instrument, Non-Magnetic (Gyroscopically Stabilized).*

TSO-C6, *Direction Instrument, Magnetic (Gyroscopically Stabilized).*

TSO-C8( ), *Vertical Velocity Instruments.*

TSO-C10( ), *Altimeter, Pressure Actuated, Sensitive Type*.

TSO-C66( ), *Distance Measuring Equipment (DME) Operating Within the Radio Frequency Range of 960-1215 Megahertz.*

TSO-88( ), *Automatic Pressure Altitude Reporting Code-Generating Equipment.*

TSO-C106( ), *Air Data Computer.*

TSO-C112( ), *Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment.*

TSO-C119( ), *Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment.*

TSO-C129( ), *Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS).*

TSO-C145( ), *Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS).*

TSO-C146( ), *Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS).*

TSO-C154c, *Universal Access Transceiver (UAT) Automatic Dependent Surveillance Broadcast (ADS-B) Equipment Operating on the Frequency of 978 MHz.*

TSO-C165( ), *Electronic Map Display Equipment for Graphical Depiction of Aircraft Position.*

TSO-C166b, *Extended Squitter Automatic Dependent Surveillance - Broadcast (ADS-B) and Traffic Information Service - Broadcast (TIS-B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz).*

TSO-C195, *Avionics Supporting Automatic Dependent Surveillance - Broadcast (ADS-B) Aircraft Surveillance Applications (ASA).*

TSO-C196( ), *Airborne Supplemental Navigation Sensors for Global Positioning System Equipment Using Aircraft-Based Augmentation.*

2. RTCA, Inc. Documents (RTCA DO) documents:

RTCA/DO-178B, *Software Considerations in Airborne Systems and Equipment Certification.*

RTCA/DO-208, *Minimum Operational Performance Standards for Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS).*

RTCA/DO-229D, *Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment.*

RTCA/DO-247, *The Role of the Global Navigation Satellite System (GNSS) in Supporting Airport Surface Operations.*

RTCA/DO-254, *Design Assurance Guidance for Airborne Electronic Hardware.*

RTCA/DO-257A, *Minimum Operational Performance Standards for the Depiction of Navigational Information on Electronic Maps*.

RTCA/DO-260B, *Minimum Operational Performance Standards for 1090 MHz Automatic Dependent Surveillance-Broadcast (ADS-B).*

RTCA/DO-282B, *Minimum Operational Performance Standards for Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS-B).*

RTCA/DO-316, *Minimum Operational Performance Standards (MOPS) for Global Positioning System/Aircraft Based Augmentation System Airborne Equipment.*

RTCA/DO-317, *Minimum Operational Performance Standards (MOPS) For Aircraft Surveillance Applications System (ASAS).*

3. ARINC Documents:

ARINC 718A, *Mark 4 Air Traffic Control Transponder (ATCRBS/MODE S).*

ARINC 735B, *Mark 2 Traffic Alert and Collision Avoidance System (TCAS).*

ARINC 738A, *Air Data and Inertial Reference System (ADRS).*

ARINC 743A, *GNSS Sensor.*

4. SAE Documents.

SAE ARP 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems

SAE ARP 4761, Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment

5. How to Get Related Documents:

a. Order copies of 14 CFR parts from the Superintendent of Documents, Government Printing Office (GPO), P.O. Box 979050, St. Louis, MO 63197. For general information, telephone (202) 512-1800 or fax (202) 512-2250. You can also get copies online at the GPO electronic CFR Internet website at www.gpoaccess.gov/cfr/.

b. Order copies of RTCA documents from RTCA Inc., 1828 L Street NW, Suite 805, Washington, D.C. 20036-4007. For general information, telephone (202) 833-9339 or fax (202) 833-9434. You can also order copies online at http:/www.rtca.org.

c. Order copies of ARINC documents from ARINC Incorporated, 2551 Riva Rd., Annapolis, MD, 21401. Telephone +1 800-633-6882, fax +1 410-956-5465. You can also get copies from their website at www.arinc.com.

d. Order copies of SAE documents from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, telephone (724) 776-4970, fax (724) 776-0790. Also, order copies online at www.sae.org.

e. Order copies of advisory circulars from the U.S. Department of Transportation, Subsequent Distribution Office, M-30, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785. You can also get copies from our website at http://www.faa.gov/regulations_policies/advisory_circulars/ or www.airweb.faa.gov/rgl.