RTCA, Inc.
1140 Connecticut Avenue, NW, Suite 1020
Washington, DC 20036-4001, USA

Minimum Operational Performance Standards (MOPS) For Airborne Separation Assurance System (ASAS)

Updated: 05/07/07
RTCA/DO-???
Prepared by: RTCA, Inc.

Copies of this document may be obtained from

RTCA, Inc.
1140 Connecticut Avenue, NW, Suite 1020
Washington, DC 20036-4001, USA

Telephone: 202-833-9339
Facsimile: 202-833-9434
Internet: www.rtca.org

Please call RTCA for price and ordering information

FOREWORD

RTCA, Incorporated is a not-for-profit corporation formed to advance the art and science of aviation and aviation electronic systems for the benefit of the public. The organization functions as a Federal Advisory Committee and develops consensus-based recommendations on contemporary aviation issues. RTCA's objectives include, but are not limited to:

- Coalescing aviation system user and provider technical requirements in a manner that helps government and industry meet their mutual objectives and responsibilities;

- Analyzing and recommending solutions to the system technical issues that aviation faces as it continues to pursue increased safety, system capacity and efficiency;

- Developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of Minimum Operational Performance Standards (MOPS) for electronic systems and equipment that support aviation; and

- Assisting in developing the appropriate technical material upon which positions for the International Civil Aviation Organization (ICAO) and the International Telecommunication Union (ITU) and other appropriate international organizations can be based.

The recommendations of RTCA are often used as the basis for government and private sector decisions as well as the foundation for many Federal Aviation Administration Technical Standard Orders (TSO).

Since RTCA is not an official agency of the United States Government, its recommendations may not be regarded as statements of official government policy unless so enunciated by the United States Government organization or agency having statutory jurisdiction over any matters to which the recommendations relate.

This Page Was Intentionally Left Blank

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

This Page Was Intentionally Left Blank

1 PURPOSE AND SCOPE

1.1 Introduction

This document contains Minimum Operational Performance Standards (MOPS) for the Airborne Separation Assurance System (ASAS). These standards specify system characteristics that should be useful to designers, manufacturers, installers and users of the equipment.

These MOPS for ASAS contain requirements for processing and display of traffic and ownship information for use by the flight crew in performing airborne applications.

Compliance with these standards is recommended as one means of assuring that the equipment will perform its intended function(s) satisfactorily under all conditions normally encountered in routine aeronautical operation. Any regulatory application of this document is the sole responsibility of appropriate governmental agencies.

Section 1 of this document provides information needed to understand the rationale for equipment characteristics and requirements stated in the remaining sections. It describes typical equipment operations and operation goals, as envisioned by the members of Special Committee **186**, and establishes the basis for the standards stated in Sections 2 through 3. Definitions and assumptions essential to proper understanding of this document are also provided in this section.

Section 2 contains the Minimum Performance Standards for the equipment. These standards specify the required performance under standard environmental conditions. Also included are recommended bench test procedures necessary to demonstrate equipment compliance with the stated minimum requirements.

Section 3 describes the performance required of installed equipment. Tests for the installed equipment are included when performance cannot be adequately determined through bench testing.

Section 4 describes the operational performance characteristics for equipment installations and defines conditions that will assure the equipment user that operations can be conducted safely and reliably in the expected operational environment.

This document considers functional requirements consisting of: airborne surveillance and separation assurance processing (ASSAP), and cockpit display of traffic information (CDTI) as described in the ASA MASPS, DO-289 Operational performance standards for functions or components that refer to equipment capabilities that exceed the stated minimum requirements are identified as optional features.

The word “function” as used in this document includes all components and units necessary for the system to properly perform its intended function(s). For example, the “function” may be implemented in hardware or software, as appropriate, and the function may be partitioned within the hardware and software as is most convenient for a particular implementation.

If the functional implementation includes a computer software package, the guidelines contained in RTCA Document No. DO-178B, *Software Consideration in Airborne Systems and Equipment Certification*, should be considered.

1.2 System Overview

The systems supporting both ground based and aircraft-to-aircraft applications consist of ground systems and the Aircraft Surveillance Applications (ASA) system (Figure 1-1). The ASA system consists of five major subsystems, of which this ASAS MOPS specifies two subsystems. The five subsystems of ASA are: a surveillance transmit processing subsystem (STP), a surveillance subsystem (including ADS-B and TIS-B transmit and receive), a surveillance data processing subsystem, Airborne Surveillance and Separation Assurance Processing (ASSAP), and a display subsystem Cockpit Display of Traffic Information (CDTI). ASA also interfaces with other aircraft systems. Figure 1-1 provides an overview of the system architecture and depicts the interfaces between functional elements for an ASA aircraft participant. Note that the ADS-B transmit and receive subsystems are specified in RTCA DO-260() and RTCA DO-282() for the 1090 and UAT systems, respectively and the Surveillance Transmit Processing subsystem is specified in RTCA DO-302.

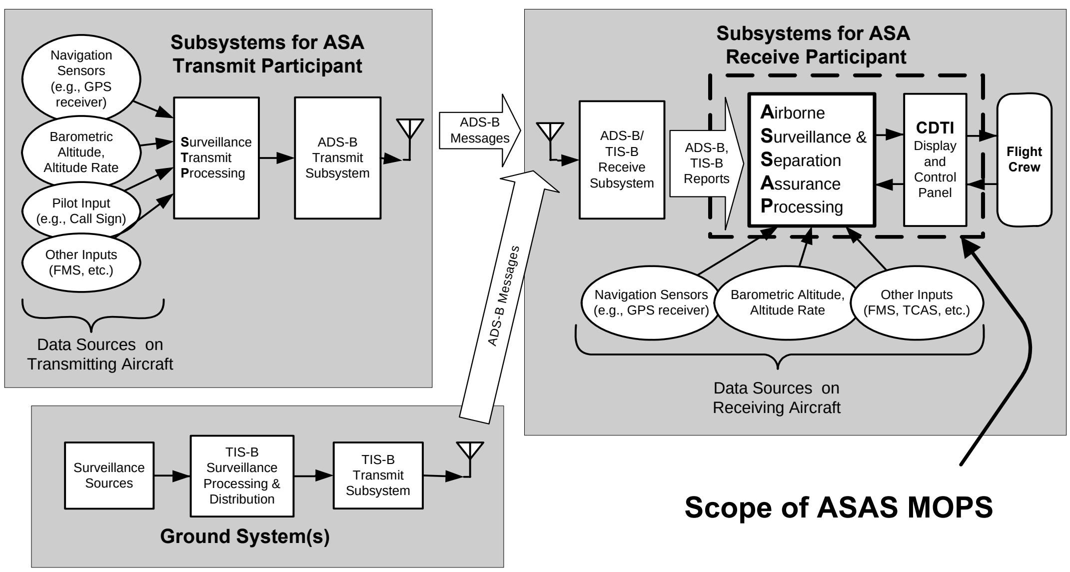

Figure 1-1: Overview of ASA Architecture

The Surveillance Transmit Processing (STP) subsystem prepares the required surveillance information from on-board aircraft sensors for the ADS-B Transmit Subsystem. Traffic Information Service Broadcast (TIS-B) messages are processed to include similar surveillance information obtained through ground surveillance systems. TIS-B messages are broadcast by the TIS-B Transmit Subsystem. ADS-B Rebroadcast (ADS-R) provides traffic information to equipped aircraft based on ADS-B transmission from aircraft on independent data links (1090ES and UAT).

ADS-B, TIS-B and ADS-R messages are received by the ADS-B/TIS-B Receive Subsystem at the receiving ASA Aircraft/Vehicle (A/V). The ADS-B/TIS-B Receive Subsystem processes these messages and provides ADS-B, TIS-B, and ADS-R traffic reports to ASSAP.

The blocks in Figure 1-1 labeled ASSAP and CDTI collectively are referred to as ASAS and are the scope of this document. ASSAP is the processing subsystem that accepts surveillance inputs, e.g., ADS-B reports, performs surveillance processing to provide reports and tracks, and performs application-specific separation assurance processing. Surveillance reports, tracks, and any application-specific alerts or guidance are output by ASSAP to the CDTI function. ASSAP surveillance processing consists of track processing and correlation of ADS-B, TIS-B, ADS-R, and TCAS reports. In addition to these interfaces and depending on the actual ASA application, ASSAP may interface to the Flight Management System (FMS) and/or the Flight Control (FC) systems for flight path changes, speed commands, etc. ASSAP also interfaces with:

- The ADS-B transmitter and receiver to support transmission of application-specific messages, etc.
- Inputs from the ownship navigation system to obtain state information on own aircraft, and
- TCAS (TCAS I and TCAS II), for combined displays. Also, some applications (e.g., CD and ACM) may suppress alerts in the event that TCAS advisories are present; other applications (e.g., ICSPA) may suppress TCAS advisories on specific targets.

The CDTI subsystem shown in Figure 1-1 includes the actual display media and the necessary controls to interface with the flight crew. Thus the CDTI consists of a display and control panel. The control panel may be a dedicated CDTI control panel or it may be incorporated into another control, e.g., multifunction display unit (MCDU). Similarly, the CDTI display may also be a stand-alone display (dedicated display) or the CDTI information may be present on an existing display (e.g., multi-function display)

1.3 Operational Application(s)

The standards defined in this version of the ASAS MOPS have been scoped to support the five initial applications defined in the ASA MASPS (DO-289) which are as follows:

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

A description of each of the supported applications follows:

Enhanced Visual Acquisition: Cockpit Display of Traffic Information (CDTI) provides traffic information to assist the flight crew in visually acquiring traffic out the window. The CDTI can be used to initially acquire traffic (that the pilot might not have known about otherwise) or as a supplement to an ATC traffic advisory. This application is expected to improve both safety and efficiency by provided the flight crew basic traffic awareness leading to better maneuver decisions.

Conflict Detection (CD): The CDTI is used to alert the flight crew of nearby traffic. The alert may prompt the flight crew to exercise see-and-avoid procedures or to contact ATC. Conflict avoidance maneuvers are not suggested by this application. This application is expected to improve safety by alerting the flight crew about potential conflicting traffic and by providing information that can aid the flight crew in making visual, out-the-window maneuver decisions.

Airport Surface Situational Awareness (ASSA), and Final Approach and Runway Occupancy Awareness (FAROA): In these applications, the CDTI is used by the flight crew to make taxiing decisions based on traffic and to determine runway and final approach occupancy. The applications will support the flight crew in making decisions about taxiing, takeoff and landing. They are expected to increase efficiency of operations on the airport surface and reduce runway incursions and collisions. Enhanced Visual Approach: 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.

Enhanced Visual Approach (EVApp): The Enhanced Visual Approach (EVApp) application is an extension of the current visual approach procedure. In this application, the CDTI is used by the flight crew to detect and track the preceding aircraft more effectively. The complete application description is included in Appendix G. EVAcq is considered to be a coupled application, as it applies only to the preceding aircraft.

1.4 Intended Function

The intended function of equipment built to the specifications in this MOPS is to perform the processing and displays that support the requirements of the applications described in section 1.3. The equipment will perform its intended function(s), as defined by this document and the manufacturer and its proper use will not create a hazard to other users of the National Airspace System.

1.5 Assumptions

Own ship position data should be delivered to ASSAP such that the uncompensated latency is less than 200 ms. GPS sensors compliant with ARINC 743A-4 and RNP FMS compliant with ARINC 702A Supplement 3 are examples of acceptable position sources.

1.5.1 ADS-B Reports

All ADS-B Reports generated by the ADS-B link receiver are subject to track initiation and update criteria as defined by the appropriate link MOPS (DO-260() and DO-282()). Therefore, ASAP is required to track all reports received from the ADS-B receiver.

1.6 Test Procedures

The test procedures specified in this document are intended to be used as one means of demonstrating compliance with the performance requirement. Although specific test procedures are cited, it is recognized that other methods may be preferred. These alternate procedures may be used if they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures.

The order of tests specified suggests that the equipment be subjected to a succession of tests as it moves from design, and design qualification, into operational use. For example, compliance with the requirements of Section 2 shall have been demonstrated as a precondition to satisfactory completion of the installed system tests of Section 3.

a. Environmental Tests

   Environmental test requirements are specified in Subsection 2.3. The procedures and their associated limits are intended to provide a laboratory means of determining the electrical and mechanical performance of the equipment under environmental conditions expected to be encountered in actual operations.

   Unless otherwise specified, the environmental conditions and test procedures contained in RTCA Document No. DO-160C, *Environmental Conditions and Test Procedures for Airborne Equipment*, will be used to demonstrate equipment compliance.

b. Bench Tests

   Bench test procedures are specified in Subsection 2.4. These tests provide a laboratory means of demonstrating compliance with the requirements of Subsection 2.2. Test results may be used by equipment manufacturers as design guidance, for monitoring manufacturing compliance and, in certain cases, for obtaining formal approval of equipment design.

c. Installed Equipment Tests

   The installed equipment test procedures and their associated limits are specified in Section 3. Although bench and environmental test procedures are not included in the installed equipment test, their successful completion is a precondition to completion of the installed test. In certain instances, however, installed equipment test may be used in lieu of bench test simulation of such factors as power supply characteristics, interference from or to other equipment installed on the aircraft, etc. Installed tests are normally performed under two conditions:

   1. With the aircraft on the ground and using simulated or operational system inputs.

   2. With the aircraft in flight using operational system inputs appropriate to the equipment under test.

   Test results may be used to demonstrate functional performance in the intended operational environment.

d. Operational Tests

The operational tests are specified in Section 4. These test procedures and their associated limits are intended to be conducted by operating personnel as one means of ensuring that the equipment is functioning properly and can be reliably used for its intended function(s).

1.7 Acronyms and Definitions of Terms

1.7.1 Acronyms

The following acronyms and symbols for units of measure are used in this document.

A/S	Adjacent Ship
A/V	Aircraft/Vehicle
AC	Aviation Circular (FAA)
AC	Aircraft
ACAS	Airborne Collision Avoidance System. (ACAS is the ICAO standard for TCAS)
ACL	ASA Capability Level
ACM	Airborne Conflict Management
ADS	Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance – Broadcast
AGL	Above Ground Level
AILS	Airborne Information for Lateral Spacing
AIM	Aeronautical Information Manual, (FAA publication)
ALPA	Air Line Pilots Association
AMASS	Airport Movement Area Safety Systems
AMMD	Aerodrome Moving Map Display (an acronym from [DO-257A])
ANSD	Assured Normal Separation Distance
AOC	Aeronautical Operational Control
AOC	Airline Operations Center
AOPA	Aircraft Owners and Pilots Association
APU	Auxiliary Power Unit
ARTCC	Air Route Traffic Control Center
ASA	Aircraft Surveillance Applications (to be distinguished from Airborne-Surveillance Applications which not referenced as ASA in this document)
ASAS	(1) Airborne Separation Assurance System (an acronym used in [PO-ASAS]) or (2) Aircraft Surveillance Applications System (an acronym from [DO-289]). The two terms are equivalent.
ASDE-3	Airport Surveillance Detection Equipment version 3
ASDE-X	Airport Surveillance Detection Equipment X-band
ASF	Air Safety Foundation (AOPA organization)
ASIA	Approach Spacing for Instrument Approaches
ASOR	Allocation of Safety Objectives and Requirements
ASRS	Aviation Safety Reporting Service
ASSA	Airport Surface Situational Awareness
ASSAP	Airborne Surveillance and Separation Assurance Processing
AT	Air Traffic
ATC	Air Traffic Control
ATCRBS	Air Traffic Control Radar Beacon System
ATIS	Automated Terminal Information System
ATM	Air Traffic Management
ATP	Airline Transport Pilot (rating)

ATS	Air Traffic Services
ATSA	Airborne Traffic Situational Awareness
ATSP	Air Traffic Service Provider
BAQ	Barometric Altitude Quality
CAASD	Center for Advanced Aviation System Development
CARE	Co-operative Actions of R&D in EUROCONTROL
CAZ	Collision Avoidance Zone
CD	Conflict Detection
CD&R	Conflict Detection and Resolution
CDTI	Cockpit Display of Traffic Information
CDU	Control and Display Unit
CDZ	Conflict Detection Zone
CFR	Code of Federal Regulations
CNS	Communications, Navigation, Surveillance
CP	Conflict Prevention
CPA	Closest Point of Approach
CPDLC	Controller Pilot Data Link Communications
CR	Conflict Resolution
CRM	Crew Resource Management
CSPA	Closely Spaced Parallel Approaches
CTAF	Common Traffic Advisory Frequency
CTAS	Center TRACON Automation System
DAG	Distributed Air Ground
DGPS	Differential GPS
DH	Decision Height
DME	Distance Measuring Equipment
DOT	Department of Transportation, U. S. Government
EMD	Electronic Map Display
EPU	Estimated Position Uncertainty
EUROCAE	European Organization for Civil Aviation Equipment
EUROCONTROL	European Organization for the Safety of Air Navigation
EVAcq	Enhanced Visual Acquisition
EVApp	Enhanced Visual Approach
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FAR	Federal Aviation Regulation
FAROA	Final Approach and Runway Occupancy Awareness
FAST	Final Approach Spacing Tool
FFAS	Free Flight Airspace
FIS-B	Flight Information Services – Broadcast
FL	Flight Level
FMEA	Failure Modes and Effects Analysis
FMS	Flight Management System
Fpm	Feet Per Minute
FSDO	Flight Standards District Office (FAA)
FSS	Flight Service Station
Ft	Feet
GA	General Aviation
GHz	Giga Hertz
GLS	GNSS Landing System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSA	Ground-based Surveillance Application
HAE	Height Above Ellipsoid
HFOM	Horizontal Figure Of Merit
HGS	Head-Up Guidance System
HMI	Hazardously Misleading Information

HPL	Horizontal Protection Limit
HUD	Head-Up Display
Hz	Hertz
ICAO	International Civil Aviation Organization
ICR	Integrity Containment Risk
ICSPA	Independent Closely Spaced Parallel Approaches
ID	Identification
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
INS	Inertial Navigation System
JTIDS	Joint Tactical Information Distribution System
LA	Los Angeles
LAAS	Local Area Augmentation System
LAHSO	Land And Hold Short Operations
LL	Low Level
LOS	Loss of Separation
m	meter (or "metre"), the SI metric system base unit for length
MA	Maneuver Advisory
MAC	Midair Collision
MACA	Midair Collision Avoidance
MAS	Managed Airspace
MASPS	Minimum Aviation System Performance Standards
MCP	Mode Control Panel
MFD	Multi-Function Display
MHz	Mega Hertz
Mm	Millimeter
MOPS	Minimum Operation Performance Standards (RTCA documents)
Mrad	milliradian. 1 mrad = 0.001 radian
MTTF	Mean Time To Failure
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
NASA	National Aeronautics and Space Administration
ND	Navigation Display
NIC	Navigation Integrity Category
NLR	Nationaal Luchten Ruimtevaartlaboratorium (National Aerospace Laboratory in the Netherlands)
NM	Nautical Mile
NMAC	Near Mid Air Collision
NMPH	Nautical Miles Per Hour
NOTAM	NOTice to AirMen
NPA	Non-Precision Approach
NSE	Navigation System Error
NTSB	National Transportation Safety Board
O/S	Own Ship
OH	Operational Hazard
OHA	Operational Hazard Assessment
OPA	Operational Performance Assessment
OSA	Operational Safety Analysis
OSED	Operational Services and Environment Description
OTW	Out-the-Window
PA	Prevention Advisory

PAPI	Precision Approach Path Indicator
PAZ	Protected Airspace Zone
PF	Pilot Flying
PFD	Primary Flight Display
PNF	Pilot Not Flying
PO-ASAS	Principles of Operation for the Uses of ASAS (See the entry in DO-189 Appendix-B for [PO-ASAS])
PRM	Precision Runway Monitor
PSR	Primary Surveillance Radar
R&D	Research and Development
RA	Resolution Advisory (TCAS II),
rad	radian, an SI metric system derived unit for plane angle
RAIM	Receiver Autonomous Integrity Monitoring
RC	Radius of Containment
REQ No.	Requirement Number
RIPS	Runway Incursion Prevention System
RMS	Root Mean Square
RNAV	Area Navigation
RNP	Required Navigation Performance
RSP	Required Surveillance Performance
RTA	Required Time of Arrival
RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minimum
rx	receive, receiver
s	second, the SI metric system base unit for time or time interval
SAE	Society of Automotive Engineers
SC	Special Committee
SF21	Safe Flight 21
SGS	Surface Guidance System
SI	Système International d'Unités (International System of Units not to be confused with the Mode Select Beacon system SI function)
SIL	Surveillance Integrity Level (sub BARO is for barometric altitude)
SIRO	Simultaneous Intersecting Runway Operations
SM	Statute Miles
SMM	Surface Moving Map
SPR	Surveillance Position Reference point
SSR	Secondary Surveillance Radar
STP	Surveillance Transmit Processing
SV	State Vector
SVFR	Special Visual Flight Rules
TA	Traffic Advisory (TCAS II)
TAWS	Terrain Awareness and Warning System
TCAS	Traffic Alert and Collision Avoidance System (See ACAS)
TCAS I	TCAS system that does not provide resolution advisories
TCAS II	TCAS system that provides resolution advisories
TCP	Trajectory Change Point
TCV	Test Criteria Violation
TESIS	Test and Evaluation Surveillance and Information System
TIS	Traffic Information Service
TIS-B	Traffic Information Service – Broadcast
TLAT	Technical Link Assessment Team
TLS	Target Level Safety
TMA	Traffic Management Area
TMC	Traffic Management Coordinator
TMU	Traffic Management Unit
TORCH	Technical ecOnomical and opeRational assessment of an ATM Concept acHeiveable from the year 2005
TQL	Transmit Quality Level

TRACON	Terminal Area CONtrol
TSE	Total System Error
TTF	Traffic To Follow
UAT	Universal Access Transceiver
UHF	Ultra High Frequency: The band of radio frequencies between 300 MHz and 3 GHz, with wavelengths between 1 m and 100 mm.
UMAS	Unmanaged Airspace
UPT	User Preferred Trajectory
USAF	United States Air Force.
UTC	Universal Time, Coordinated, formerly Greenwich Mean Time
Vapp	Final Approach Speed
VDL-4	Very High Frequency Data Link Mode 4
VEPU	Vertical Position Uncertainty
VFOM	Vertical Figure Of Merit
VFR	Visual Flight Rules
VHF	Very High Frequency The band of radio frequencies between 30 MHz and 300 MHz, with wavelengths between 10 m and 1 m.
VMC	Visual Meteorological Conditions
VOR	Very High Frequency Omni-directional Radio
VPL	Vertical Protection Limit
Vref	Reference Landing Velocity
WAAS	Wide Area Augmentation System
WCB	Worst Case Blunder
WG	Working Group
WGS-84	World Geodetic System-1984
xmit	transmit, transmitter

1.7.2 Definitions of Terms

The following are definitions of terms used in this document. Square brackets, e.g. [RTCA DO-242A], refer to entries in the bibliography in Appendix AB.

Airborne Separation Assurance 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.

Airborne Separation Assistance Application - A set of operational procedures for controllers and flight crews that makes use of an Airborne Separation Assurance system to meet a defined operational goal.

Airborne Traffic Situational Awareness applications (ATSA applications) - These applications are aimed at enhancing the flight crews' knowledge of the surrounding traffic situation, both in the air and on the airport surface, and thus improving the flight crew's decision process for the safe and efficient management of their flight. No changes in separation tasks are required for these applications." [PO-ASAS, p.1]

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

Applications - These are the functions for which the ASA system is to be used (§1.3.7).

Approach Spacing for Instrument Approaches (ASIA) - An application, described in Appendix I, in which, when approaching an airport, the flight crew uses the CDTI display to help them control their own-ship distance behind the preceding aircraft.

ASAS application - A set of operational procedures for controllers and flight crews that makes use of the capabilities of ASAS to meet a clearly defined operational goal. [PO-ASAS, p. 1]

Assured Collision Avoidance Distance (ACAD) - The minimum assured vertical and horizontal distances allowed between aircraft geometric centers. If this distance is violated, a collision or dangerously close spacing will occur. These distances are fixed numbers calculated by risk modeling.

Assured Normal Separation Distance (ANSD) - The normal minimum assured vertical and horizontal distances allowed between aircraft geometric centers. These distances are entered by the pilot or set by the system. Initially the ANSD will be based on current separation standards (and will be larger than the ACAD). In the long term, collision risk modeling will set the ANSD. Ultimately the ANSD may be reduced toward the value of the ACAD.

Automatic Dependent Surveillance-Broadcast (ADS-B) - ADS-B is 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.

Availability - Availability is 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.

Background Application - An application that applies to all surveilled 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: Enhanced Visual Acquisition (EVAcq), Conflict Detection (CD), Airborne Conflict Management (ACM), Airport Surface Situational Awareness (ASSA), and Final Approach and Runway Occupancy Awareness (FAROA).

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 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.

Collision Avoidance Zone (CAZ) - Zone used by the system to predict a collision or dangerously close spacing. The CAZ is defined by the sum of Assured Collision Avoidance Distance (ACAD) and position uncertainties.

Collision Avoidance Zone (CAZ) Alert - An alert that notifies aircraft crew that a CAZ penetration will occur if immediate action is not taken. Aggressive avoidance action is essential.

Conflict - A predicted violation of parameterized minimum separation criteria for adverse weather, aircraft traffic, special use airspace, other airspace, turbulence, noise sensitive areas, terrain and obstacles, etc. There can be different levels or types of conflict based on how the parameters are defined. Criteria can be either geometry based or time-based. This document only addresses aircraft traffic. See *Traffic Conflict*.

Conflict Detection - The discovery of a conflict as a result of a computation and comparison of the predicted flight paths of two or more aircraft for the purpose of determining conflicts (ICAO).

Conflict Detection Zone (CDZ) Alert - An alert issued at the specified look ahead time prior to CDZ penetration if timely action is not taken. Timely avoidance action is required.

Conflict Detection Zone (CDZ) Penetration Notification - Notification to the crew when the measured separation is less than the specified CDZ.

Conflict Detection Zone (CDZ) - Zone used by the system to detect conflicts. The CDZ is defined by the sum of ANSD, position uncertainties, and trajectory uncertainties. By attempting to maintain a measured separation no smaller than the CDZ, the system assures that the actual separation is no smaller than the ANSD.

Conflict Prevention - The act of informing the flight crew of flight path changes that will create conflicts.

Conflict Resolution - A maneuver that removes all predicted conflicts over a specified "look-ahead" horizon. (ICAO - The determination of alternative flight paths, which would be free from conflicts and the selection of one of these flight paths for use.)

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 sense by the angle between the corresponding curves on the other surface.

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

Coupled Application - Coupled applications are those applications that operate 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, Approach Spacing for Instrument Approaches, and Independent Closely Spaced Parallel Approaches.

Coupled Target - A coupled target is a target upon which a coupled application is to be conducted.

Covariance - A two dimensional symmetric matrix representing the uncertainty in a track's state. The diagonal entries represent the variance of each state; the off-diagonal terms represent the covariances of the track state.

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

Data Tag - A block of information about a target that is displayed next to symbol representing that target in the main part of the CDTI display.

Desirable - The capability denoted as *Desirable* is not required to perform the procedure but would increase the utility of the operation.

Display Range - The maximum distance from own-ship that is represented on the *CDTI* display (§3.3.3.1.1.1). 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.

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 four domains: surface, terminal, en route, and 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 IFR separation standards are normally 3 miles horizontally and 1000 feet vertically.

Enhanced Visual Acquisition (EVAcq) - The enhanced visual acquisition application is an enhancement for the out-the-window visual acquisition of aircraft traffic and potentially ground vehicles, (§C.1.1.2 of Appendix C). Pilots will use a *CDTI* to supplement and enhance out-the-window visual acquisition. Pilots will continue to visually scan out of the window while including the *CDTI* in their instrument scan, (§C.1.2.1 of Appendix C),***Note:*** *An extended display range capability of at least 90 NM from own-ship is desirable for the ACM application*

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

Explicit Coordination - Explicit coordination of resolutions requires that the aircraft involved in a conflict communicate their intentions to each other and (in some strategies) authorize/confirm each other's maneuvers. One example of an explicit coordination technique would be the assignment of a 'master' aircraft, which determines resolutions for other aircraft involved in the conflict. Another is the crosslink used in *ACAS*.

Extended Display Range - Extended display range is the capability of the CDTI to depict traffic at ranges beyond the standard display range maximum of 40 NM.

Note: *An extended display range capability of at least 90 NM from own-ship is desirable for the ACM application. (§3.3.3.1.1.3)*

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

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

Field of View - The *field of view* of a *CDTI* is the geographical region within which the *CDTI* shows *traffic targets*. (Some other documents call this the field of regard.)

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

Generic Conflict - A violation of parameterized minimum separation criteria for adverse weather, aircraft traffic, special use airspace, other airspace, turbulence, noise sensitive areas, terrain and obstacles, etc. There can be different levels or types of conflict based on how the parameters are defined. Criteria can be either geometry based or time-based.

GNSS Sensor Integrity Risk - The probability of an undetected failure that results in NSE (navigation system error) that significantly jeopardizes the total system error (TSE) exceeding the containment limit. [DO-247, §5.2.2.1]

Ground Speed - The magnitude of the horizontal velocity vector (see *velocity*). In these MASPS 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.

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

Hazard Classification - An index into the following table:

Hazard Class	Acceptable failure rate
1 "Catastrophic" consequences	10^{-9} per flight hour
2 "Hazardous/Severe Major" consequences	10^{-7} per flight hour
3 "Major" consequences	10^{-5} per flight hour
4 "Minor" consequences	10^{-3} per flight hour
5 Inconsequential no effect	

Horizontal Velocity - The horizontal component of velocity relative to a ground reference (see *Velocity)*.

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

Implicit Coordination - Implicitly coordinated resolutions are assured not to conflict with each other because the responses of each pilot are restricted by common rules. A terrestrial example of an implicit coordination rule is "yield to the vehicle on of conflict based on how the parameters are defined." Criteria can be either geometry based or time-based.

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*.)

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

Latency - Latency is the time incurred between two particular interfaces. Total latency is the delay between the true time of applicability 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 (see column C of Table 2-4).

Low Level Alert - An optional alert issued when CDZ penetration is predicted outside of the CDZ alert boundary.

Mixed Equipage - An environment where all aircraft do not have the same set of avionics. 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.

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.

Navigation Accuracy Category Position (NACP) - 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.

Navigation Accuracy Category Velocity (NACV) - 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.

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.

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. [RTCA DO-247, §5.2.2.3]

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. [RTCA DO-247, §5.2.2.2]

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. [RTCA DO-247, §5.2.2.2]

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.

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.

Persistent Error - A persistent error is an error that occurs regularly. 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.

Positional Uncertainty - Positional uncertainty is 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. However, use of GPS as the position fixing system for ADS-B cannot be assured, and positional accuracy variations must be take into account in the calculation of CDZ and CAZ. When aircraft are in close proximity and are using the same position-fixing system, they may be experiencing similar degrees of uncertainty. In such a case, accuracy of relative positioning between the two aircraft may be considerably better than the absolute positional accuracy of either. If, in the future, the accuracy of relative positioning can be assured to the required level, it may be possible to take credit for the phenomenon in calculation of separation minima. For example, vertical separation uses this principle by using a common barometric altitude datum that is highly accurate only in relative terms.

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.

Proximity Alert - An alert to the flight crew that something is within pre-determined proximity limits (e.g., relative range, or relative altitude difference) of own vehicle.

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

Regime - Divisions in the future airspace structure in contrast to the current concept of domains. Based on the European concept, the three regimes are:

1. **Managed Airspace (MAS)**
    - Known traffic environment
    - Route network 2D/3D and free routing
    - Separation responsibility on the ground, but may be delegated to the pilots in defined circumstances
2. **Free Flight Airspace (FFAS)** – FFAS is also known as Autonomous Airspace.
    - Known traffic environment
3. **Autonomous operations Separation responsibility in the air Unmanaged Airspace (UMAS**)
    - Unknown traffic environment
    - See [Rules of the air] See section H.1.1.3.

Registration - The process of aligning measurements from different sensors by removing systematic biases.

Required - The capability denoted as Required is necessary to perform the desired application.

Safe Flight 21 - The Safe Flight 21 Program is a joint government/industry initiative designed to demonstrate and validate, in a real-world environment, the capabilities of advanced surveillance systems and air traffic procedures. The program is demonstrating nine operational enhancements selected by RTCA, and providing the FAA and industry with valuable information needed to make decisions about implementing applications that have potential for significant safety, efficiency, and capacity benefits.

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*.

Selected Target - A selected target is a target for which additional information is requested by the flight crew.

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* (PSR) 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* (SSR) 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.

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

Separation Violation - Violation of appropriate separation requirements.

Source Track - A track that is composed of measurements and state information that are derived from a single surveillance source.

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

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. (§3.3.1.2)

Surveillance Integrity Level (SIL) - The Surveillance Integrity Level (SIL) defines the probability of the integrity containment region that is indicated by the NIC parameter being exceeded, without alerting, including the effects of the airborne equipment condition.

State (vector) - An aircraft's current horizontal position, vertical position, horizontal velocity, vertical velocity, turn indication, and navigational accuracy and integrity.

Target Selection - Manual process of flight crew selecting a target.

Target - Traffic of particular interest to the flight crew.

TCAS Potential Threat - A traffic target, detected by TCAS equipment on board the own-ship, that has passed the Potential Threat classification criteria for a TCAS TA (traffic advisory) and does not meet the Threat Classification criteria for a TCAS RA (resolution advisory). ([DO-185A, §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, possibly via the ASSAP function.)

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

TCAS-Only Target - A traffic target about which TCAS has provided surveillance information, but which the ASSAP function has not correlated with targets from other surveillance sources (such as ADS-B, TIS, or TIS-B).

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

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 target.

Track Angle - See *ground track angle*.

Track State - The basic kinematic variables that define the state of the aircraft or vehicle of a track, e.g., position, velocity, acceleration.

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

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

Traffic Information Service – Broadcast - 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.

Traffic Symbol - A depiction on the CDTI display of an aircraft or vehicle other than the *own-ship* (§3.3.3.1.2.2).

Traffic Target - This is an aircraft or vehicle under surveillance. In the context of the ASA subsystems at a receiving ASA participant, traffic targets are aircraft or vehicles about which information is being provided (by ADS-B, TIS-B, TCAS, etc.) to the ASSAP

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.

Trajectory Uncertainty - Trajectory uncertainty is a measure of predictability of the future trajectory of each aircraft. There are a number of factors involved in trajectory predictability. These include knowledge of a valid future trajectory, capability of the aircraft to adhere to that trajectory, system availability (e.g., ability to maintain its intended trajectory with a system failure in a non redundant system versus a triple redundant system), and others.

User-Preferred Trajectories (UPT) - A series of one or more waypoints that the crew has determined to best satisfy their requirements.

Velocity - The rate of change of position. Horizontal velocity is the horizontal component of velocity and vertical velocity is the vertical component of velocity. In these MASPS, velocity is always expressed relative to a frame of reference, such as the WGS-84 ellipsoid

Vref - The reference landing air speed for an aircraft. It is weight dependent. Flight crews may vary their actual landing speed based on winds, etc.

2 Equipment Performance Requirements and Test Procedures

2.1 General Requirements

General equipment requirements need not be tested in the test procedure subsection. If a requirement needs to be tested, it is not a general requirement and should be included in section 2.2**.**

2.1.1 Airworthiness

In the design and manufacture of the equipment, the manufacturer **shall** (R2.1) provide for installation so as not to impair the airworthiness of the aircraft.

2.1.2 Intended Function

The equipment **shall** (R2.2) perform its intended function(s), as defined by the manufacturer, and its proper use **shall** (R2.3) not create a hazard to other users of the National Airspace System.

2.1.3 Federal Communications Commission Rules

All equipment **shall** (R2.4) comply with the applicable rules of the Federal Communication Commission.

2.1.4 Fire Protection

All materials used **shall** (R2.5) be self-extinguishing except for small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire.

Note: *One means of showing compliance is contained in Federal Aviation Regulations (FAR), Part 25, Appendix F.*

2.1.5 Operation of Controls

The equipment **shall** (R2.6) be designed so that controls intended for use during flight cannot be operated in any position, combination or sequence that would result in a condition detrimental to the reliability of the equipment or operation of the aircraft.

2.1.6 Accessibility of Controls

Controls that do not require adjustment during flight **shall** (R2.7) not be readily accessible to flight personnel.

2.1.7 Effects of Test

The equipment **shall** (R2.8) be designed so that the application of specified test procedures shall not be detrimental to equipment performance following the application of the tests, except as specifically allowed.

2.1.8 Design Assurance

Reference back to the ASA MASPS for design assurance requirements. This paragraph will discuss the appropriate design assurance level(s) that would be expected as a result of the function definitions and failure categorization(s) contained in Section 1 of the document. This should be based upon the criteria of AC 23.1309 and 25.1309-1b. This paragraph should address both misleading information and the loss of the function. MOPS should point to the latest revision of the RTCA ~~Document No.~~ DO-178() and DO-254() document as a method of establishing the appropriate software levels. A specific software level should not be established in the MOPS since the definitions of the levels could change in RTCA ~~Document~~ DO-178() and DO-254 after the MOPS is issued. The MOPS under development should also point to any hardware or system design assurance standards that are in effect at the time or writing (i.e., SAE ARP-4754).

The hardware and software **shall** (R2.9) be designed and developed such that the probability of providing misleading information (MI) and the probability of loss of function at interface F1 in Figure 1-1 are acceptable based on the overall allocated system integrity and continuity requirements, respectively ~~(see RTCA DO-289[])~~. 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.

My guess is this could be generalized for both ASSAP and CDTI. Need to check with them.

2.2 Airborne Surveillance and Separation Assurance Processing (ASSAP) Subsystem Requirements

2.2.1 Introduction

Larry B. and Randy S on the hook

2.2.2Requirements

2.2.2.12.2.2 ASSAP Input/Output Requirements

Tom Eich

2.2.2.22.2.3 Surveillance Processing

Surveillance processing includes the functions source-level track generation and maintenance, inter-source correlation, and best source selection. The purpose of source-level track generation and maintenance is to establish tracks from ADS-B/ADS-R and TIS-B sources separately and thereafter maintain the tracks. The purpose of inter-source correlation is to perform correlation between source-level tracks (ADS-B/ADS-R tracks and TIS-B tracks) to detect when an A/V is tracked by multiple sources; to perform correlation between ownship track and TIS-B track to remove "shadows" on ownship; and to perform correlation between TCAS reports and current source-level tracks and tag the source-level tracks with the correlation status. The purpose of best source selection is to select the best track when source-level tracks from ADS-B/ADS-R and TIS-B sources correlate.

AThe functional architecture for surveillance processing is illustrated in Figure 2-1: Example Surveillance Processing ArchitectureFigure 2-1: Surveillance Processing Architecture, which shows the relationships among these functions, as well as their relationships to the upstream function, surveillance (not part of ASSAP) and the downstream function, application processing.

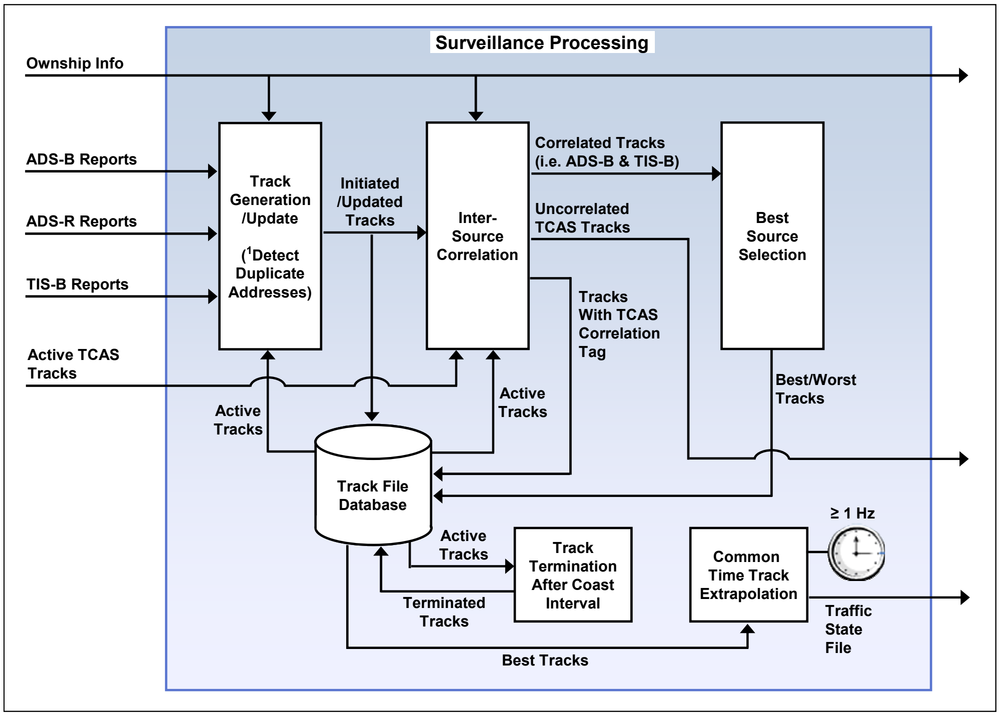

Figure 2-1: Example Surveillance Processing Architecture

The rationale for this architecture is the need to provide tracks from the best source (if more than one) to application processing, while avoiding the complexity of a fusion tracker as a minimum requirement. However, these requirements do not preclude the use of sensor fusion techniques. The rarity of simultaneous reporting of an A/V by both TIS-B and ADS-B services does not ~~warrant~~necessitate requiring the complexity of "fusion" tracking. The rare case in which both services report on the same A/V must be detected by ASSAP to mitigate sending dual tracks to the CDTI for the same A/V.

~~2.2.2.2.1~~2.2.3.1 Source Level Track Generation

Reports from each available source (i.e., ADS-B, ADS-R, and TIS-B) are tracked and maintained separately.

a. ASSAP **shall** attempt to correlate each received report to an existing track~~maintain a report to track association for each report update from each source available~~.

b. A track shall be updated when a report ~~report **shall** be resolved to update a track when the report~~ correlates with the track.

~~*Note: An acceptable method of correlation is the use of a spatial validation region and logic based on report and track addresses as described in Appendix X.*~~

c. A report **shall** ~~be resolved to~~ initiate a new track when the report does not correlate with an existing track.

d. Report to track correlation logic **shall** take into consideration all of the following criteria: address, altitude, velocity, position, and quality.

e. The correlation algorithm **shall** perform at least as well as the example algorithm given in Appendix TBD with respect to distinguishing unique tracks and miscorrelating reports. This intent is met by passing the correlation test scenarios given in section 2.TBD.

f. ASSAP **shall** be capable of maintaining at least 130 source tracks. Priority will determine which tracks are maintained when more than 130 unique reports are presented to ASSAP.

Note: Source tracks do not include TCAS tracks.

2.2.3.1.1 Track Estimation

a. Track estimates **shall** be generated at a rate of 1 Hz or greater.

b. Track estimates **shall** include target horizontal position, altitude, and horizontal position accuracy indicators estimated to a common time of applicability for all tracks.

Note: An acceptable method for generating these estimates is the degenerate Kalman Filter described in Appendix X.

b. ASSAP shall have a track initiation delay that is less than or equal to [2] updates from the source.

ASSAP shall be capable of maintaining at least 200 tracks.

b. ASSAP shall correctly identify two targets/tracks as separate when they are reporting the same address when the second track initiates at least [6] NM apart from the first.

Notes:

2. This could occur between ADS-B targets due to unconfigured or mis-configured avionics. Since address uniqueness cannot always be assured, ASSAP should not place total reliance on the reported address for maintaining tracks.

2. This requirement is tested with the stimulus described in Appendix ??

b. ASSAP shall identify multiple TIS-B report streams on the same detected target as a single track with [X%] confidence.

Notes:

2.This is necessary to handle service volume boundary cases where the same target is independently detected and tracked by 2 separate radars/trackers.

2.This requirement is tested with the stimulus specified in Appendix ??

2.2.2.2.22.2.3.2 Inter-source Correlation

The purpose of iInter-source Ccorrelation is to ensure that the samea single target detected onfrom different surveillance sources isare properly identified as such to prevent the display of spurious targets on the CDTI. -See Appendix ?? TBD for one acceptable method of performing track inter-source correlation.

2.2.2.2.2.12.2.3.2.1 Correlate Source ADS-B, ADS-R, and TIS-BLevel Tracks

When the same target is detected by more than one source, ASSAP shall correlate these source tracks in every case.The inter-source correlation algorithm shall perform at least as well as the example algorithm given in Appendix TBD with respect to distinguishing unique tracks and miscorrelating tracks between ADS-B, ADS-R, and TIS-B sources. This intent is met by passing the correlation test scenarios given in section 2.TBD.

b. There shall be no false correlation among source tracks.

Note: These requirements are tested using the scripted scenario specified in Appendix ??

2.2.2.2.2.22.2.3.2.2 Correlate TIS-B with Ownship

The inter-source correlation algorithm shall perform at least as well as the example algorithm given in Appendix TBD with respect to correlating a TIS-B shadow with ownship. This intent is met by passing the correlation test scenarios given in section 2.TBD.

b. ASSAP shall correlate TIS-B tracks reported on the ownship in every case.

b. There shall be no false correlations between TIS-B tracks and ownship.

Note: These requirements are tested using the scripted scenario specified in Appendix ??

Note: TIS-B tracks correlated with Ownship are suppressed for display.

2.2.2.2.2.32.2.3.2.3 Correlate TCAS with ADS-B, ADS-R, and TIS-B Source Level Tracks

a.The inter-source correlation algorithm shall perform at least as well as the example algorithm given in Appendix TBD with respect to distinguishing unique tracks and miscorrelating tracks between TCAS and ADS-B, ADS-R, or TIS-B sources. This intent is met by passing the correlation test scenarios given in section 2.TBD.ASSAP **shall** correlate TCAS tracks with ASSAP source level tracks on the same target with [99%] confidence against Mode S equipped targets and [95%] against ATCRBS equipped targets.

b.The rate of false TCAS/Source track correlation **shall** be less than [1%] against Mode S equipped targets and less than [2%] against ATCRBS-equipped targets

Note: These requirements are tested using the scripted scenario specified in Appendix ??

Note: Source tracks that correlate with TCAS are indicated as such to CDTI

2.2.2.2.32.2.3.3 Best Source Selection

Best Source Selection identifies the best source for display when multiple source tracks and/or TCAS tracks are determined by ASSAP to correlate.

				Track Outcome
				No Track

				~~**Track Outcome**~~
				~~TIS-B~~
				~~ADS-R~~
				~~Choose ADS-R assuming it is higher quality than TIS-B.~~
				~~ADS-B~~
				~~Choose ADS-B assuming it is higher quality than TIS-B.~~
				~~Choose the track with higher quality. Very low probability.~~
				~~Choose ADS-B assuming it is higher quality.~~
				~~TCAS Track~~
				~~TCAS Track ??~~
				~~Most likely ADS-R, depends on quality.~~
				~~Choose ADS-R assuming it is higher quality.~~
				~~Choose ADS-B assuming it is higher quality than TCAS.~~
				~~Choose ADS-B assuming it is higher quality.~~
				~~Choose ADS-B assuming it is higher quality.~~
				~~Choose ADS-B assuming it is higher quality.~~

When multiple source tracks correlate, the best quality source track **shall** be chosen using the following criteria in priority order:

1. Source with the greatest reported SIL
2. Source with the greatest reported NIC
3. Source with the greatest extrapolated NACp
4. Source with the greatest extrapolated NACv

TCAS reports do not contain any of these criteria. When a TCAS track correlates with an existing track it **shall** only be chosen as the best track when all other source position accuracies drop below the minimum threshold for performing the Enhanced Visual Acquisition application. This establishes a minimum requirement for source selection and is not intended to prohibit source fusionTable 2-1. [Strawman] Likely Outcome of Source Selection for Available Surveillance Sources

2.2.2.2.3.1Case 1. Correlation among 2 or more source tracks, No TCAS

ASSAP **shall** determine selection based on best NIC followed by best NACp value.

2.2.2.2.3.2Case 2. Correlation among 2 or more source tracks and TCAS (no RA)

ASSAP **shall** determine selection based on best NIC followed by best NACp value.

2.2.2.2.3.3Case 3 Correlation among 2 or more source tracks and TCAS (with RA)

ASSAP shall select TCAS track [is this right?] techniques.

2.2.2.2.42.2.3.4 Track Termination

a.ASSAP **shall** terminate a track when the maximum coast interval has been exceeded for all of the applications for which the track is potentially being used. The coast interval is the elapsed time since a report from any source has been correlated with the track.

If a terminated track corresponds to a target with multiple surveillance sources, ASSAP **shall** make the next best source available to the application processor.

2.2.1.3.0Track Estimation

b. Track estimates **shall** be generated at a rate of 1 Hz or greater.

b. Track estimates **shall** include both target state and quality indicators estimated to a common time for all tracks.

Note: An acceptable method for generating these estimates is the degenerate Kalman Filter described in Appendix X.

2.2.2.32.2.4 Application Processing

2.2.2.3.12.2.4.1 General Requirements

Tom Eich is on the hook

Own ship position data should be delivered to ASSAP such that the uncompensated latency is less than 200 ms. GPS sensors compliant with ARINC 743A-4 and RNP FMS compliant with ARINC 702A Supplement 3 are examples of acceptable position sources.

The ASSA/FAROA requirements for airborne targets are consistent with the EVAcq requirements for airborne targets. The only difference is that ASSA/FAROA requires ADS-B reports have a valid altitude to be displayed. Without that, the presentation could depict an aircraft flying over the airfield at altitude. This is a nuisance at best, and potentially false and misleading information. Regarding the accuracy requirements, targets with NACp less than 8 have the potential to be depicted on a movement area they are not on. This is considered unacceptable.

~~2.2.2.3.2~~2.2.4.2 Application-Specific Requirements

~~2.2.2.3.2.1~~2.2.4.2.1 Enhanced Visual Acquisition (EVAcq)

ASSAP's contribution to this application includes the tracking and target correlation requirements that are applicable to all applications. ASSAP also determines whether own aircraft information and target vehicle information is good enough to perform EVAcq. The delivery of target information to the CDTI interface is the final step of ASSAP's EVACq responsibility.

~~2.2.2.3.2.1.1~~2.2.4.2.1.1 Own Aircraft Requirements for EVAcq

ASSAP may perform the Enhanced Visual Acquisition application when own aircraft horizontal position is valid. When own aircraft horizontal position is invalid, ASSAP **shall** (R2.xxx) signal that EVAcq is inoperative via the CDTI interface. When own aircraft horizontal position accuracy is greater than 1.0 Nm (1852m), ASSAP **shall** (R2.xxx) signal that EVAcq is inoperative via the CDTI interface.

ASSAP may perform the Enhanced Visual Acquisition application when own aircraft pressure altitude is invalid. However, without ownship altitude, the relative altitude tags on the targets will have to be removed from the display. This is considered a degraded mode. No ASSAP system should be designed or installed without a pressure altitude source.

~~**The following paragraph should be moved to the general requirements section.~~

~~Own ship position data should be delivered to ASSAP such that the uncompensated latency is less than 200 ms. GPS sensors compliant with ARINC 743A-4 and RNP FMS compliant with ARINC 702A Supplement 3 are examples of acceptable position sources.~~

~~2.2.2.3.2.1.2~~2.2.4.2.1.2 Target Vehicle Requirements for EVAcq

All versions of existing ADS-B links are eligible to be EVAcq targets (e.g. DO-260 Version 0).

An EVAcq target **shall** (R2.xxx) be derived from a target track with valid horizontal position. A target track with NACp less than 4 or NUC less than 3 **shall** (R2.xxx) be dropped from the CDTI interface.

If an EVAcq track is not updated within 24.2 seconds, ASSAP **shall** (R2.xxx) drop the target from the CDTI interface. This is a maximum allowed ~~timeout~~ coast interval based on a TIS-B update. A manufacturer is encouraged to use shorter ~~timeouts~~ coast intervals for ADS-B and ADS-R targets.

The integrity requirement of this application was determined to be 10^{-2}. This is the same order of magnitude as the accuracy parameter. As a result, the community decided that the accuracy parameter was sufficient to determine state data quality for this application.

~~2.2.2.3.2.2~~2.2.4.2.2 Airport Surface Situational Awareness/Final Approach and Runway Occupancy Awareness (ASSA/FAROA)

ASSAP's contribution to this application includes the tracking and target correlation requirements that are applicable to all applications. ASSAP also determines whether own aircraft information and target vehicle information is good enough to perform ASSA/FAROA. The delivery of target information to the CDTI interface is the final step of ASSAP's ASSA/FAROA responsibility.

2.2.2.3.2.2.12.2.4.2.2.1 Own Aircraft Requirements for ASSA/FAROA

Note: revisit altitude source issues after geo altitude action is resoved

ASSAP may perform the ASSA/FAROA application when own aircraft horizontal position and vertical position is valid and of sufficient quality. Vertical position is satisfied by Height Above the Ellipsoid (HAE) or pressure altitude when airborne. Vertical position is satisfied by definition when on the ground. When own aircraft horizontal or vertical position is invalid, ASSAP **shall** (R2.xxx) signal that ASSA/FAROA is inoperative via the CDTI interface. When own aircraft SIL is zero or Radius of Containment is greater than 0.1 Nm (185.2 m) or accuracy is greater than 0.04TBD Nm (TBD 74 m) (pending Sheila's action item to check on Boeing/Jeppeson Database error), ASSAP **shall** (R2.xxx) signal that ASSA/FAROA is inoperative via the CDTI interface.

2.2.2.3.2.2.22.2.4.2.2.2 Target Vehicle Requirements for ASSA/FAROA

All versions of existing ADS-B links are eligible to be ASSA/FAROA targets (e.g. DO-260 Version 0).

An ASSA/FAROA target **shall** (R2.xxx) be derived from a target track with valid horizontal and vertical position. Vertical position is satisfied by Height Above the Ellipsoid (HAE) or pressure altitude when airborne. Vertical position is satisfied by definition when on the ground.

A DO-260A and DO-282A Version 1 surface target track **shall** (R2.xxx) have a NACp of 8 or greater, a NIC of 8 or greater, and a SIL of 1 or greater to be marked a valid ASSA/FAROA target.

A DO-260 and DO-282 Version 0 surface target track **shall** (R2.xxx) have a NUC of 7 or greater to be marked a valid ASSA/FAROA target.

An ASSA/FAROA target **shall** (R2.xxx) be derived from a target track with valid horizontal position. An airborne target track with NACp less than 4 or NUC less than 3 **shall** (R2.xxx) be dropped from the CDTI interface.

** work the language so both requirements are stated consistently i.e dropped or displayed

** This paragraph needs revised and move to the general requirements section.

It is the intent of these requirements to be compatible with the EVAcq requirements for airborne targets. The only difference is that ASSA/FAROA requires ADS-B reports have a valid altitude to be displayed. Without that, the presentation could depict an aircraft flying over the airfield at altitude. This is a nuisance at best, and potentially false and misleading information. Regarding the accuracy requirements, targets with NACp less than 8 have the potential to be depicted on a movement area they are not on. This is considered unacceptable.

If an ASSA/FAROA target in motion is not updated within 11 seconds (**11 seconds is twice the terminal radar sweep rate), ASSAP **shall** (R2.xxx) mark the target invalid for ASSA/FAROA on the CDTI interface. This ~~timeout~~ coasting interval is based on the TIS-B update rate. A manufacturer is encouraged to use shorter coasting interval~~timeout~~s for ADS-B and ADS-R targets. In motion is defined as moving more than 10 meters in 30 seconds. If an ASSA/FAROA target stopped is not updated within 15 seconds (**15 seconds is 3 times the low squitter rate), ASSAP **shall** (R2.xxx) mark the target invalid for ASSA/FAROA on the CDTI interface.

~~2.2.2.3.2.3~~2.2.4.2.2.3 Conflict Detection (CD)

The objective of Conflict Detection (CD) is to enhance the flight crew's awareness of participating proximate traffic by providing alerts when aircraft separation is predicted to become compromised. The alerts may prompt the flight crew to exercise "see and avoid" procedures~~, or contact ATC for instructions~~. Avoidance maneuvers are not ~~suggested~~ provided by the application, and the flight crew must not maneuver based solely on the CDTI information. The CD application is a subset of the Airborne Conflict Management (ACM) application.

ASSAP's contribution to this application includes the tracking and target correlation requirements that are applicable to all applications. ASSAP determines whether the quality of own aircraft information and target vehicle information is sufficient to perform CD.

If the installed system has the option for conflict detection (CD), ASSAP **shall** (R3.199) determine if each track is eligible for CD processing. Each track that is eligible for CD **shall** (R3.200) be processed by the CD alerting function. ~~, and~~ CAZ alerts and~~or~~ CDZ alerts **shall** (R3.201) be issued as appropriate. ASSAP **shall** (R3.202) include in the ASSAP track report the status of the CAZ alert and the CDZ alert.

The CD algorithm **shall** perform at least as well as the example algorithm given in Appendix TBD with respect to time to alert and false alarm rate. This intent is met by passing the conflict detection test scenarios given in section 2.TBD.

~~2.2.2.3.2.3.1~~2.2.4.2.2.3.1 Own Aircraft Requirements for CD

ASSAP may perform the Conflict Detection application when own aircraft horizontal and vertical positions are valid and of sufficient quality. Vertical position is satisfied by Height Above the Ellipsoid (HAE) or pressure altitude. When own aircraft horizontal or vertical position is invalid, ASSAP **shall** (R2.xxx) signal that CD is inoperative via the CDTI interface. When own aircraft horizontal position uncertainty is greater than 0.5 NM, ASSAP **shall** (R2.xxx) signal that CD is inoperative via the CDTI interface. When HAE is used for vertical position and own aircraft vertical position uncertainty is greater than 45 m, ASSAP **shall** (R2.xxx) signal that CD is inoperative via the CDTI interface.

ASSAP may perform the CD application when own aircraft horizontal velocity is of sufficient quality. When own aircraft horizontal velocity uncertainty is greater than 3 m/s, ASSAP **shall** (R2.xxx) signal that CD is inoperative via the CDTI interface.

When own aircraft Integrity Containment Risk is greater than 10^{-2}/hr or Radius of Containment is greater than 1 NM, ASSAP **shall** (R2.xxx) signal that CD is inoperative via the CDTI interface.

~~2.2.2.3.2.3.2~~2.2.4.2.2.3.2 Target Vehicle Requirements for CD

TBD versions of existing ADS-B links are eligible to be CD targets (e.g. DO-260 Version 0).

A CD target **shall** (R2.xxx) be derived from a target track with valid horizontal and vertical position. Vertical position is satisfied by Height Above the Ellipsoid (HAE) or pressure altitude. When pressure altitude is used for vertical position, a target track **shall** (R2.xxx) have a NACp of 5 or greater to be marked as a valid CD target. When HAE is used for vertical position, a target track **shall** (R2.xxx) have a NACp of 9 or greater to be marked as a valid CD target.

A target track **shall** (R2.xxx) have a NACv of 2 or greater to be marked as a valid CD target.

A target track **shall** (R2.xxx) have a SIL of 0 (10^{-2}/hr) or greater and a NIC of 5 or greater to be marked as a valid CD target.

If a CD target is not updated within 30 seconds, ASSAP **shall** (R2.xxx) mark the target as invalid for the Conflict Detection application.

~~2.2.2.3.2.4~~2.2.4.2.2.4 Enhanced Visual Approach (EVApp)

The Enhanced Visual Approach (EVApp) application is an extension of the current visual approach procedure. In this application, the CDTI is used by the flight crew to detect and track the preceding aircraft more effectively, thereby preventing numerous traffic call outs by ATC, allowing for the closure of large gaps between traffic, and reducing the number of go-arounds.

ASSAP's contribution to this application includes the tracking and target correlation requirements that are applicable to all applications. ASSAP determines whether the quality of own aircraft information and target vehicle information is sufficient to perform EVApp. If information quality requirements for EVApp are satisfied, ASSAP calculates range and closure rate between own aircraft and a target selected on the CDTI. The delivery of a target data block to the CDTI interface is the final step of ASSAP's EVApp responsibility. The data block contains the ID (call sign/flight ID), ground speed, range, and closure rate of the selected target.

~~2.2.2.3.2.4.1~~2.2.4.2.2.4.1 Own Aircraft Requirements for EVApp

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 Height Above the Ellipsoid (HAE) or pressure altitude. When own aircraft horizontal or vertical position is invalid, ASSAP **shall** (R2.xxx) signal that EVApp is inoperative via the CDTI interface. When own aircraft horizontal position uncertainty is greater than 0.1 NM (185.2 m), ASSAP **shall** (R2.xxx) signal that EVApp is inoperative via the CDTI interface. When HAE is used for vertical position and own aircraft vertical position uncertainty is greater than 45 m, ASSAP **shall** (R2.xxx) signal that EVApp is inoperative 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 is greater than 10 m/s, ASSAP **shall** (R2.xxx) signal that EVApp is inoperative via the CDTI interface.

When own aircraft Integrity Containment Risk is greater than 10^{-3}/hr or Radius of Containment is greater than 0.2 NM (370.4 m), ASSAP **shall** (R2.xxx) signal that EVApp is inoperative via the CDTI interface.

~~2.2.2.3.2.4.2~~2.2.4.2.2.4.2 Target Vehicle Requirements for EVApp

TBD versions of existing ADS-B links are eligible to be EVAPP targets (e.g. DO-260 Version 0).

An EVApp target **shall** (R2.xxx) be derived from a target track with valid horizontal and vertical position. Vertical position is satisfied by Height Above the Ellipsoid (HAE) or pressure altitude. When pressure altitude is used for vertical position, a target track **shall** (R2.xxx) have a NACp of 7 or greater to be marked as a valid EVApp target. When HAE is used for vertical position, a target track **shall** (R2.xxx) have a NACp of 9 or greater to be marked as a valid EVApp target.

A target track **shall** (R2.xxx) have a NACv of 1 or greater to be marked as a valid EVApp target.

A target track **shall** (R2.xxx) have a SIL of 1 or greater and a NIC of 7 or greater to be marked as a valid EVApp target.

If an EVApp target is not updated within 15 seconds, ASSAP **shall** (R2.xxx) mark the target as invalid for the Enhanced Visual Approach application.

~~2.2.2.4~~2.2.4.3 Monitoring

~~2.2.2.4.1~~2.2.4.3.1 General Requirements

~~2.2.2.4.1.1~~2.2.4.3.1.1 Self Test

The Monitor shall include a self-test function, capable of being initiated by the pilot. As a minimum, self-test shall test all audible and visual annunciators and activate each display element in a pre-determined temporal pattern to allow visual verification that display outputs issued by the digital processor can be correctly interpreted by the pilot. The self-test function shall not interfere with the normal operation of the equipment.

Note: Flight-crew-initiated operation of display indications for test purposes is not considered interference with normal equipment operation.

~~2.2.2.4.1.2~~2.2.4.3.1.2 Non Interference

The Monitor shall not interfere with the normal operation of ASA. Any RF test signals used by the Monitor shall be restricted by the compatibility requirements [TCAS and ADS-B MOPS?]

~~2.2.2.4.2~~2.2.4.3.2 Monitoring of ASAS Computer Resources

ASAS shall include provision for monitoring its computer resources. As a minimum this monitoring shall include random access memory (RAM) pattern tests, central processing unit (CPU) instruction tests, program memory tests, CPU input/output functions tests, and CPU timing tests. The Monitor shall be capable of detecting a failure in the computer performance monitoring and upon detection shall annunciate a failure. A means of computer performance testing is required to enable ASAS computer performance to be monitored both under normal bench test conditions and under environmental extremes. These computer performance tests may be included in the Monitor or may be a separate test program for use during environmental testing.

~~2.2.2.4.3~~2.2.4.3.3 ASAS Input Data Monitoring

~~2.2.2.4.3.1~~2.2.4.3.3.1 ADS-B Receive Subsystem

ASAS shall monitor the ADS-B report interface from each ADS-B receiver. ASAS shall annunciate a failure on loss of input data from any ADS-B receive subsystem.

Note: this could be accomplished though a periodic heartbeat message that would indicate function in the absence of traffic

~~2.2.2.4.3.2~~2.2.4.3.3.2 TCAS

ASAS shall monitor TCAS output to verify TCAS function. ASAS shall annunciate a failure on loss of data from TCAS

Note: this could be accomplished though a periodic heartbeat message that would indicate function in the absence of traffic

~~2.2.2.4.3.3~~2.2.4.3.3.3 Ownship State Data

ASAS shall monitor the inputs that provide ownship state data. ASAS shall annunciate a failure on loss of any positional or velocity data.

2.3 Cockpit Display of Traffic Information (CDTI) Subsystem Requirements

2.4 Equipment Performance – Environmental Conditions

2.4.1 General Requirements (info was in 2.4)

The environmental tests and performance requirements described in this subsection 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 No. DO-160D, *Environmental Conditions and Test Procedures for Airborne Equipment*. General information on the use of RTCA/DO-160D 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-160D.

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

In addition to the exceptions above, certain environmental tests contained in this subsection are not required for minimum performance equipment unless the manufacturer wishes to qualify the equipment for additional environmental conditions. If the manufacturer wishes to qualify the equipment to these additional conditions, then these tests **shall** be performed.

Use only those tests listed below that are necessary to assure proper operation in the aeronautical environments envisioned by the Committee. Paragraph 1.0 of RTCA/DO-160D provides additional information on this subject.

2.4.2 ASSAP

2.4.3 CDTI (was section 2.5, but listed as 2.4.3 in writing responsibilities)

2.5 ASSAP Equipment Test Procedures (listed as 2.6 in writing responsibilities, but no 2.5 existed).

3 Installed Equipment Performance

This section states the minimum acceptable level of performance for the equipment when installed in the aircraft. For the most part, installed performance requirements are the same as those contained in Section 2, which were verified through bench and environmental test. However, certain requirements may be affected by the physical installation (e.g., antenna patterns, receiver sensitivity, etc.) and can only be verified after installation. The installed performance limits stated below take in consideration these situations.

3.1 Equipment Installation

3.1.1 Accessibility

Controls and monitors provided for in-flight operations shall be readily accessible from the pilot's normal seated position. The appropriate operator/crew member(s) shall have an unobstructed view of displayed data when in the normal seated position.

3.1.2 Aircraft Environment

Equipment shall be compatible with the environmental condition present in the specific location in the aircraft where the equipment is installed.

3.1.3 Display Visibility

Display intensity shall be suitable for data interpretation under all cockpit ambient light conditions ranging from total darkness to reflected sunlight.

Note: *Visors, glare-shields or filters may be an acceptable means of obtaining daylight visibility.*

3.1.4 Dynamic Range

Operation of the equipment shall not be adversely affected by aircraft maneuvering or changes in attitude encountered in normal flight conditions.

3.1.5 Failure Protection

Any probable failure of the equipment shall not degrade the normal operation of equipment or systems connected to it. Likewise, the failure of interfaced equipment or systems shall not degrade normal operation of this equipment.

3.1.6 Interference Effects

The equipment shall not be the source of harmful conducted or radiated interference nor be adversely affected by conducted or radiated interference from other equipment or systems installed in the aircraft.

Note: *Electromagnetic compatibility problems noted after installation of this equipment may result from such factors as the design characteristics of previously installed systems or equipment and the physical installation itself. It is not intended that the equipment manufacturer design for all installation environments. The installing facility will be responsible for resolving any incompatibility between this equipment and previously installed equipment in the aircraft. The various factors contributing to the incompatibility shall be considered.*

3.1.7 Inadvertent Turnoff

Appropriate protection shall be provided to avert the inadvertent turnoff of the equipment.

3.1.8 Aircraft Power Source

State any requirements for connecting the equipment to the aircraft power source(s) to assure the equipment will perform its intended function(s) in the operational environment.

3.1.9 Other Requirements

Continue with other requirements concerning equipment installation items such as antenna, etc.

3.2 Installed Equipment Performance Requirements

The installed equipment shall meet the requirements of Subsections 2.1 and 2.2 in addition to, or as modified by, the requirements stated below.

State the requirements that the equipment must meet when installed in the aircraft. The following guidelines, although not all inclusive, serve to illustrate some of the more important aspects that should be considered:

a. ***Requirements should be strictly limited to those that the Committee considers necessary for all applications and user classes.***

b. ***In general, use one paragraph to express a single requirement.***

c. ***Requirements should be expressed in a manner that does not constrain design innovation.***

d. ***Requirements should not place undue constraints on installation flexibility.***

e. ***Care should be taken to define requirements that may be at variance with those stated in Section 2 because of physical or other installation constraints.***

f. ***State those requirements that the equipment must meet to perform its intended function(s) but can only be verified after installation.***

g. ***Unless a requirement can be verified solely through visual inspection, it should be expressed in measurable terms.***

h. ***Particular care must be taken to assure that the requirement statement is compatible with test procedures to be developed for paragraph 3.4.***

3.3 Conditions of Test

The following subparagraphs define conditions under which tests, specified in paragraph 3.4, shall be conducted.

3.3.1 Safety Precautions

State any personnel and/or equipment safety precautions that should be observed because of any unique characteristics of the equipment or installation.

3.3.2 Power Input

Unless otherwise specified, all aircraft electrically operated equipment and systems shall be turned ON before conducting interference testing.

3.3.3 Environment

During testing, the equipment shall not be subjected to environmental conditions that exceed those specified by the equipment manufacturer.

3.3.4 Adjustment of Equipment

Circuits of the equipment under test shall be properly aligned and otherwise adjusted in accordance with the manufacturer’s recommended practices prior to application of the specified tests.

3.3.5 Warm-up Period

Unless otherwise specified, tests shall be conducted after a warm-up (stabilization) period of not more than fifteen (15) minutes.

3.3.6 Continue with Other Conditions as Necessary

3.4 Test Procedures for Installed Equipment Performance

The following test procedures provide one means of determining installed equipment performance. Although specific test procedures are cited, it is recognized that other methods may be preferred by the installing activity. These alternate procedures may be used if they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures. The equipment shall be tested to determine compliance with the minimum requirements stated in Subsection 2.2. In order to meet this requirement, test results supplied by the equipment manufacturer or other proof of conformity may be accepted in lieu of bench tests performed by the installing activity.

3.4.1 Ground Test Procedures

3.4.1.1 Conformity Inspection

Visually inspect the installed equipment to determine the use of acceptable workmanship and engineering practices. Verify that proper mechanical and electrical connections have been made and that the equipment has been located and installed in accordance with the manufacturer’s recommendations.

3.4.1.2 Equipment Function

Vary all controls of the equipment through their full range to determine that the equipment is operating according to the manufacturer’s instruction and that each control performs its intended function.

3.4.1.3 Interference Effects

With the equipment energized, individually operate each of the other electrically operated aircraft equipment and systems to determine that significant conducted or radiated interference does not exist. Evaluate all reasonable combinations of control settings and operating modes. Operate communication and navigation equipment on the low, high and at least on, but preferably four, mid-band frequencies. Make note of system or modes of operation that should also be evaluated during flight. If appropriate, repeat tests using emergency power with the aircraft’s batteries alone and the inverters operating.

3.4.1.4 Power Supply Fluctuations

Under normal aircraft conditions, cycle the aircraft engine(s) through all normal power settings and verify proper operation of the equipment as specified by the equipment manufacturer.

3.4.1.5 Equipment Accessibility

Determine that all equipment controls and displayed data are readily accessible and easily interpreted.

3.4.1.6 Continue with Other Test Procedures

Continue with other test procedures to verify those installed performance requirements of paragraphs 3.1 and 3.2 that can be demonstrated with the aircraft on the ground.

3.4.2 Flight Test Procedures

3.4.2.1 Displayed Data Readability

Determine that normal conditions of flight do not significantly affect the readability of displayed data.

3.4.2.2 Interference Effects

For aircraft equipment and systems that can be checked only in flight, determine that operationally significant conducted or radiated interference does not exist. Evaluate all reasonable combinations of control settings and operating modes. Operate communications and navigation equipment on the low, high and at least one, but preferable four, mid-band frequencies.

3.4.2.3 Continue with Other Test Procedures

Continue with other test procedures to verify those installed performance requirements of paragraphs 3.1 and 3.2 that can only, or more conveniently, be demonstrated in flight. Certain cases such as navigation performance, airborne coverage, etc., may require that the aircraft fly paths having specific characteristics. These essential characteristics, including typical flight test paths, should be included together with suggested data acquisition and analysis methods.

4 Equipment Operational Performance Characteristics

4.1 Required Operational Performance Requirements

To ensure the operator that operations can be conducted safely and reliably in the expected operational environment, there are specific minimum acceptable performance requirements that shall be met. The following paragraphs identify these requirements.

4.1.1 Power Inputs

Prior to flight, verify that the equipment is receiving primary input power necessary for proper conditions.

4.1.2 Equipment Operating Modes

The equipment shall operate in each of its operating modes.

4.1.3 Continue with Other Operational Requirements as Necessary

4.2 Test Procedures for Operational Performance Requirements

Operation equipment tests may be conducted as part of normal pre-flight tests. For those tests that can only be run in flight, procedures should be developed to perform these tests as early during the flight as possible to verify that the equipment is performing its intended function(s).

4.2.1 Power Input

With the aircraft's electrical power generating system operating, energize the equipment and verify that electrical power is available to the equipment.

4.2.2 Equipment Operating Modes

Verify that the equipment performs its intended function(s) for each of the operating modes available to the operator.

4.2.3 Continue with Other Test Procedures

Continue with other test procedures to verify the requirements of paragraph 4.1.

This Page Was Intentionally Left Blank

Appendix AA
Acronyms and Definitions of Terms

Appendix AB
Bibliography

Appendix B
Conflict Detection (CD)

B Conflict Detection (CD)

B.1 Introduction

The core function of the Conflict Detection (CD) application is the issuing of conflict alerts based on two sets of detection thresholds.

B.2 Operational Performance Assessment

This section describes the purpose, method, and results of the operational performance assessment for the Conflict Detection application.

B.2.1 Purpose

The goals of the CD application are to enhance safety and to enhance airborne traffic awareness. The CD application detects conflicts based on predicted flight paths of aircraft.

For the CD application, there are two sets of alerting criteria: the Collision Avoidance Zone (CAZ) and the Collision Detection Zone (CDZ). An alert is issued by a CD application if the predicted aircraft positions violate either of the two zones. CAZ and CDZ are defined in terms of the following parameters: horizontal size, vertical size. An alert time will be used to determine when the alert should go off. The separation parameters vary with the domain of operations which include GA traffic pattern operations, terminal area operations, and high altitude en route operations.

B.2.2 Method

In this sub-section, we describe the method that we used to establish the requirements. We describe the CD algorithm, the data that we used in simulation, metrics, and the trial-and-error method that we used to establish the requirements. The following items are described:

a. A CD algorithm.

b. Data used to test the algorithms.

c. Metrics used to rate the algorithms.

B.2.2.1 A CD Algorithm

We established the requirements on the parameters for the CD application by using Monte Carlo simulation. A Conflict Detection algorithm was used in the simulation. The algorithm calculates the predicted horizontal and vertical separations of the aircraft pair based on the current reported positions and velocity vectors of the two aircraft. The reported positions and velocity vectors contain error terms caused by underlying navigation systems among other things. NACp and NACv values were used to generate such error terms in Monte Carlo simulation. The error terms were then added to the true positions and true velocity vectors to form the reported positions and velocity vectors.

The CD alerts are based on predicted separation. The predicted separation is compared with the CAZ (or CDZ) alert thresholds. The algorithm issues an alert if it predicts a violation of the horizontal separation threshold and the vertical separation threshold within the alert time.

The CD algorithm uses rigid criteria to determine whether there will be a violation of the CAZ (or CDZ). Even if the predicted separation is very close to (but greater than) the separation thresholds, the CD algorithm determines that there will be no violation of the CAZ (or CDZ).

B.2.2.1.1 CAZ Algorithm

The CAZ algorithm depends upon difference in position and speed between own aircraft and the target vehicle, defined in (1). The subscript “i” in (1) refers to target and the subscript “o” refers to own aircraft.

$$
\begin{aligned}
dx &= x_o - x_i \\
dy &= y_o - y_i \\
d\dot{x} &= \dot{x}_o - \dot{x}_i \\
d\dot{y} &= \dot{y}_o - \dot{y}_i \\
\rho(t) &= [(dx + td\dot{x})^2 + (dy + td\dot{y})^2]^{1/2} \qquad (1)
\end{aligned}
$$

Differentiating (1) with respect to time t, we obtain the time to closest point of approach (CPA):

$$t_{CPA} = -\frac{(dx)(d\dot{x}) + (dy)(d\dot{y})}{(d\dot{x})^2 + (d\dot{y})^2}$$

The horizontal miss distance at t_{CPA} is

$$hmd = \frac{\left|(dx)(d\dot{y}) - (dy)(d\dot{x})\right|}{\sqrt{(d\dot{x})^2 + (d\dot{y})^2}}$$

The height difference at t_{CPA} is

$$dh_{TCPA} = (h_o - h_i) + t_{CPA}(\dot{h}_o - \dot{h}_i) \qquad (2)$$

If (hmd < T_{hmd} and dh_{TCPA} < T_h and t_{CPA} <T_t) then issue CAZ alert, where T_{hmd}, T_h, and T_t are the horizontal, vertical and time alert thresholds, respectively.

B.2.2.1.2 CDZ Algorithm

Let C_h be the horizontal CDZ threshold. Then the horizontal CDZ is violated if $\rho(t) <$ C_h.

That is equivalent to

$$t_{CPA} - \sqrt{\frac{c_h^2 - (hmd)^2}{(d\dot{x})^2 + (d\dot{y})^2}} < t < t_{CPA} + \sqrt{\frac{c_h^2 - (hmd)^2}{(d\dot{x})^2 + (d\dot{y})^2}} \qquad (3)$$

Let $\Delta h(t) = (h_0 - h_i) + t(\dot{h}_0 - \dot{h}_i)$ and let C_v be the vertical CDZ threshold. Then the vertical CDZ is violated if $\Delta h(t) < C_v$.

That is equivalent to

$$t > \frac{C_v - (h_o - h_i)}{\dot{h}_o - \dot{h}_i} \text{ if } h_o - h_i > 0 \text{ or } t < \frac{C_v - (h_o - h_i)}{\dot{h}_o - \dot{h}_i} \text{ if } h_o - h_i < 0 \quad (4)$$

If the time intervals defined in (3) and (4) overlap, then issue a CDZ alert.

B.2.2.2 Data

For terminal and en route operation scenarios, we used real operational data in the form of ARTS data files in Monte Carlo simulation. The ARTS data files were used in operational evaluations of TCAS [1] when TCAS was developed. They were recorded at 11 facilities and contain about 4000 encounters. For terminal and en route operation CAZ simulations, trajectories were offset in the simulation to induce collision in order to ensure sufficient sample sizes. For GA traffic pattern operations, representative GA scenarios developed by RTCA SC 186 WG 1 were used.

For terminal operations, ARTS data for layers 1, 2, and 3 were used in the simulation. For en route operations, ARTS data for layers 4 and 5 are used. Layers 1, 2, 3, 4 and 5 are defined in terms of altitude (see Table B-1).

Layer	Altitude
1	1450 ft AGL – 2350 ft AGL
2	2350 ft AGL – 5000 ft MSL

3	5000 ft MSL – 10000 ft MSL
4	10000 ft MSL – 20000 ft MSL
5	20000 ft MSL – 41000 ft MSL

Table B-1. Definition of Layers

B.2.2.3 Metrics

The following metrics were used to measure the performance of the CD application:

a. Average duration of false alerts per non-violation encounter.

b. Average number of missed detections per violation encounter.

A "non-violation encounter" is an encounter between two aircraft where there is no violation of CAZ (or CDZ). On the other hand, a "violation encounter" is an encounter between two aircraft where there is at least one violation of CAZ (or CDZ).

The duration of false alerts and the number of missed detections are determined as follows. The simulation records two sets of positions of aircraft: the true positions and the reported positions. The true positions of aircraft come directly from the ARTS data files or GA pattern scenario files. The reported positions of aircraft are generated by adding error terms to the true positions. The error terms are caused by navigation errors and so on. If the true positions of the aircraft indicate that there is no penetration of the CAZ (or CDZ) (a non-violation encounter) but the CD algorithm predicts a penetration and issues an alert, then the alert is considered a false alert. The sum of the time span between the start and the end of each false alert in an encounter is the duration of false alert for that encounter. On the other hand, if the true positions of the aircraft indicate there is a penetration of the CAZ (or CDZ) (a violation encounter) and the CD algorithm did not issue an alert before penetration occurs, then there is a missed detection.

Appendix C
Enhanced Visual Approach (EVApp)

C Enhanced Visual Approach (EVApp)

C.1 Introduction

The core function of the Enhanced Visual Approach (EVApp) application is the calculation of range and closure rate between own aircraft and a target selected on the CDTI. This appendix presents an analytical comparison of sample algorithms for the calculation of closure rate.

C.2 Operational Performance Assessment

This section describes the purpose, method, and results of the operational performance assessment for the Enhanced Visual Approach application.

C.2.1 Purpose

The primary goal of the EVApp application is to allow the flight crew to detect and track the preceding aircraft more effectively. The purpose of this operational performance assessment is to identify an algorithm that produces an accurate closure rate with information available to own aircraft.

C.2.2 Method

In this subsection, the following items are described:

a. Two closure rate algorithms.

b. Data used to test the algorithms.

c. Metrics used to rate the algorithms.

C.2.2.1 Closure Rate Algorithms

Closure rate is defined as the change in slant range between own aircraft and a target vehicle with respect to time. ADS-B/TIS-B reports limit potential approaches to a position-based algorithm or position and velocity-based algorithm. The algorithms presented here use the Cartesian East North Up (ENU) coordinate system; WGS-84 positions are converted to ENU.

C.2.2.1.1 Position-Based Algorithm for Closure Rate

The position-based algorithm for closure rate solely depends upon difference in position between own aircraft and the target vehicle, defined in (1). The subscript "t" in (1) refers to target and the subscript "o" refers to own aircraft. Difference in velocity is defined as a function of difference in position and time (2). Closure rate, *cr*, is defined in (3). The negative sign in (3) is due to convention; a positive closure rate represents decreasing range and a negative closure rate represents increasing range.

$$dx = x_t - x_o \quad (1)$$
$$dy = y_t - y_o$$
$$dz = z_t - z_o$$

$$d\dot{x} = \frac{\Delta dx}{\Delta t} = \frac{dx_2 - dx_1}{t_2 - t_1} \quad (2)$$
$$d\dot{y} = \frac{\Delta dy}{\Delta t} = \frac{dy_2 - dy_1}{t_2 - t_1}$$
$$d\dot{z} = \frac{\Delta dz}{\Delta t} = \frac{dz_2 - dz_1}{t_2 - t_1}$$

$$cr = -\frac{dx(d\dot{x}) + dy(d\dot{y}) + dz(d\dot{z})}{\sqrt{dx^2 + dy^2 + dz^2}} \quad (3)$$

C.2.2.1.2 Position and Velocity-Based Algorithm for Closure Rate

The position and velocity-based algorithm for closure rate depends upon difference in position and difference in velocity between own aircraft and the target vehicle. Equations (1) and (3) remain valid, however, (2) is rewritten as (4) using velocities for own and target aircraft.

$$d\dot{x} = v_{x_t} - v_{x_o} \quad (4)$$
$$d\dot{y} = v_{y_t} - v_{y_o}$$
$$d\dot{z} = v_{z_t} - v_{z_o}$$

C.2.2.2 Data

A terminal scenario was generated to test the closure rate algorithms. Truth trajectories for two large aircraft, a leader and a follower, were generated using the following specifications:

a. A final approach distance of 10 NM (18520 m).
b. A descent angle of three degrees.
c. An in-trail separation distance of 2.5 NM (4630 m).
d. Constant, nominal speeds of 150 knots (77.16 m/s).

To simulate information available to own aircraft, state data was sampled at 1 Hz and noise was added to positions and velocities with random variables. Position and velocity noise for both own and target aircraft corresponded to the minimum requirements of the EVApp application (NACp = 7, NACv = 1).

To represent the worst case scenario, there was no serial correlation between errors in consecutive states for either aircraft. Own aircraft was set as the follower. Figure A-1 contains a visualization of this scenario as it would appear on the CDTI.

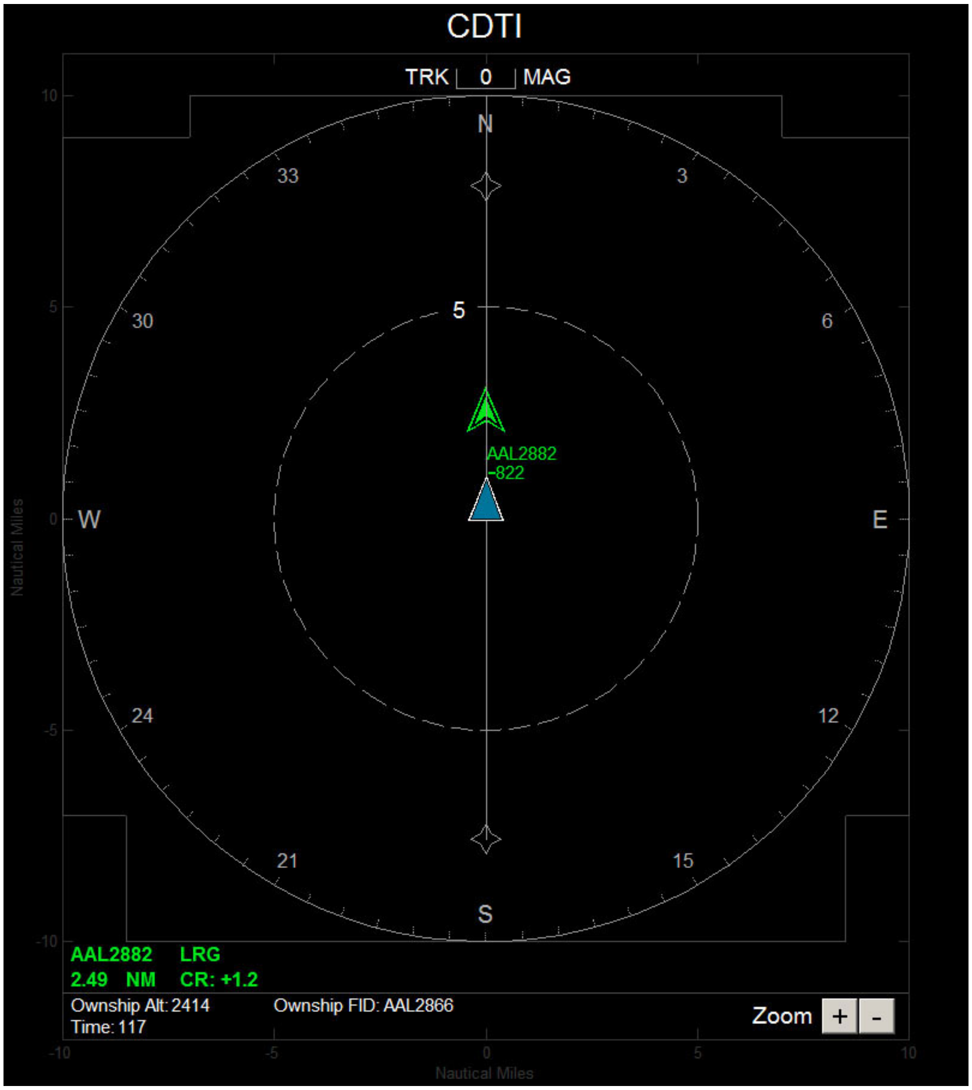

Figure A-1: Depiction of the scenario used to test closure rate algorithms for EVApp.

C.2.2.3 Metrics

The metric used to compare closure rate algorithms is the difference between true and observed closure rate (i.e. error). Given that the terminal scenario was set up with constant, equal velocities for both aircraft, true closure rate any point in time is zero. Thus in this case, the observed closure rate represents the difference between true and observed values. The final approach scenario was repeated 10000 times and prediction intervals were calculated for closure rate error produced by both algorithms.

C.2.3 Results

Table A-1 contains 95% prediction intervals for closure rate error produced by the two algorithms presented in this appendix.

Closure Rate Algorithm	**95% PI Bounds for Closure Rate Error (knots)**
Position-Based	±507.365
Position and Velocity-Based	±19.213

Table A-1: 95% prediction intervals for closure rate error produced by position-based and position and velocity-based algorithms.

Since this analysis focused on the worst case scenario with minimal state data accuracy, any permutation of the state data vector available to EVApp will produce closure rate error within the bounds listed in Table A-1. The accuracy of the presented closure rate algorithms can be summarized as follows:

a. A closure rate algorithm based solely upon difference in position between own aircraft and a target vehicle will produce a closure rate within ±507.365 knots (260.988 m/s) of the true value 95% of the time.
b. A closure rate algorithm based upon differences in position and velocity between own aircraft and a target vehicle will produce a closure rate within ±19.213 knots (9.883 m/s) of the true value 95% of the time.

The dramatic difference in algorithm performance is due to the effect of position error. In the position-based algorithm, current and previous positions are factored into the equations for difference in velocity, which is evident when (2) is rewritten as (5).

$$d\dot{x} = \frac{dx_2 - dx_1}{t_2 - t_1} = \frac{\left(x_{t_2} - x_{o_2}\right) - \left(x_{t_1} - x_{o_1}\right)}{t_2 - t_1} \qquad (5)$$

$$d\dot{y} = \frac{dy_2 - dy_1}{t_2 - t_1} = \frac{\left(y_{t_2} - y_{o_2}\right) - \left(y_{t_1} - y_{o_1}\right)}{t_2 - t_1}$$

$$d\dot{z} = \frac{dz_2 - dz_1}{t_2 - t_1} = \frac{\left(z_{t_2} - z_{o_2}\right) - \left(z_{t_1} - z_{o_1}\right)}{t_2 - t_1}$$

As a result, there are twenty-four position variables in the position-based closure rate formula, as opposed to twelve in the position/velocity-based formula. The multiplication of variables further degrades the accuracy of the position-based formula.

It is concluded that a position/velocity-based algorithm for closure rate is the most accurate approach. If a position-based algorithm is considered, it is recommended that an appropriate filter is added to dampen the effect of position error. The potential error in a position-based closure rate is nearly half as large as the maximum possible closure rate between two commercial aircraft.

Appendix X

Traceability Matrix to DO-289 ASA MASPS