1. Purpose and Scope

1.1 Introduction

This document contains Minimum Aviation System Performance Standards (MASPS) for Aircraft Surveillance Applications (ASA). This document is intended to specify requirements for and describe assumptions for all sub-systems supporting the operational application of ASA, e.g., Automatic Dependent Surveillance - Broadcast (ADS-B), Airborne Surveillance and Separation Assurance Processing (ASSAP), and Cockpit Display of Traffic Information (CDTI).

These standards specify characteristics that should be useful to designers, installers, manufacturers, service providers and users for systems intended for operational use within the United States National Airspace System (NAS). Where systems are global in nature, the system may have international applications that are taken into consideration.

Compliance with these standards is recommended as one means of assuring that the system and each subsystem will perform its intended function(s) satisfactorily under conditions normally encountered in routine aeronautical operations for the environments intended. This MASPS may be implemented by one or more regulatory documents or advisory documents (e.g., certifications, authorizations, approvals, commissioning, advisory circulars, notices, etc.) and may be implemented in part or in total. Any regulatory application of this document is the sole responsibility of the appropriate governmental agencies.

Chapter 1 of this document describes the Aircraft Surveillance Applications system and provides information needed to understand the rationale for function characteristics and requirements. This section describes typical applications and operational goals, as envisioned by members of RTCA Special Committee 186, and establishes the basis for the standards stated in Chapters 2 through 4. Definitions and assumptions essential to the proper understanding of this document are also provided in this section. Additional definitions are provided in Appendix A.

Chapter 2 describes minimum system performance requirements for the ASA system under standard operating and environmental conditions. ASA functional requirements and associated performance requirements are provided. ASA Capability Levels (ACLs) are identified and specified.

Chapter 3 contains the minimum performance standards for each subsystem that is a required element of the minimum system performance specified in Chapter 2, as well as the interface requirements between these subsystems. Assumptions about expected standards for systems external to ASA are also documented.

Chapter 4 contains the minimum performance standards for each ASSAP system application requiring the processing of ADS-B messages that have been received and assembled into reports. The applications are grouped into broad categories of situational awareness, spacing applications, and separation applications.

The appendices are as follows:

A: Acronyms and Definitions of Terms
B: Bibliography and References
C: Derivation of Link Quality Requirements for Future Applications
D: Design Trade-Off Considerations
E: Receive Antenna Coverage Constraints
F: Integrity Considerations for ADS-B Applications

G: Latency and Report Time Error Data
H: Derivation of Track Acquisition and Maintenance Requirements
I: Future Air-Referenced Velocity (ARV) Broadcast Conditions
J: (under review to include old Do-242A App J)
K: Compatibility of ASA MASPS with ADS-B standards and fielded systems
L: MASPS / LINK MOPS Compliance Matrices (tentative)
M: Traceability matrix to show disposition of DO-289 and DO-242A into DO-3xx

The word "sub-function" as used in this document includes all components that make up a major independent, necessary and essential functional part of the system (i.e., a subsystem) so that the system can properly perform its intended function(s). If the system, including any sub-functions, includes computer software or electronic hardware, the guidelines contained in [RTCA DO-178B and DO-254] should be considered even for non-aircraft applications.

1.2 System Overview

Today's airspace system provides separation assurance for aircraft operating under Instrument Flight Rules (IFR) via air traffic control and air traffic services (ATC/ATS), which are ground-based. These services utilize ground radar surveillance (primary and secondary surveillance radars), controller radar displays, air route infrastructure, airspace procedures including flight crew see and avoid, and VHF voice communications to assure separation standards are maintained. In the event of failure of this separation assurance system, aircraft equipped with Airborne Collision Avoidance Systems (ACAS), i.e., TCAS, are warned of potential mid-air collisions as a safety back up.

In order to accommodate expected increases in air traffic, a future separation assurance system is evolving using new technologies and automation processing support that is expected to enable the delegation of certain spacing or separation tasks to the flight deck. ASA represents the aircraft-based portion of this future separation assurance system. A wide range of separation assurance applications are expected to be developed over time that will enable enhanced airspace operations. These enhanced operations are intended to provide improved operational efficiencies, such as increased system capacity and throughput, while maintaining or improving air safety. ~~Only~~ Both aircraft-based and ground-based applications are discussed in this document. ~~Ground-based applications are being developed, but are not within the scope of this document.~~

1.2.1 Definition of Aircraft Surveillance Applications

The ASA system comprises a number of flight-deck-based aircraft surveillance and separation assurance capabilities that may directly provide flight crews with surveillance information, as well as surveillance-based guidance and alerts. Surveillance information consists of position and other state data about other aircraft and surface vehicles and obstacles when on or near the airport surface.

ASA applications are intended to both enhance safety and increase the capacity and efficiency of the air transportation system. Safety will be enhanced by providing improved traffic situational awareness to pilots, as well as capabilities to assist in conflict prevention, conflict detection, and 4-D conflict resolution. Capacity and efficiency will be enhanced by enabling aircraft to fly closer to one another and potentially delegating certain spacing or separation tasks to the flight crew, for example:

- Improving runway throughput in instrument meteorological conditions (IMC) through use of new cockpit tools;
- More efficient departure sequencing without increases in ATC workload
- Enabling aircraft in oceanic airspace to fly more optimal cruise profiles and pass other aircraft on parallel routes
- Accommodating more kinds of flight trajectories than ATC currently authorizes.

The individual ASA applications are described in §1.3. It is a goal of these applications to minimize any increase in workload while ensuring safety. Particular attention is paid to preventing workload increases during critical phases of flight, such as final approach and landing.

Some ASA applications are independent of ground systems and air traffic control, while others depend on or interact with services provided by ground systems and air traffic control. This MASPS does ~~not~~ specify requirements for ground systems ~~other than~~such as Traffic Information Service – Broadcast (TIS-B) and the Automatic Dependent Surveillance – Rebroadcast (ADS-R) service ~~but does~~and states assumptions about the functional and performance capabilities of the services they provide to the extent that these are required by ASA applications. ~~While~~ ADS-B ~~may be~~is used to augment or improve current ATC ground surveillance~~, these uses are outside the scope of this MASPS~~.

1.2.2 Application Assumptions

To achieve the expected gains, this document makes certain assumptions about the use of new technology. These assumptions include, but are not limited to:

A. Flight crews, in appropriately equipped aircraft, will be able to perform some functions currently done by ATC, some of which may be at reduced separation standards compared to current separation standards.
B. The variability in the spacing between aircraft in the airport arrival and/or departure streams will be reduced with the use of certain ASA applications.
C. Pilots will be willing to accept additional separation responsibility beyond what they have today that is currently provided by ATC.
D. Pilot and ATC workload will not be increased substantially by ASA applications.
E. Most aircraft will eventually be equipped with avionics to perform ASA applications (this is necessary to maximize system benefits).
F. ATC will be willing to act as a “monitor” and retain separation responsibility between designated aircraft.
G. ADS-B avionics and applications will be compatible with future ATC systems and operating procedures.

These assumptions have not yet been fully validated.

1.2.3 ASA Architecture

Figure 1-1 provides an overview of the ASA system architecture and depicts the interfaces between functional elements for an ASA aircraft participant and external systems. The ASA system architecture consists of three major components: subsystems for the transmit participant, subsystems for the receive participant, and the ground systems. The ASA also interfaces with other aircraft systems.

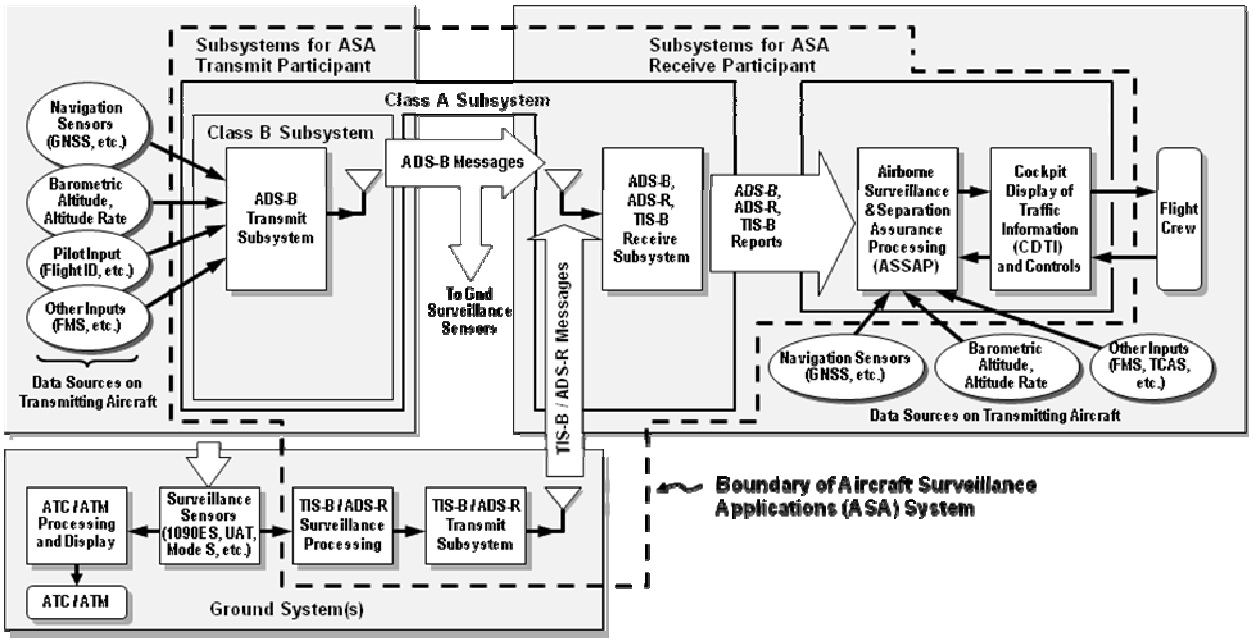

Figure 1-1: Overview of ASA Architecture

Note that there is a clear distinction in the diagram between messages and reports. An ADS-B message is a block of formatted data that conveys the information elements used in the development of ADS-B reports. Message content and formats are unique for each of the ADS-B data links. The MASPS does not address these message definitions and structures. An ADS-B Report contains the information elements assembled by an ADS-B receiver using message content received from ADS-B, ADS-R, and TIS-B messages from transmitting airborne and ground participants. These reports are available for use by applications external to the ADS B system.

Aircraft ASA systems which include both link message transmit and receive capability are defined to be Class A systems. Systems which include only the link transmit capability are defined to be Class B systems. Subcategories within the classes define capability thresholds based on parameters such as transmit power and receiver sensitivity to align equipment capabilities with intended applications. Ground systems are defined to be Class C systems.

1.2.3.1 ASA Transmit Participant Subsystem

The subsystem for the ASA transmit participant accepts navigation and other data inputs from the aircraft, processes it to create the link unique ADS-B messages, and then broadcasts those ADS-B messages. The navigation data contains position and velocity information, as well as the accuracy and integrity parameters characterizing that data, either directly from a Global Navigation Satellite System (GNSS) receiver or a GNSS based navigation system. There are increasingly restrictive thresholds for the accuracy and integrity metrics of the navigation data as the system applications progress in criticality from situational awareness to separation assurance.

Other data sources include the barometric altitude and altitude rate and pilot inputs such as the flight identification. A critical performance requirement in the transmit subsystem is minimizing the latency between the time the GNSS sensor makes the position measurement and broadcasting it in the ADS-B messages.

1.2.3.2 ASA Receive Participant Subsystem

The subsystem for the ASA receive participant accepts ADS-B message from aircraft and other vehicles, ADS-R and TIS-B messages from the ground system, and navigation and other data inputs from the aircraft.

1.2.3.2.1 ADS-B, ADS-R, TIS-B Receive Subsystem

The received ADS-B, ADS-R, and TIS-B messages are processed by the ADS-B, ADS-R, TIS-B receive subsystem in the ASA aircraft. The receive subsystem processes these messages and provides reports to the ASSAP subsystem. The reports are then processed by the ASSAP subsystem.

1.2.3.2.2 ASSAP Subsystem

Processing is performed by ASSAP, which takes the incoming surveillance information and processes it according to the appropriate ASA application(s) as selected by the flight crew. For example, the ASSAP may predict a violation of the applicable separation minima, and determine appropriate resolution guidance.

ASSAP is the processing subsystem that accepts surveillance reports, performs any necessary correlation and/or tracking, 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. 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.

1.2.3.2.3 CDTI

Display is accomplished through a Cockpit Display of Traffic Information (CDTI). The CDTI provides the flight crew interface to the ASA system. It displays traffic information as processed by the ASSAP. It provides other necessary information, such as alerts and warnings, and guidance information. The CDTI also provides flight crew inputs to the system, such as display preferences, application selection, and designation of specific targets and parameters for certain applications.

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

The TCAS traffic display may be a separate display or TCAS traffic may be integrated with ASA surveillance data and presented in a combined format. If TCAS traffic is integrated with other surveillance data, only one symbol should be displayed to the flight crew for any one aircraft.

Note: *It is highly desirable that the TCAS traffic display be integrated with the CDTI.*

1.2.3.3 Ground Subsystems

1.2.3.3.1 TIS-B

Not all aircraft will be equipped to broadcast their position via ADS-B. It is anticipated that there will be a long transition period over which aircraft owners decide to equip their aircraft, and that some aircraft owners may choose never to equip. In addition, situations will occur where the ADS-B reporting equipment on an aircraft is not operating although it is installed.

To fill this information gap, the concept of Traffic Information Service Broadcast (TIS-B) was developed. Within their coverage areas, ground surveillance systems can determine the positions of transponder-equipped aircraft and broadcast this position data to ASA-equipped aircraft via TIS-B. Recently developed multi-lateration surveillance systems planned for the airport surface can provide position accuracies comparable to those from GPS. Away from the vicinity of the airport, ground radar systems will provide less accuracy, but the position information may still be suitable for providing situational awareness with respect to aircraft not equipped with ADS-B position reporting.

1.2.3.3.2 ADS-R

Automatic Dependent Surveillance – Rebroadcast (ADS-R) messages are crosslink translations from UAT to 1090ES and from 1090ES to UAT provided by the ground surveillance service. The ADS-R service is only provided when an aircraft in range of the broadcast antenna indicates that it has the capability to accept messages that are relayed from the UAT ADS-B link to 1090 ES ADS-B link, and likewise from 1090 ES to ~~UAt~~ UAT equipped aircraft.

1.2.3.3.3 ADS-B Surveillance Sensors

The ADS-B ground system is comprised of a network of radio stations designed to provide surveillance coverage throughout the NAS that is equivalent or better that existing radar coverage. The ADS-B system will provide aircraft position and state data with substantially better accuracy and update rates for ATC automation systems, which provide an opportunity for reduced separation standards and more efficient flight operations.

1.2.4 Relationship to TCAS

The Traffic-Alert and Collision Avoidance System (TCAS), known internationally as the Airborne Collision Avoidance System (ACAS), provides flight crews with a traffic situation display and with safety alerts. Its success, and the attempt to use it for some additional applications for which it was not intended or well suited, helped promote interest in a more general ASA system to address those applications not directly associated with collision avoidance.

TCAS provides a backup safety system for separation assurance. On aircraft that carry both an ASA and a TCAS, the TCAS collision avoidance function must continue to function correctly when ASA fails. This need does not preclude an avionics architecture that integrates TCAS and ASA functionality in the same equipment, provided the frequency of common mode failures is sufficiently small in the context of providing collision avoidance protection when separation provision has failed. The operational uses of TCAS and ASA, and in particular their flight crew interfaces, will have to be carefully coordinated in order to ensure that all the intended safety and operational benefits are provided.

Note: *If future ASA applications are proven to provide increased safety, the interaction between ASA and TCAS may be altered; this will require validation.*

ADS-B surveillance differs from TCAS surveillance in that ADS-B broadcasts position and velocity information while TCAS derives relative position information through an interrogate – reply protocol. ADS-B covers a larger range (potentially 90 to 120 NM), and has greater overall accuracy. Altitude information in both systems is dependent upon on-board equipment. As a last-minute safety system, TCAS only needs to provide surveillance to approximately 15 NM. While TCAS measures range with great accuracy, it is unable to make highly accurate bearing measurements because of the limitations imposed by the available antenna technology that can be installed on aircraft. When GNSS is used as the navigation data source for ADS-B, highly accurate position measurements can generally be provided in all dimensions. This may allow added integrity to vertical height based only on pressure altitude. The relative position between two aircraft is calculated from these position reports, rather than measured, and the accuracy does not depend on the distance between the aircraft. The relative position will also differ from TCAS systems in allowing for relatively compact and inexpensive implementations suitable for categories of aircraft where TCAS is not required and is not economically attractive.

1.2.5 Relationship to Other RTCA / EUROCAE Documents

The diagram in Figure 1-2 shows the relationships between the Aircraft Separation Assurance (ASA) MASPS and other RTCA SC-186 documents, such as the Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Service – Broadcast (TIS-B) MASPS and the various link Minimum Operational Performance Standards (MOPS).

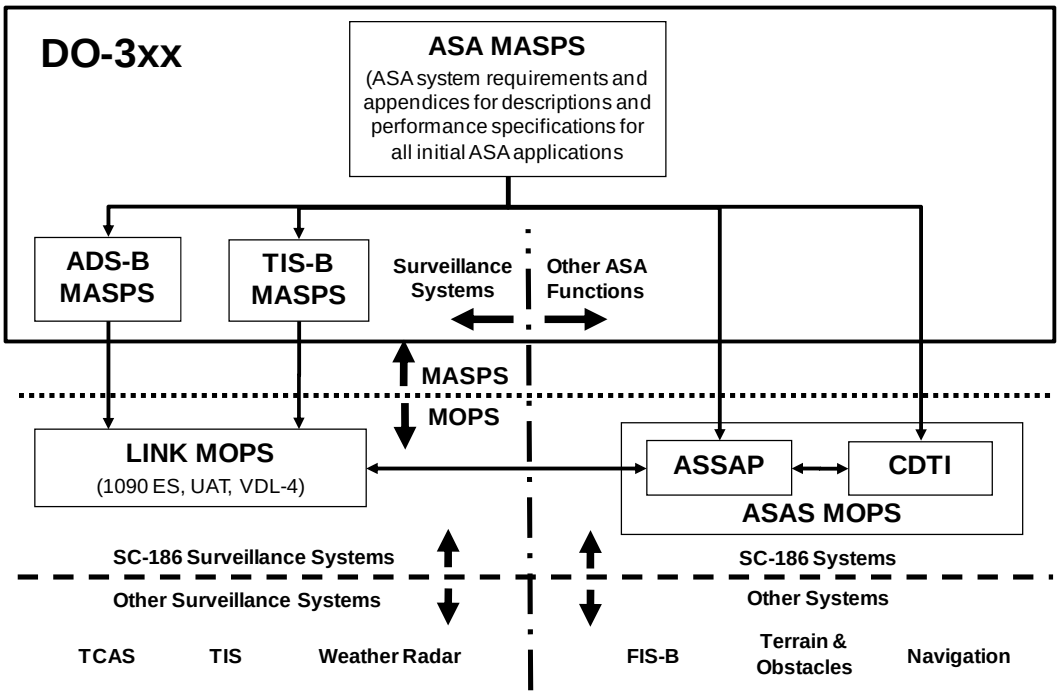

Figure 1-2: Relationship Between ASA MASPS And Other RTCA Documents

Two RTCA link MOPS have been identified: 1090 MHz Extended Squitter ADS-B (1090ES) and Universal Access Transceiver (UAT). The 1090ES MOPS has recently been revised and issued as [RTCA DO-260B], Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services (TIS-B) [RTCA DO-260B]. The UAT MOPS has been published as [RTCA DO-282B], Minimum Operational Performance Standards for Universal Access Transceiver (UAT) Automatic Dependent Surveillance – Broadcast (ADS-B) [RTCA DO-282B]. EUROCAE Working Group 51 has issued [ED-108], a MOPS for VDL Mode 4 and a third ADS-B link. Additionally, EUROCAE Working Group 51 has released [ED-102A] which is identical to [RTCA DO-260B].

Note: *The VDL-4 link MOPS is a EUROCAE document, not an RTCA document.*

The Airborne Surveillance and Separation Assurance Processing (ASSAP) and the Cockpit Display of Traffic Information (CDTI) functions are closely related items and are written as a joint MOPS [RTCA DO-317A], Airborne Surveillance Application System~~s~~ (ASA~~S~~) MOPS.

Figure 1-2 also shows the functions under the auspices of RTCA SC-186 and those systems outside the scope of RTCA SC-186. This MASPS document makes requirements allocations to the functions under the auspices of RTCA SC-186 and makes assumptions on the systems outside the scope of RTCA SC-186.

Surveillance Systems that are outside of the scope of RTCA SC-186 are the TCAS, Traffic Information Service (TIS), weather radar, and Flight Information Service – Broadcast (FIS-B). Terrain systems, e.g., Terrain Awareness and Warning System (TAWS) and Navigation systems, e.g., GPS, are also outside the scope of RTCA SC-186.

1.3 Operational Applications

The situational awareness and separation assurance capabilities of ASA are provided by applications. Numerous applications have been proposed, and it is expected that additional applications will be developed and standardized in future versions of this MASPS. The applications fall into five broad categories: situational awareness, enhanced situational awareness, spacing, delegated spacing, and self-separation.

Situational awareness 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 or responsibility are required for these applications Enhanced situational applications add provisions ~~for~~ such as cueing to the pilot through indications and alerts, or providing a new separation standard during the procedure.

Spacing applications require flight crews to achieve and maintain a given spacing with designated aircraft, as specified in a new ATC instruction. Although the flight crews are given new tasks, separation provision is still the controller's responsibility and applicable separation minima are unchanged. In delegated separation applications, the controller delegates separation responsibility and transfers the corresponding separation tasks to the flight crew, who ensures that the applicable airborne separation minima are met. The separation responsibility delegated to the flight crew is limited to designated aircraft, specified by a new clearance, and is limited in time, space, and scope. Except in these specific circumstances, separation provision is still the controller's responsibility. These applications will require the definition of airborne separation standards.

Self separation applications require flight crews to separate their flight from all surrounding traffic, in accordance with the applicable airborne separation minima and rules of flight.

1.3.1 Initial Applications

This document specifies detailed requirements for an initial set of applications.

1.3.1.1 Enhanced Visual Acquisition (EVAcq)

The Enhanced Visual Acquisition (EVAcq), application represents the most basic of ASA applications, and use of the CDTI. The CDTI provides relative range, altitude and bearing data for participating aircraft, which will assist the flight crew in their aircraft visual search task.
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1.3.1.2 ~~Enhanced Visual Approach (EVApp)~~Visual Separation on Approach (VSA)

The ~~Enhanced Visual Approach (EVApp)~~Visual Separation on Approach (VSA), 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.

1.3.1.3 ~~Airport~~ Basic Surface Situational Awareness (~~ASSA~~SURF)

The ~~Airport~~ Basic Surface Situational Awareness (~~ASSA~~SURF), application is to provide the flight crew with own-ship positional and traffic situational awareness information relative to an airport map. This information may be used to support determination of

their position, and subsequently determine the appropriate taxi route while also observing other traffic along that route. The flight crew may use the display as a supplemental aid to their out-the-window visual scan and taxi task. The flight crew must not use the display as the primary means of information for taxiing (i.e., blind taxiing).

1.3.1.4 Oceanic In-Trail Procedures (ITP)

In-Trail Procedures (ITP) in Oceanic Air Space enables flight level change maneuvers that are otherwise not possible within Oceanic procedural separation standards. ITP allows ATC to approve these flight level change requests between properly equipped aircraft using reduced procedural separation minima during the maneuver.

1.3.2 Emerging Applications

This document specifies detailed requirements for an initial set of applications.

1.3.2.1 Airport Surface situational Awareness with Indications and Alerts (SURF IA)

Airport Surface situational Awareness with Indications and Alerts (SURF IA) is a flight-deck based application that adds to the Airport Traffic Situation Awareness application by graphically highlighting traffic or runways on the airport map to inform flight crew of detected conditions which may require their attention. For detected non-normal—alert level—situations, which require immediate flight crew awareness, additional attention getting cues are provided.

1.3.2.2 Traffic Situational Awareness with Alerts (TSAA)

Traffic Situational Awareness with Alerts (TSAA) will provide traffic advisories in the near term by using the CDTI and alerts to assist the pilot or flight crew with visual acquisition and avoidance of traffic in both Visual Meteorological Conditions and Instrument Meteorological Conditions. The application is applicable under both Visual Flight Rules (VFR) and Instrument Flight Rules (IFR). It builds on the Basic Traffic Situational Awareness application by providing the pilot or flight crew with alerts for conflicting traffic that may or may not have been pointed out by ATC. This alert is for detected airborne conflicts

1.3.2.3 Flight-Deck Based Interval Management-Spacing (FIM-S)

Flight-Deck Based Interval Management-Spacing (FIM-S) is a suite of functional capabilities that can be combined to produce operational applications to achieve or maintain an interval or spacing from a target aircraft. ATC will be provided with a new set of (voice or datalink) instructions directing, for example, that the flight crew establish and maintain a given time from a reference aircraft.