



The European Organisation for Civil Aviation Equipment
L'Organisation Européenne pour l'Équipement de l'Aviation Civile

SAFETY, PERFORMANCE AND INTEROPERABILITY REQUIREMENTS DOCUMENT FOR ENHANCED TRAFFIC SITUATIONAL AWARENESS DURING FLIGHT OPERATIONS (ATSA-AIRB)

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ED-164

March 2010

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FOREWORD

1. The document ED-164 "SAFETY, PERFORMANCE AND INTEROPERABILITY REQUIREMENTS DOCUMENT FOR ENHANCED TRAFFIC SITUATIONAL AWARENESS DURING FLIGHT OPERATIONS (ATSA-AIRB)" was prepared by EUROCAE Working Group 51, in the framework of the Requirements Focus Group (RFG), and was accepted by the Council of EUROCAE on 19 March 2010.
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CHAPTER 1

INTRODUCTION

This document provides the minimum operational, Safety and Performance Requirements (SPR) and Interoperability Requirements (INTEROP) for the implementation of Airborne Traffic Situational Awareness (ATSAW) for “Enhanced Traffic Situational Awareness during flight operations” (ATSA-AIRB). The ATSA-AIRB application is fully defined in the Operational Services and Environment Definition (OSED) found in Annex A.

All material in this document was developed jointly by EUROCAE Working Group 51 and RTCA Special Committee 186 within the group commonly referred to as the “ADS-B Requirements Focus Group” (RFG).

This document was developed based on the criteria for SPR and INTEROP documents set forth in EUROCAE ED-78A/RTCA DO-264, “Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications.” [9]. It provides the minimum ATSA-AIRB requirements - and allocations thereof - based on the results of a coordinated requirements determination process.

The requirements contained in this document are necessary to provide adequate assurance that the appropriate aspects of the relevant Communication Navigation Surveillance and Air Traffic Management (CNS/ATM) system, when operating together, will perform their intended function in an acceptably safe manner for the operations defined in the OSED.

Whilst all detailed SPR related assessments are found in Annexes to this document, Chapter 3 presents the outcome of the reconciliation process of all of these results into a single set of underlying Safety and Performance Requirements. This process retains the most stringent requirement for those attributes or parameters commonly treated by both the safety and performance assessments. Traceability of those requirements back to the corresponding assessment(s) is provided.

1.1 PURPOSE OF THE DOCUMENT

This document defines and allocates the set of minimum requirements for the end-to-end operational, safety, performance and interoperability aspects for implementations of the ATSA-AIRB application. Allocation of these requirements is done by this SPR/INTEROP to the necessary domains of the CNS/ATM system, i.e. at aircraft and ground domain level.

These requirements can be used as a component for approval processes including aircraft type design approval, aircraft operator operational approval and Air Traffic Services (ATS) provider operational approval. This SPR/INTEROP document is also written to support system specific standards (e.g. MOPS, TSOs) which will be required for many airspace regulators.

NOTE: *Requirements for EVAcq (Enhanced Visual Acquisition) in DO-317 [17], which is an application similar to ATSA-AIRB, are different than those for ATSA-AIRB. A Change Proposal will be developed to harmonize the ASAS MOPS with this SPR by advocating changes to make a DO-317 revision consistent with ATSA-AIRB SPR/INTEROP.*

In addition, this document provides guidance to determine the levels of design assurance and performance that are needed for each element (aircraft, operator and ANSP – Air Navigation Service Provider) to support the ATSA-AIRB application.

The ATSA-AIRB SPR/INTEROP document is also envisaged to be used along with those from other surveillance applications based on Automatic Dependent Surveillance-Broadcast (ADS-B) to develop minimum standards for avionic systems to assure that all subsystems perform their intended functions adequately for these applications.

This document treats ATSA-AIRB as a stand-alone application with a dedicated display. However, it is recognized that other Airborne Surveillance Applications will be layered on top of the nominal ATSAW display, and that some ATSA-AIRB implementations will be done on shared displays with other surveillance sources such as TCAS (Traffic alert and Collision Avoidance System). The requirements of such shared displays, the correlation between multiple surveillance sources and source selection for display of data are left to lower level requirements documents such as DO-317. Nevertheless, an Operational Requirement and training consideration addressing separate TCAS Traffic Display are identified in this document.

NOTE: *It is anticipated that some regulatory authorities will require TCAS and ADS-B displays to be integrated.*

1.1.1

ATSA-AIRB application

During flight operations, flight crews should, to the greatest extent possible, maintain a general awareness of the environment in which they are operating. In particular, flight crews must attempt to maintain traffic situational awareness.

Traffic situational awareness is an asset in terms of safety and flight efficiency. During flight operations, flight crews use all available sources of information to build their mental traffic picture by scanning for traffic out the window and listening to radio communications. However, these sources may present some limitations. Visual acquisition of Surrounding Traffic is not usually possible in reduced visibility and can be difficult even in good conditions. Radio communications may only provide a partial picture (e.g. different VHF frequencies used in the same airspace for departures and arrivals in TMA, information about traffic only provided when the controller has time available to make non-mandatory transmissions for instance between IFR (Instrument Flight Rules) flights in class A airspace).

The ATSA-AIRB application aims at enhancing flight crews' traffic situational awareness through the provision of an appropriate on-board graphical display of airborne Surrounding Traffic transmitting ADS-B data and qualified for ATSA-AIRB (i.e. referred to as AIRB Traffic) relative to their aircraft together with supporting information on that traffic. It is expected that this enhanced traffic situational awareness will contribute to improve flight safety and flight operations.

In the context of this document, the term flight crew refers to one or more pilots. The analysis does not take credit for any advantages that may be provided by additional pilots. As a result, the requirements for conducting ATSA-AIRB are applicable to both single and multiple pilot operations.

The ATSA-AIRB application will supplement the other available sources of information (i.e. out the window and/or radio communication) on AIRB Traffic and should support the rapid and accurate mental integration of out the window and radio communication information (e.g. the display of Aircraft Identification in conjunction with the voice communications party-line effect helps the flight crew in building their mental traffic picture) and help the flight crew to address the limitations of these sources (e.g. identification of the presence of a Traffic of Interest that cannot be visually acquired for instance due to limited visibility conditions or aircraft being out of the field of vision).

The ATSA-AIRB application can be used anytime the aircraft operating the ATSA-AIRB application (referred to as AIRB Aircraft) is airborne, i.e. from the runway departure on take-off, through in-flight operations, and during approach to touchdown, in all classes of airspace, in both Instrument Meteorological Conditions (IMC) and Visual Meteorological Conditions (VMC), by aircraft operating under Instrument Flight Rules (IFR) and Visual Flight Rules (VFR) and by all types of aircraft, from large commercial jets to small General Aviation aircraft. The actual expected benefits will vary depending on the airspace and operational flight rules.

The ATSA-AIRB application does not supersede any existing ICAO SARPS (Standards and Recommended Practices). For example, Annex 2 “Rules of the Air” [2] regarding adherence to the flight plan remain unchanged (see Annex 2 - Rules of the Air, Chapter 3 - General Rules, Section 3.6 - Air Traffic Control Service, paragraph 3.6.2 - Adherence to Flight Plan.). The first sub-paragraph (3.6.2.1) mentions that *"Except as provided for in 3.6.2.2 and 3.6.2.4, an aircraft shall adhere to the current flight plan or the applicable portion of a current flight plan submitted for a controlled flight unless a request for a change has been made and clearance obtained from the appropriate air traffic control unit, or unless an emergency situation arises which necessitates immediate action by the aircraft, in which event as soon as circumstances permit, after such emergency authority is exercised, the appropriate air traffic services unit shall be notified of the action taken and that this action has been taken under emergency authority."*

1.1.2 Use of document for approvals

This document is intended to support the approval of all elements of the CNS/ATM system relating to the ATSA-AIRB application.

The corresponding safety, performance and interoperability assessments are based on the detailed specification of the OSED. States or regions implementing an application different to that specified in the OSED must take into account those differences in the operations or environment in supporting analysis and must analyze the impact of these differences on the requirements.

The assessments and specifications in this document are not intended to be the sole basis for operational and airworthiness approval. However, this material can be used as an important component for establishing minimum design and system performance standards for ANSP, aircraft operator and aircraft certification approvals for the ATSA-AIRB application.

Aircraft and avionics system designers should consider any additional specifications that may enhance the system supporting the ATSA-AIRB application in view of other future Airborne Surveillance Applications (ASA) so that systems designed for ATSA-AIRB will easily accommodate more demanding ADS-B enabled operations in the future.

1.2 SCOPE OF THE DOCUMENT

This document includes the definition of the services and the Environmental Conditions relevant to the implementation of the ATSA-AIRB application and the operational, safety, performance and interoperability requirements for using the application.

NOTE: *Requirements that provide protection against intentional behaviour causing harm or sabotage are beyond the scope of this document.*

NOTE: *Requirements related to the recording of ADS-B data for accident or incident investigation purposes are beyond the scope of this document.*

1.2.1 ATSA-AIRB context

ATSA-AIRB is one of many envisioned applications based on an ADS-B “IN” function that relies on the participation of ADS-B OUT equipped aircraft. There is a strong expectation that ADS-B OUT will be implemented widely using, for example, the published SPR/INTEROP documents such as ADS-B-NRA [13] and ADS-B-RAD [14]. Furthermore, some SPR/INTEROP documents for Airborne Surveillance Applications are already published (i.e. ATSA-ITP [16] and ATSA-VSA [15]). This document has therefore been developed considering the assessments of these Ground and Airborne Surveillance Applications.

ATSA-AIRB is one of the applications originally defined as a first package of Ground and Airborne Surveillance Applications enabled by ADS-B and collectively called "Package 1" [6]. All applications defined within Package 1 are enabled by ADS-B given a sufficient level of equipage of aircraft broadcasting ADS-B information and/or ground stations and/or other aircraft receiving and processing that same data.

This document considers ATSA-AIRB as an isolated application. However, all Package 1 Applications are envisioned to be implemented and it should be noted that system requirements that satisfy the ATSA-AIRB application do not necessarily satisfy others. Implementation of all Package 1 applications will require harmonization of minimum system requirements to facilitate interoperability between applications. Additionally, differences between similar applications specified in DO-317 [17] and Package 1 should be harmonized in the future.

The envisioned applications within Package 1 fall into two categories as follows:

ADS-B Package 1 Ground Surveillance Applications (GSA) which are:

- ADS-B-NRA Enhanced ATS in non-radar areas using ADS-B surveillance
- ADS-B-RAD Enhanced ATS in radar areas using ADS-B surveillance
- ADS-B-APT Airport surface surveillance
- ADS-B-ADD Aircraft derived data for Air Traffic Control tools

ADS-B Package 1 Airborne Surveillance Applications which are:

- ATSA-VSA Enhanced visual separation on approach
- ATSA-ITP In-trail procedure in procedural airspace
- ATSA-AIRB Enhanced traffic situational awareness during flight operations
- ATSA-SURF Enhanced traffic situational awareness on the airport surface
- ASPA-IM Interval Management

NOTE: *ADS-B-RAD is a combination of the former ADS-B-ACC (Area Control Centre) and ADS-B-TMA (Terminal control Area) which defined ATC services based on ADS-B in en-route and terminal areas, respectively in Package 1.*

NOTE: *ATSA-AIRB has been combined with the Package 1 definition of ATSA-S&A ("Enhanced Visual Acquisition for See-and-Avoid").*

NOTE: *ASPA-IM is a toolbox of functions and procedures defined to support a variety of airborne spacing operations, including the former ASPA-S&M (Sequencing and Merging) application.*

NOTE: *Enhanced Crossing and Passing Operations (ASPA-C&P), as defined in Package 1 has been dropped from the RFG work plan by RTCA SC-186 and EUROCAE WG-51.*

Separate publication of the SPR/INTEROP documents for each application will allow States, ANSPs and airspace users to select those applications that are best suited to their operations and needs. However, to ensure seamless growth and global interoperability, any new installation of ADS-B should meet the full minimum requirements for the given data link as specified in published ADS-B link Minimum Operational Performance Specifications (MOPS).

1.2.2

Assumed airborne & ground generic surveillance functional architecture

Figure 1.1 presents the generic surveillance functional architecture considered by the RFG to support all Package 1 applications. The figure identifies the airborne domains and the ground domain associated with ADS-B enabled Ground and Airborne Surveillance Applications. The airborne domain consists of the Transmit Aircraft Domain and the Receive Aircraft Domain. The Transmit Aircraft Domain represents the functions associated with providing the ADS-B OUT capability needed to support ground-based or aircraft-based surveillance applications. The Receive Aircraft Domain provides the ADS-B IN capability to host Airborne Surveillance Applications. The Ground Domain represents the capability to host ground-based surveillance applications in support of Air Traffic Services.

FIGURE 1.1: SURVEILLANCE FUNCTIONAL ARCHITECTURE

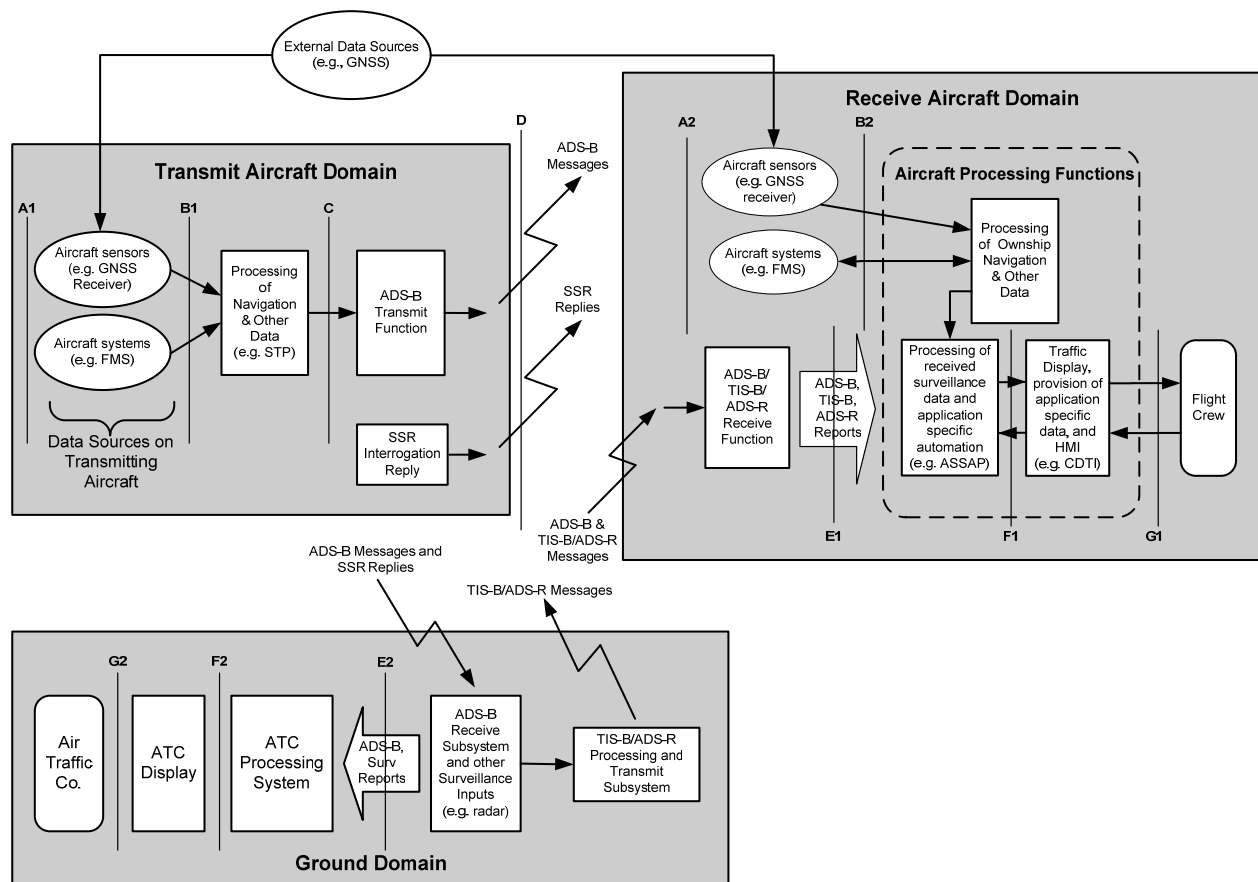


Figure 1.1 also identifies the system functions and functional interfaces (small lines with associated letters and numbers, e.g. B1) associated with the aircraft domains and the ground domain. The figure identifies the functional interfaces (e.g. D, G1) to which the Safety and Performance Requirements (SPR) are allocated. These interfaces are referenced throughout the document where requirements are provided.

NOTE: When addressing operations, this document uses the term “AIRB Aircraft” for the aircraft which is using the ATSA-AIRB application. The AIRB Aircraft is represented in Figure 1.1 as the Receive Aircraft Domain. For ATSA-AIRB operations, the Transmit Aircraft Domain is named as the “AIRB Traffic”, which is the aircraft for which the flight crew of the AIRB Aircraft is using information provided by the Traffic Display to enhance traffic situational awareness. The surveillance functional architecture supporting the ATSA-AIRB application is described in §3.1.3.

General functional capabilities and key aspects of the architecture are specified below.

For the Receive Aircraft Domain:

- The minimum surveillance functional architecture includes:
 - reception of ADS-B messages (represented by the ADS-B Receive Function);
 - ownship sensor data processing;
 - where applicable, surveillance data processing, and applications-specific processing (represented by the Airborne Surveillance and Separation Assurance Processing Function, ASSAP); and
 - where applicable, the provision of necessary information to the flight crew by the Traffic Display Function and its associated control interface.
- Requirements allocated to the Receive Aircraft Domain are measured from the time of transmission or reception (interface D) for the ADS-B information, at the time of measurement of sensor data (interface A2) or at the output of the aircraft sensors and systems (interface B2) through the conveyance of needed information to the flight crew (interface G1).

NOTE: *TIS-B (Traffic Information Service - Broadcast) and ADS-R (Automatic Dependent Surveillance – Rebroadcast) data are shown in Figure 1.1 as potential other sources of surveillance data. In addition to ADS-B, these sources may be employed for some of the Package 1 applications.*

For the Transmit Aircraft Domain:

- The minimum surveillance functional architecture includes onboard aircraft sensors and associated processing (represented by the Surveillance Transmit Processing Function, STP) and the subsequent formulation of ADS-B messages to be transmitted (represented by the ADS-B Transmit Function).
- Assumptions placed on the Transmit Aircraft Domain are measured from:
 - the time of measurement of sensor data (interface A1 for positioning data);
 - sensor outputs and flight crew control panel inputs, e.g. Aircraft Identification (interface B1); and
 - at the point of transmission of ADS-B OUT (interface D).

For the Ground Domain:

- The minimum functional architecture for the generic ASA/GSA systems includes an ADS-B Receive Function, an ATC Processing Function and an ATC Surveillance Data Display Function.
- Requirements allocated to the Ground Domain begin at interface D (i.e. the Ground Domain performance must take into consideration all aspects after the transmission of ADS-B data including time between transmission and reception, terrain and atmospheric conditions).

NOTE: *The Ground Domain is not pertinent to the ATSA-AIRB application, but its description is provided here for completeness.*

1.3

DEFINITION OF TERMS

The following is a list of definitions that is essential for the correct interpretation of this document. Also note that cross-referencing of definitions occurs within this section.

Accuracy: The degree of conformance between a platform's true position and/or velocity and its estimated or reported position and/or velocity.

ADS-B IN function: Represents the ADS-B functional capability of the Receive Aircraft Domain. The 'ADS-B IN' function includes the ADS-B Receive function, which generates ADS-B reports from received ADS-B messages, the ASSAP function, which performs surveillance and application-specific processing and the Traffic Display function, which provides the Human Machine Interface (HMI) to the flight crew.

ADS-B Message: A packet of information broadcast by an aircraft/vehicle. Each ADS-B message contains a defined set of aircraft/vehicle parameters. Multiple messages may be used to transmit all required data. Message formats are link specific, as is the number of different messages required to provide a complete set of parameters.

ADS-B OUT function: Represents the ADS-B functional capability of the Transmit Aircraft Domain. The 'ADS-B OUT' function consists of the Surveillance Transmit Processing (STP) function and the ADS-B Transmit Function. STP receives and processes pertinent ADS-B information from on-board aircraft sensors and aircraft systems for subsequent transmission by the ADS-B Transmit Function.

ADS-B Receive function: Function that receives ADS-B messages. The receiver processes these messages and provides ADS-B reports to the ASSAP function.

ADS-B Report: One of the data reports specifically defined in the ADS-B MASPS (either RTCA DO-242 [10], DO-242A [11]) or more recent standards (e.g. ED-102A/DO-260B [1]a)i)[30] or DO-282B [1]a)i)[24]). A report can contain information from multiple messages.

ADS-B Surveillance Report: Contains aircraft/vehicle parameters determined from ADS-B message(s) received and successfully decoded by the receiving system. The data format of the ADS-B Surveillance report should be independent of the particular type of ADS-B link and serve as the input of surveillance information to ATC ground systems or ADS-B IN systems. There are three different types of ADS-B Surveillance data that are likely to be grouped together into Surveillance Reports. These data types have different requirements with respect to update rates and some requirements are applicable only to certain data types. The data types are as follows:

- Surveillance Position Data: Information on the position and velocity of an aircraft, including associated quality indicators.
- Surveillance Identity Data: Information related to an aircraft's identity such as Aircraft Identification, Mode A Code, ICAO 24 bit aircraft address and other relatively static data.
- Surveillance Emergency or SPI Data: Information conveying any emergency status indicators or Special Position Ident (SPI). (This type of data is usually transmitted due to the flight crew setting either an emergency or an SPI condition.)

NOTE: *STP automation will need to be able to associate these different types of data if they are delivered separately from the Receive subsystem and package the data into reports used by the onboard processing subsystem. The ICAO 24 bit address or some other field incorporated into the system will need to be sent with all ADS-B messages so that the required association can be performed.*

ADS-B Transmit Function: Function that transmits ADS-B messages.

AIRB Aircraft: The aircraft that is equipped with AIRB Equipment and is operating the ATSA-AIRB application.

AIRB Equipment: All avionics which perform functions needed to support or perform the ATSA-AIRB application. In Figure 3.1, the dotted box represents the functional aspects referred to as “AIRB Equipment”.

AIRB Traffic: A Transmitting Traffic that is qualified for ATSA-AIRB, i.e. its system integrity and horizontal position meet associated requirements derived in the OPA and OSA.

Airborne Surveillance and Separation Assurance Processing (ASSAP) function: Function that processes surveillance data using ADS-B reports from the ADS-B receive function and performs application-specific processing. Surveillance reports, tracks and any application-specific information, e.g. alerts or guidance cues are output to the Traffic Display function. The ASSAP function also interfaces with on-board aircraft sensors and aircraft systems through the STP.

Aircraft Identification: A group of letters, figures or a combination thereof which is either identical to, or the coded equivalent of, the aircraft call sign to be used in air-ground communications and which is used to identify the aircraft in ground-ground air traffic services communications (Doc 4444 – PANS-ATM, Chapter 1).

Availability: The probability that a system will perform its required function at the initiation of the intended operation. Availability is calculated as the Mean Time Between Failures (MTBF) divided by the Mean Time Between Failures plus the Mean Time To Repair (MTTR) (periods of planned maintenance are discounted from the availability figures). $MTBF/(MTBF+MTTR)$.

Continuity: The probability that a system will perform its required function without unscheduled interruption, assuming that the system is available when the procedure is initiated. (Continuity is expressed per unit of time).

Integrity (data): The level of trust in the positioning source providing the input to the ADS-B reported position. Integrity is defined relative to the probability that an error larger than a certain threshold in the information is undetected (i.e. not alerted) for longer than a time to alert threshold.

Integrity (system): The probability per flight hour of an undetected failure of a functional element that results in erroneous information.

Latency: The amount of time it takes to deliver data from one interface to another interface point.

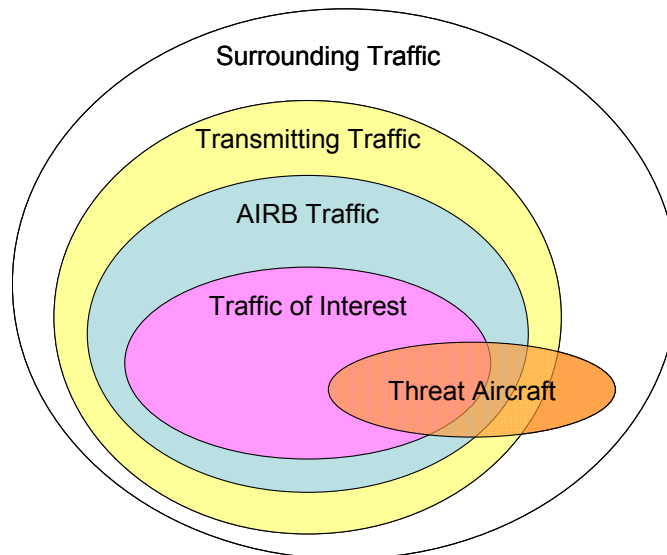
Latency Compensation: The process of extrapolating position data to a new time of applicability in order to reduce the effects of latency on reported position.

Receive Aircraft Domain: The minimum surveillance functional architecture which includes reception of ADS-B messages (by the ADS-B Receive Function) and, where applicable, surveillance data processing, AIRB Aircraft's sensor data processing and applications-specific processing. In addition, where applicable, the provision of necessary information to the flight crew is provided by the Traffic Display Function and its associated control interface.

Reliability: The probability that a system or service will be available throughout a specified geographic volume for a specified amount of time without degradation or failure to the service or system.

Spacing: Distance or time interval between aircraft.

Surrounding Traffic: An airborne aircraft in the vicinity of the AIRB Aircraft.



Surveillance Transmit Processing (STP) function: Function that prepares the required ADS-B information for transmission by the ADS-B transmit function from on-board aircraft sensors and aircraft systems (e.g. FMS – Flight Management System) in the Transmit Aircraft Domain. STP also provides on-board sensor and systems information to the ASSAP function in the Receive Aircraft Domain.

Threat Aircraft: A Surrounding Traffic which may be in proximity to the position or whose flight path crosses the intended route of the AIRB Aircraft and presents a risk of mid-air collision.

Total Latency: The difference between the time of applicability of data at the output of the sensor and the time of observation of that data. When there is need to discuss total latency between specific interfaces, those interfaces and the associated times will be explicitly described.

Traffic Display: Graphical display of traffic information component of the AIRB Equipment which supports the flight crew in the tasks of building traffic situational awareness and enhancing flight operations.

NOTE: *While this document does not specify a specific implementation, minimum performance requirements are provided in Table 3.3.*

Traffic of Interest: A subset of AIRB Traffic which is considered of interest by the flight crew.

Transmit Aircraft Domain: The minimum surveillance functional architecture which includes onboard aircraft sensors and associated processing and the subsequent formulation of ADS-B messages to be transmitted (represented by the ADS-B Transmit Function).

Transmitting Traffic: A Surrounding Traffic transmitting ADS-B messages and within ADS-B range.

Uncompensated Latency: That portion of Total Latency that is not compensated for and that cannot be compensated for later in the data stream. The uncompensated latency of AIRB Traffic or the AIRB Aircraft is defined from the time of applicability of the position data at the output of the position sensor to the time of transmit or observation of that data. When there is need to discuss uncompensated latency between specific interfaces, those interfaces and the associated times will be explicitly described.

Velocity: The speed and direction of motion of an aircraft. Velocity is a vector quantity.

1.4 STRUCTURE OF THE DOCUMENT

- Chapter 1 (the current chapter) provides an explanation of the purpose and scope of this document and introduces the ATSA-AIRB application and the SPR/INTEROP document and processes.
- Chapter 2 describes the approach and methodology aspects applied for the development of this application and the safety, performance and interoperability assessments.
- Chapter 3 provides the consolidated Safety and Performance Requirements applicable to the ATSA-AIRB application. It also includes the key assumptions made for the ATSA-AIRB application.
- Chapter 4 introduces the data-link independent Interoperability Requirements applicable to the ATSA-AIRB application.
- Annex A is the Operational Services and Environment Definition (OSD) for ATSA-AIRB. This describes the services, intended functions and associated procedures of the ATSA-AIRB application and the assumptions about the environment in which the application is specified to operate. It also contains phase diagrams that give an illustrative (flow chart) description of the steps of the fundamental procedures applied and which are used as part of the analysis process. It includes two appendices; one providing description of the services provided and flight requirements depending on the airspace as defined in ICAO Annex 11 [4] and one illustrating possible ATSA-AIRB operations.
- Annex B is the Operational Performance Assessment (OPA). This determines minimum Performance Requirements for the surveillance data (received and from AIRB Aircraft), associated processing and the display of traffic for the Receive Aircraft Domain. The OPA also derives a set of assumptions on the Transmit Aircraft Domain needed for the application. It includes two appendices; one providing the details of the mathematical analysis and one providing ATSA-AIRB availability enhancement techniques, including a table of conversions between ADS-B data quality indicators.
- Annex C is the Operational Safety Assessment (OSA). This Annex explains in detail the methodology used for this assessment, which is based on ED-78A/DO-264 [9]. The Annex also presents the detailed tables of results of the Safety Assessment itself. It includes three appendices, providing the Hazard Classification matrix, the analysis of the safety implications of using ATSA-AIRB in an ADS-B environment on the ground and the Fault Trees symbols legend.
- Annex D provides the list of acronyms used in this document.
- Annex E provides a list of participants who have contributed to the development of this document.

1.5 REFERENCES

This SPR/INTEROP document considers material from ICAO, EUROCONTROL and EUROCAE/RTCA, as listed below.

1.5.1 ICAO

- [1] "Air Traffic Management", ICAO, Procedures for Air Navigation Services, Document 4444, Fifteenth edition-2007
- [2] Annex 2, Rules of the Air, 10th Edition, Amendment No. 39, 23 November 2006
- [3] Annex 10, Volume 4, Volume IV, Surveillance Radar and Collision Avoidance Systems, Fourth Edition, July 2007
- [4] Annex 11, Air Traffic Services, 13th Edition, Amendment No. 40, July 2001
- [5] "Aircraft Operations", ICAO Procedures for Air Navigation Services, Doc 8168, Volume 1, Fifth edition, Amendment 3, 20 November 2008

1.5.2**EUROCONTROL**

- [6] Description of a First Package of GS/AS Applications, CARE/ASAS Ref. CA-02-040 (2.2), version 2.2, September 30, 2002
- [7] EUROCONTROL Safety Regulatory Requirement – ESARR 4: Risk Assessment and Mitigation in ATM, Edition 1.0
- [8] EUROCONTROL ACAS Safety Bulletin # 6, "Incorrect Use of the TCAS Traffic Display", March 2005

1.5.3**EUROCAE/RTCA**

- [9] ED-78A/DO-264: Guidelines for Approval of the Provision and Use of air Traffic Services Supported by Data Communications, March 2002
- [10] DO-242, Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS-B), February 19, 1998
- [11] DO-242A, Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS-B), June 25, 2002
- [12] DO-242A, Change 1, Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS-B)
- [13] ED-126/DO-303, Safety, Performance and Interoperability Requirements Document For ADS-B-NRA application, December 2006
- [14] ED-161/DO-318, Safety, Performance and Interoperability Requirements Document for Enhanced Air Traffic Services in Radar-Controlled Areas Using ADS-B Surveillance (ADS-B-RAD), September 2009
- [15] ED-160/DO-314, Safety, Performance and Interoperability Requirements Document for Enhanced Visual Separation on Approach (ATSA-VSA), December 2008
- [16] ED-159/DO-312, Safety, Performance and Interoperability Requirements Document for the In-Trail Procedure in Oceanic Airspace (ATSA-ITP) Application, June 2008
- [17] DO-317, Minimum Operational Performance Standards for Aircraft Surveillance Applications System (ASAS), April 2009
- [18] ED-12B/DO-178B, Software Considerations in Airborne Systems and Equipment Certification, December 1992
- [19] ED-80/DO-254, Design Assurance Guidance for Airborne Electronic Hardware, April 2000
- [20] DO-208, Minimum Operational Performance Standards for Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS), RTCA Inc., July 1991
- [21] DO-229D, Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment, RTCA Inc., Issued December 2006
- [22] DO-253C, Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment, December 2008
- [23] DO-282A, Minimum Operational Performance Standards for Universal Access Transceiver (UAT) Automatic Dependent Surveillance – Broadcast, July 2004
- [24] DO-282B, Minimum Operational Performance Standards for Universal Access Transceiver (UAT) Automatic Dependent Surveillance – Broadcast, December 2009
- [25] DO-286A, Minimum Aviation System Performance Standards (MASPS) for Traffic Information Service – Broadcast (TIS-B), April 2005

- [26] DO-286B, Minimum Aviation System Performance Standards (MASPS) for Traffic Information Service – Broadcast (TIS-B), October 2007
- [27] DO-310, Minimum Operational Performance Standards for GPS Ground-based Regional Augmentation System Airborne Equipment, March 2008
- [28] DO-316, Minimum Operational Performance Standards for Global Positioning System/Aircraft Based Augmentation System Airborne Equipment, April 09
- [29] ED-125, Process Specification for Performing Risk Assessment and Mitigation in ATM in Compliance with ESARR4, November 2009
- [30] ED-102A/DO-260B, Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B), December 2009
- [31] DO-260A, Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B), April 2003

CHAPTER 2

APPROACH AND METHODOLOGY

2.1 DOCUMENT DEVELOPMENT PROCESS

This document was developed in accordance with the ED-78A/DO-264 guidelines for the definition of operational, safety, performance and interoperability requirements [9].

The approach used is top-down in nature with an initial focus on the operational perspective. The gradual increase of the involvement of systems expertise (and decrease of the relevance of operational aspects) occurs when the work advances to the SPR and INTEROP process.

This work is iterative in nature as each phase of the process feeds back into the previous work to mature and refine the work and to ensure completeness and consistency. As an example, during initial Operational Safety Assessment (OSA), comments are fed back into the OSED identifying required additions or needs for clarification.

While the process moves from a more operational perspective to a system oriented one, it is critical that key operational and analytical people are involved throughout, to ensure overall consistency and coherence of the work and material.

2.2 METHODOLOGY

Requirements are developed for ATSA-AIRB by developing an Operational Services and Environment Definition (OSED), deriving Safety and Performance Requirements (SPR), allocating those requirements to the relevant domains and developing Interoperability Requirements (IR) which specify the exchange of data between the domains. Each of these areas is described in the subsections below.

2.2.1 Operational Services and Environment Definition (OSED)

The OSED (Annex A) describes the services, intended functions and associated procedures of the ATSA-AIRB application and the assumptions about the environment in which the application is specified to operate. It provides a detailed list of Assumptions and Operational Requirements (OR) characterizing the application to be assessed.

The OSED was developed to enhance flight crews' traffic situational awareness and thus possibly improving flight operations on the basis of existing procedures defined in ICAO documents, in particular Doc 4444 [1], Doc 8168 [5] and Annex 2 [2].

The ATSA-AIRB application is broken down into two phases. These are: "Building of enhanced traffic situational awareness" and "Enhanced flight operations". For each of these phases, detailed descriptions and phase diagrams are provided in 0.

The OSED also defines the characteristics of the environment in which the ATSA-AIRB application is intended to be used. These Environmental Conditions play a role in determining the assumptions, requirements and mitigations derived in the Operational Safety Assessment (OSA) and Operational Performance Assessment (OPA).

2.2.2 Safety and Performance Requirements (SPR)

Based on the description elements of the OSED, two assessments were performed to derive the requirements needed to assure proper and safe execution of the ATSA-AIRB application.

The two assessments and how they are used to derive final SPR requirements are as follows:

- The OPA derives Performance Requirements (PR) by examining all Operational Requirements and assumptions defined in the OSED. These Performance Requirements establish the minimum requirements for the ATSA-AIRB application under nominal conditions. The OPA is found in Annex B;
- The OSA derives Safety Requirements (SR) by considering Operational Hazards introduced by ATSA-AIRB. These Operational Hazards are examined in order to control their likelihood and their effects. The OSA is found in Annex C.

NOTE: *For a more detailed description of the methodologies used for these assessments, please refer to §3.1 and the Annexes themselves.*

A key component of the OPA and OSA processes is to provide feedback to the OSED when it is realized that necessary material is missing, clarification is needed, or changes are required to make the application more workable. In turn, any changes to the OSED must be examined alongside their effects on both the OPA and OSA. This iterative cycle continues until the OPA and OSA are completed.

The OPA and OSA processes also apportion the requirements between the relevant domains. For the ATSA-AIRB application, these requirements are placed on the Receive Aircraft (see Figure 1.1 and Figure 3.1).

NOTE: *Transmit Aircraft Domain and Receive Aircraft Domain are terms used when allocating requirements. For operational aspects or explanatory text, the terms “AIRB Traffic” / “Traffic of Interest” and “AIRB Aircraft” are respectively used throughout this document.*

The final step is a reconciliation process in which the underlying requirements are identified in the OSED, OPA and OSA and brought forward into Chapter 3. When a requirement on the same attribute is derived independently from multiple assessments, the most demanding value is retained.

The ATSA-AIRB application does not forbid aircraft, regardless of the level of their ADS-B equipage, from flying in airspace where ATSA-AIRB operations are conducted. As a result of the OPA and the OSA, assumptions are made about the Transmit Aircraft and Safety and Performance Requirements are levied on the Receive Aircraft. This includes, for example, stating requirements such that the Receive Aircraft is only permitted to perform the ATSA-AIRB application against Transmitting Traffic for which the received ADS-B data meet the safety, performance and interoperability requirements defined for ATSA-AIRB. This does not place data quality requirements on all aircraft transmitting ADS-B data in the airspace, but rather qualifies when the AIRB Aircraft may conduct an ATSA-AIRB operation.

2.2.3 Interoperability Requirements (INTEROP)

The objective of the interoperability assessment is to identify the minimum requirements needed to ensure that the elements of the CNS/ATM system employed for ATSA-AIRB will correctly work together to carry out their intended function in a safe manner. Recommendations are also proposed so that systems are designed in a robust fashion to accommodate growth and other ADS-B applications.

The Interoperability Requirements (IR) for the ATSA-AIRB application are defined as the minimum interface needed between the Transmit Aircraft Domain and Receive Aircraft Domain (i.e. AIRB Traffic and AIRB Aircraft) as measured at interface D in Figure 1.1. These requirements are expressed in a manner that is independent of any data link technology, but do differentiate between requirements for DO-242 [10], DO-242A [11] and more recent standards (e.g. ED-102A/DO-260B [30] or DO-282B [24]) compliant systems where appropriate.

The set of Interoperability Requirements is meant to specify the required capabilities of the Receive Aircraft Domain regarding the data received from the Transmitting Traffic, for the proper operation of the ATSA-AIRB application.

2.3 KEY TERMS

The following subsections define four key terms used throughout this document; these are: assumptions, mitigation means, requirements and recommendations. Assumptions are important aspects of the operational definition of the ATSA-AIRB application and have a profound impact on the associated requirements. While the primary objective of this document is to present minimum requirements needed for the operations defined for the application, recommendations are also proposed – found primarily in the INTEROP – which identify highly desirable options or performance above the absolute minimum specified.

2.3.1 Uses of requirements and recommendations and key words

The SPR/INTEROP chapters contain "shall" and "should" statements with the following meanings:

- **"Shall"** statements ensure safe, compatible and interoperable systems of sufficient performance for the ATSA-AIRB application. The use of the word "shall" indicates a minimum requirement for the application.
- The use of the word **"should"** indicates a recommendation that would typically improve the application but does not constitute a minimum requirement; and
- The use of the word **"will"** describes expected system behaviour when the system complies with the references requirements and/or this section's requirements.

2.3.2 Assumptions

Assumptions form an important basis for all assessments and analyses contained in this document. All requirements must be considered within the context of the assumptions made, as well as the operations and environments defined. For the implementation of ATSA-AIRB, any deviation from the assumptions noted in this document could impact the corresponding requirements and therefore must be accounted for in supporting analysis or introduction of other assumptions and/or mitigations.

Assumptions have been made at various stages of the development process of this document. These assumptions include procedural and environmental assumptions within both the OSED and SPR work.

A listing of major assumptions used in the SPR process is found in §3.2.

2.3.3 Requirements

Requirements are expressed using the word **"shall"**.

Operational Requirements are identified within the OSED. These include procedures that must be followed for the operations defined for the application to be properly executed. Within the OSED (Annex A), these Operational Requirements are enumerated with the **"OR#"** tag.

Performance Requirements are identified within the OPA (Annex B). These are minimum requirements needed for the application to properly work under nominal (no fault) conditions. These Performance Requirements are enumerated with the “**PR#**” tag.

Safety Requirements are identified within the OSA (0). They correspond to minimum quantitative or functional requirements that are defined on the AIRB Equipment (see §1.3 for definition) to meet the Safety Objective assigned to each Operational Hazard. These requirements are enumerated with the “**SR#**” tag.

Chapter 3 contains all of the Safety and Performance Requirements which are then categorized as Operational Requirements, AIRB Equipment requirements and ATSA-AIRB data requirements on the Receive Aircraft Domain. The SPR retains the most demanding requirements when they are common to both the OPA and OSA. The consolidated SPR represents the minimum requirements needed for implementation of the ATSA-AIRB application and are enumerated with the “**SPR#**” tag.

The last category of requirements is Interoperability Requirements. These are specified in Chapter 4 and are enumerated with the “**IR#**” tag. Interoperability Requirements are requirements for the interchange of data between the Transmit Aircraft Domain and the Receive Aircraft Domain and are based on the final SPR requirements. Chapter 4 specifies these requirements at an ADS-B system level (i.e. independent of any specific ADS-B data link).

FIGURE 2.1: TRACEABILITY SCHEME

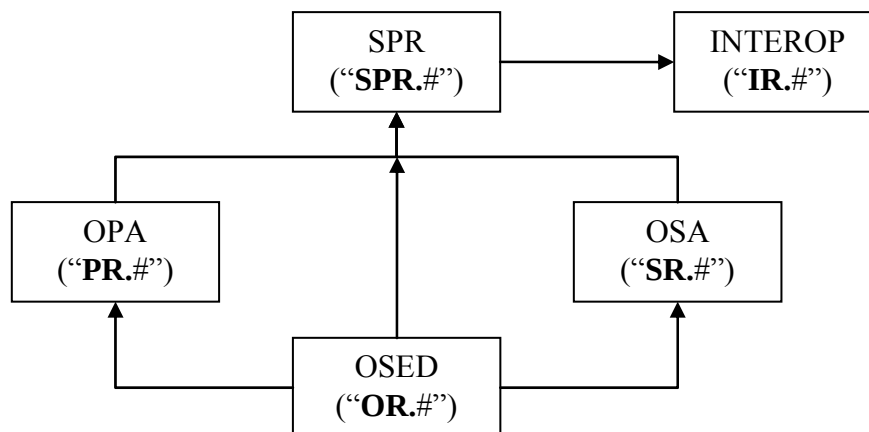


Figure 2.1 illustrates the different types of requirements and shows where they are specified and what is used to derive them.

2.3.4

Recommendations

The primary objective of this document is to specify the minimum requirements needed for implementation of the ATSA-AIRB application as defined in the OSER. While these requirements consider ATSA-AIRB as an isolated application, it is recognized that other ADS-B applications are likely to be performed by both aircraft and ground systems. An application of particular interest is ATSA-SURF because it is the complementary application of ATSA-AIRB to address traffic situational awareness on the airport surface. Therefore, this document also proposes many recommendations, primarily in the INTEROP (Chapter 4). These recommendations are not minimum requirements for ATSA-AIRB but are optional capabilities or desired performance levels above the minimum required. Many of these recommendations are made to ensure development of robust ATSA-AIRB avionics systems capable of supporting multiple Airborne Surveillance Applications.

Recommendations are specified using the word “**should**” and within the INTEROP are given an “**IRec#**” tag.

CHAPTER 3

SAFETY & PERFORMANCE REQUIREMENTS (SPR)

3.1 BACKGROUND/INTRODUCTION

Chapter 3 contains the outcome of the Safety and Performance Requirements (SPR) assessment for the ATSA-AIRB application. These requirements were developed based on the process defined in RTCA DO-264/EUROCAE ED-78A [9]. The Safety and Performance Requirements detailed here are the requirements that resulted from retaining the most stringent values from the Operational Performance Assessment (OPA, Annex B) and the Operational Safety Assessment (OSA, Annex C).

3.1.1 OPA process

The OPA derives Performance Requirements (PR) by examining all Operational Requirements (OR) and assumptions defined in the OSED. Performance Requirements establish the minimum requirements for the ATSA-AIRB application to perform as intended under nominal conditions. The OPA is found in Annex B.

3.1.1.1 Operational objectives

The OPA examines the needs of the application as defined in the OSED and establishes operational objectives that should be met during fault-free ATSA-AIRB operations. These operational objectives then constrain the OPA analysis to determine minimum Performance Requirements.

Operational experts provide important feedback, in operational terms, for what minimum performance is needed from the AIRB Equipment to support their operational needs and to provide operational benefits. This input is translated into operational objectives, generally set at the interface between the flight crew and the Traffic Display. These objectives constrain the performance of the AIRB Equipment. The detailed analysis of each operational objective can be found in Annex B.

3.1.1.2 Data and display requirements

Throughout the analysis, Performance Requirements are set and assumptions are made on the various components of the surveillance functional architecture described in Figure 1.1. Based on the OSED (Annex A), the OPA determines the minimum data set needed to properly perform the ATSA-AIRB application under nominal conditions and then derives minimum requirements on the quality of that data and means in which it is displayed or conveyed to the flight crew.

3.1.1.3 Design considerations

Some consideration is given to certain aspects of the design of the AIRB Equipment, but no requirements are derived. These design considerations identified during the OPA process are provided in §3.6 and Annex B.

3.1.2 OSA process

The OSA derives Safety Requirements (SR) by considering unique Operational Hazards introduced by ATSA-AIRB or existing Operational Hazards that the ATSA-AIRB application might adversely affect. These Operational Hazards are examined in order to control their likelihood and their effects. The OSA is found in Annex C.

3.1.2.1 Operational Hazards

The two Operational Hazards studied in the OSA result from the flight crew being misled by the Traffic Display. In the first hazard, the flight crew is misled into thinking there is a threat situation whereas there is none and in the second, that there is no threat situation whereas there is one. It is important to note that while the flight crew could be misled in a similar manner in standard operations (incorrect visual interpretation of a traffic situation), the OSA considers these Operational Hazards that occur as the result of the Traffic Display scan by the flight crew. If one of this Operational Hazard occurs, the first action that the flight crew must perform before undertaking any action (e.g. to contact ATC) is to correlate the information provided by the Traffic Display with other available information (i.e. out the window and radio communications).

3.1.2.2 Mitigation means

Mitigation means are procedures or other aspects that are put in place to help reduce the frequency of exposure to Operational Hazards and/or to alleviate the consequences of Operational Hazards when encountered.

Some mitigation means are fall-back procedures or capabilities. These are called External Mitigation Means (**EMM**). They are mitigations that help to reduce the impact of an Operational Hazard once it has occurred.

Other mitigation means are called Internal Mitigation Means (**IMM**). They help to meet the Safety Objective assigned to the Operational Hazard by reducing the Operational Hazard's probability of occurrence.

Both External and Internal Mitigation Means are defined as Operational Requirements. Furthermore, Safety Requirements are defined on the AIRB Equipment to meet the Safety Objective assigned to each Operational Hazard (see §3.1.2.5).

All requirements specified in this document are done so within the context of these mitigation means being present. The removal or modification of any of these will require a demonstration that safety is still ensured, for example via proof that other mitigation means are at least equivalent.

3.1.2.3 Environmental Conditions

Environmental Conditions (**EC**) are used to describe the environment external to the application. Environmental Conditions may affect the effectiveness of a mitigation means, help to understand the apportionment of risk and may help to reduce the exposure to a hazard.

All requirements specified in this document are done so within the context of the Environmental Conditions enumerated in the OSA. If the operating environment for an implementation of ATSA-AIRB deviates from these ECs, then a demonstration that safety is still ensured will be required.

3.1.2.4 Event Trees

The analysis of an Operational Hazard begins with assuming that it has occurred and modelling the effects of its occurrence by way of an Event Tree. The modelling includes quantifying Barriers probability of success, which is determined by the effectiveness of the External Mitigation Means. The probability of Operational Effects such as increased flight crew workload, wake vortex encounter and collision, are estimated. For each Operational Hazard, a Safety Objective (SO) is derived, this being the greatest frequency of the hazard such that the Safety Target is met for every Operational Effect, when considering the estimated probability of the Operational Effects.

Operational input is a critical facet of the Event Tree analysis. As there are many decades of experience with the application of building traffic situational awareness in different environments, the behaviour of the flight crew and the controller when exposed to some Operational Hazards is well-understood. The analysis draws on this experience, for example in characterizing the effectiveness of human detection Barriers or in determining the severity of an effect.

3.1.2.5 Fault Trees

When the Safety Objective for an Operational Hazard is derived, the frequency of the Operational Hazard is modelled by a Fault Tree. Basic Causes are identified, modelled and combined according to the laws of probability, estimating the probability of occurrence of the Operational Hazard. Assumptions are made and Safety Requirements (SR) established so that each Safety Objective is met, concluding the safety analysis. Again, operational input plays an important part of this segment of the analysis.

3.1.2.6 Conclusion of the OSA

While specific conclusions are spelled out per Operational Hazard in Annex C, the OSA generally concludes that when the following requirements are respected, the AIRB Equipment will support the conduct of safe ATSA-AIRB:

- The probability of the AIRB Aircraft system integrity failure leading to AIRB data corruption is not greater than 1.0E-03 per flight hour and the probability of the AIRB Aircraft's horizontal position being incorrect and larger than the error bound (interface at B2) is not greater than 1.0E-03 per flight hour when reported as valid.
- The AIRB Traffic are such that the probability of their system integrity failure leading to ADS-B data corruption is no more than 1.0E-03 per flight hour and the probability of their horizontal position being incorrect and larger than the error bound (interface at B1) is no more than 1.0E-03 per flight hour when reported as valid.

NOTE: *The measurement error bound requirement in the above bullets for both AIRB Aircraft and AIRB Traffic is ensured by the accuracy requirement (refer to Table 3.6).*

The Safety Requirements on the system integrity are the major contributions from the OSA to the final Safety and Performance Requirements found in the rest of Section 3 and are listed in §3.4.2.1. The Safety Requirements on the horizontal position are consolidated together with the Performance Requirements on the horizontal position determined in the OPA in §3.5.

Furthermore, Appendix C.2 of the OSA has assessed that ATSA-AIRB operations in airspace where surveillance is based on ADS-B surveillance instead of radar surveillance, i.e. having common mode of horizontal position failures in both AIRB Aircraft and ATC display, are acceptable.

3.1.3 SPR process

The consolidated requirements expressed in this chapter are the final Safety and Performance Requirements and are enumerated with the "SPR#" tag. SPR.# requirements are allocated to the following:

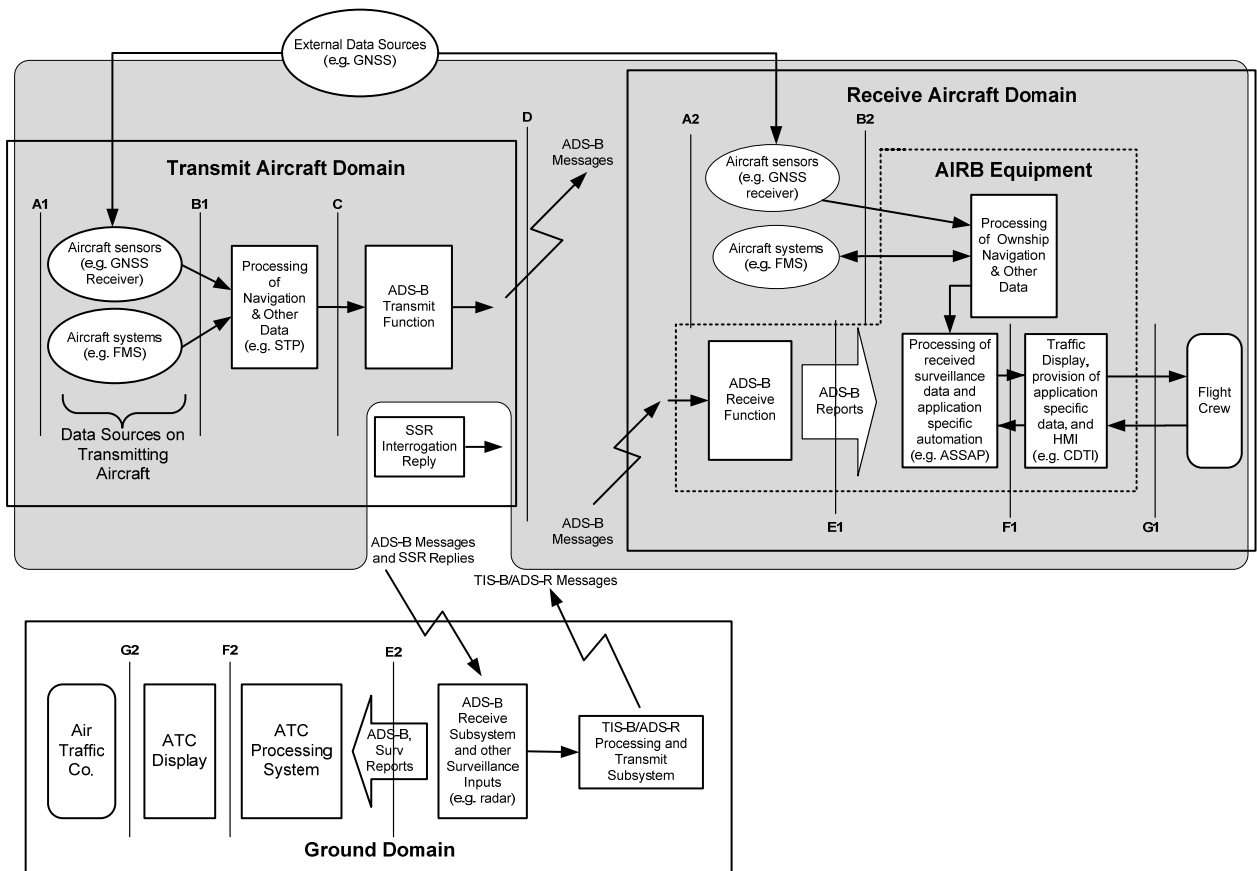
- Requirements on controller or flight crew procedures (see §3.3);
- Requirements on the Receive Aircraft Domain, i.e. the AIRB Equipment (see §3.4); and
- Requirements on the data from ownship (i.e. Receive Aircraft Domain) and received from Transmitting Traffic (i.e. Transmit Aircraft Domain) (see §3.5).

NOTE: *The SPR.# requirements in this Chapter represent the integration of requirements from the various annexes of this document (OR.#s from the OSED in Annex A, PR.#s from the OPA in Annex B and SR.#s from the OSA in 0). OR.#s, PR.#s and SR.#s should be interpreted to represent “OSED Requirements”, “OPA Requirements” and “OSA Requirements”, respectively. While the OR.#, PR.# and SR.# primarily specify operational, performance and safety requirements, respectively, functional requirements are also brought forward from the OSED and the OPA. The tags are used simply for traceability back to the annexes. The final SPR.#s specified in this chapter are organized by Operational Requirements (Table 3.1), Equipment Requirement (Table 3.2), Functional Requirements (Table 3.3), system-related (Aircraft Domain) Performance Requirements (Table 3.4 and Table 3.5) and data-related requirements (Table 3.6). Each SPR.# is associated with at least one requirement from the OSED, OPA or OSA as noted in the tables.*

NOTE: *ATSA-AIRB is necessarily focused on the Receive Aircraft Domain (i.e. the AIRB Equipment and the data used by the AIRB Equipment). While the data on the AIRB Traffic is generated and broadcast from the Transmit Aircraft Domain, the requirements are specified for the use of the received data which meets the SPR requirements in this document (see Figure 3.1 below for illustration of domains relevant to ATSA-AIRB application.).*

This document makes no indication of whether aircraft are required to meet the ATSA-AIRB transmit requirements for a particular airspace - merely that in order to be considered for the application by the Receive Aircraft Domain, transmit requirements must be met.

Figure 3.1 replicates the Package I functional architecture depicted in Figure 1.1, however the shaded area illustrates the parts of each domain relevant to the ATSA-AIRB application.

FIGURE 3.1: SURVEILLANCE FUNCTIONAL ARCHITECTURE FOR ATSA-AIRB

NOTE: In Figure 3.1, the dotted box – including both the “ADS-B Receive Function” and the three boxes of the “Aircraft Processing Functions” as defined in Figure 1.1 earlier in §1.2.2 – represents the functional aspects referred to as “AIRB Equipment” throughout this document.

NOTE: TIS-B and ADS-R are not required for the ATSA-AIRB application. Therefore, references to TIS-B and ADS-R in the Receive Aircraft Domain that are included in Figure 1.1 have been removed. However, TIS-B and ADS-R could also support the application if available and compliant with safety, performance and interoperability requirements developed for ATSA-AIRB.

NOTE: The role of the ground domain for ATSA-AIRB is captured in the OSED (Annex A). No system capabilities are imposed on the ground domain.

3.2

ASSUMPTIONS

This section outlines the key assumptions used in the analyses contained in this document for the use of the ATSA-AIRB application. The assumptions described in this section are brought forward from those stated in the OSED (Annex A), the OPA (Annex B) and the OSA (Annex C).

IMPORTANT: This is not a listing of all assumptions made for every analysis used for this report, but a listing of only those considered to be the most relevant. All the detailed assumptions can be found in the OPA (see §0 in Annex B,) and the OSA (see §0 in Annex C). All the assumptions in the SPR and the annexes have to be considered and checked before implementing ATSA-AIRB requirements provided in this document.

§3.2.1 describes a group of general assumptions, which provide the foundation for the ATSA-AIRB application. §3.2.2 provides the assumptions about the environment in which the ATSA-AIRB application is based. §3.2.3, §3.2.4 and §3.2.5 provide the assumptions that apply to the domains of the Receive Aircraft, Transmit Aircraft and Ground respectively and are mostly at a more detailed level than those in §3.2.1 and §3.2.2 but are derived from the same sources (i.e. Annex A, Annex B and Annex C).

3.2.1

General assumptions

This section describes the general assumptions about the ATSA-AIRB application and the scope of this document.

- The ATSA-AIRB application may be used from the runway departure on take-off, through in-flight operations and during approach to touchdown. (ASSUMP-OSD.5)
- It is a flight crew's decision whether to use the Traffic Display during flight operations. The scope of the ATSA-AIRB application only includes the situations where the flight crew uses the Traffic Display. (ASSUMP-OSD.13)
- When the flight crew disregards the information given by the Traffic Display, it is assumed that they will react to the situation in the same manner as they would do today without a display and this has been considered as acceptably safe and classified as "No Safety Effect" (severity 5) when studying the impact of the ATSA-AIRB application. (ASSUMP-OSA.1)
-

The scope of the ATSA-AIRB application only provides for the display of traffic which meets the requirements derived in the OPA and OSA (Annexes B and C, respectively) and specified in Chapter 3. The display of traffic that does not meet these requirements is outside the scope of this application. Any implementation that supports the display of traffic that does not meet the minimum requirements needed for ATSA-AIRB will need appropriate safety and performance assessments. (ASSUMP-OSED.14)

- There is no change in existing phraseology when using the ATSA-AIRB application. (ASSUMP-OSED.15)
- Abuse and intentional misuses of information provided by the Traffic Display to the flight crew are outside the scope of the ATSA-AIRB assessment (e.g. manoeuvring the aircraft based solely on information provided by the Traffic Display, and voluntarily ignoring other sources of information). (ASSUMP-OSED.6)
- Security issues are outside the scope of this document. (ASSUMP-OSA.3)
- The integration of the ATSA-AIRB application with other Airborne Surveillance Applications and in particular ATSA-SURF is outside the scope of the ATSA-AIRB assessment. (ASSUMP-OSED.10)

NOTE: *ATSA-AIRB can be implemented as a standalone application (e.g. in a General Aviation environment) but when it is integrated in a more complicated system with other Airborne Surveillance Applications, it should be the nominal display over which other applications are laid.*

- Functions such as an alerting function, use of CPDLC, or provision of information regarding aircraft equipment capabilities to controllers are out of the scope of this document. (ASSUMP-OSED.7)
- The use of TIS-B or ADS-R to supplement ADS-B surveillance sources for ATSA-AIRB is predicated on received data quality for the associated source. (ASSUMP-OSED.8)

NOTE: *Although TIS-B and ADS-R are not minimum requirements for the ATSA-AIRB application, they could also support the application if available and compliant with safety, performance and interoperability requirements developed for ATSA-AIRB. Specific TIS-B/ADS-R link requirements can be found in DO-260A&B, DO-282A&B and DO-286A&B.*

- Safety nets, such as conflict alerts, alerting functions and TCAS, are not used as mitigation means. (ASSUMP-OSA.2)

3.2.2

Environmental assumptions

This section describes the major assumptions about the operational environment for the ATSA-AIRB application.

- The ATSA-AIRB application can be used by aircraft operating in any airspace class (i.e. A to G). (ASSUMP-OSED.1)
- The ATSA-AIRB application can be used by aircraft operating under Instrument Flight Rules (IFR) and Visual Flight Rules (VFR). (ASSUMP-OSED.2)
- The ATSA-AIRB application can be used under both Instrument Meteorological Conditions (IMC) and Visual Meteorological Conditions (VMC). (ASSUMP-OSED.3)
- The ATSA-AIRB application can be used in airspace of any traffic density. (ASSUMP-OSED.4)
- In airspace where ATC services are not available and the visibility conditions are below ICAO VMC thresholds, the traffic density is low. (ASSUMP-OSA.10)
- The ADS-B equipage (i.e. ADS-B OUT and ADS-B IN) within the deployment environment will be partial. (ASSUMP-OSED.12)

- For the purpose of the safety assessment, it is assumed that Surrounding Traffic is not equipped with ADS-B IN. (ASSUMP-OSA.8)

3.2.3

Receive Aircraft Domain assumptions

This section focuses on the assumptions made concerning the roles of the flight crew and the AIRB Equipment of the AIRB Aircraft, i.e. the Receive Aircraft Domain as defined in Figure 1.1.

- The ATSA-AIRB application does not change roles or responsibilities for flight crews in comparison with existing operations. (ASSUMP-OSD.17)
- The pressure altimetry system of the Receive Aircraft Domain is assumed to perform as well as or better than what is encountered during existing operations. (ASSUMP-OPA.9)

NOTE: *Current altitude system performance for transponder-based surveillance is defined in ICAO Annex 10.*

- The AIRB Aircraft's heading or track errors are assumed to be less than 5 degrees, 95%. (ASSUMP-OPA.3)

NOTE: *If the orientation of the Traffic Display is derived from ownship horizontal velocity, then the Traffic Display will be more prone to orientation errors at lower speeds. For example, when ownship's velocity is 90 knots and horizontal velocity errors are 20 knots, 95%, the orientation of the display will be in error by 10 degrees, 95%. Such systems are permissible, but the flight crew should be made aware of this aspect of the display.*

- At a range of 5 NM, the 95% update interval for both horizontal position and velocity data is assumed to be no more than 3 seconds. (ASSUMP-OPA.14)

NOTE: *This assumption is supported by the modelling in the link MOPS, ED-102/DO-260, DO-260A and DO-282.*

NOTE: *The assumed update interval for traffic far away is not expected to be met; however the impact on ATSA-AIRB operations is assessed negligible. The operational need for situational awareness for traffic far away is less time critical and less stringent with respect to position accuracy on the display.*

3.2.4 Transmit Aircraft Domain assumptions

This section focuses on assumptions that are made for the AIRB Traffic, i.e. the Transmit Aircraft Domain as defined in Figure 1.1.

- Some Surrounding Traffic is equipped with ADS-B OUT transmitters and broadcast ADS-B data meeting requirements to support the ATSA-AIRB application. (ASSUMP-OSED.11)
- The following data items are provided to the AIRB Equipment via ADS-B OUT by the Transmit Aircraft Domain when available to the ADS-B Transmit Function in the Transmit Aircraft Domain (ASSUMP-OPA.1):
 - Horizontal Position
 - Altitude
 - Horizontal Velocity
 - Aircraft Identification
 - Horizontal Position Accuracy
 - Horizontal Velocity Accuracy
- The Transmit Aircraft Domain is assumed to provide sufficient means to enable the Receive Aircraft Domain to correctly associate all the following Transmit Aircraft Domain data items (i.e. the ADS-B link must have functional mechanisms to associate all received messages from each aircraft so that ADS-B reports can be correctly assembled) (ASSUMP-OPA.2):
 - Horizontal Position
 - Altitude
 - Horizontal Velocity
 - Aircraft Identification
 - Horizontal Position Accuracy
 - Horizontal Velocity Accuracy
- The transmitted uncompensated latency from the time of applicability of the measurement of position data at interface B1 to the time of applicability at reception at interface D is less than 1.5 seconds, 95%. (ASSUMP-OPA.6)

NOTE: *In this analysis, transmitted uncompensated latency is modelled as Gaussian with a mean of 300 milliseconds and a standard deviation of 600 milliseconds. Onboard uncompensated latency is a fixed worst-case value.*

- The total latency of horizontal position and velocity data between interfaces B1 and D is less than 1.5 seconds, 95%. (ASSUMP-OPA.13)
- The NACp value transmitted by ADS-B is derived directly from the quality metrics provided by the source at interface B1. (ASSUMP-OPA.7)
- The Transmit Aircraft Domain provides measurements of horizontal position and velocity to interface B1 at a rate of at least once per second. (ASSUMP-OPA.12)
- The ADS-B pressure altimetry and reporting system of the Transmit Aircraft Domain is assumed to perform as well as or better than what is encountered during existing operations. (ASSUMP-OPA.8)

NOTE: *Current altitude system performance for transponder-based surveillance is defined in ICAO Annex 10.*

- If the vertical tendency is determined from ADS-B transmitted vertical rate, the ADS-B barometric altimetry and reporting system of the Transmit Aircraft Domain is assumed to report vertical rate with an accuracy that is at least in line with certified Vertical Velocity Instruments. (ASSUMP-OPA.11)

NOTE: *The use of geometric vertical data and geometric vertical rate data (from both AIRB Traffic and AIRB Aircraft) to indicate the vertical tendency is acceptable as long as the characteristics and the quality is at least as good as from a certified barometric altimetry system.*

- The transmitted Aircraft Identification is identical to, or the coded equivalent of, the aircraft call sign to be used in air-ground communications and which is used to identify the aircraft in ground-ground air traffic services communications (Doc 4444 – PANS-ATM, Chapter 1). (ASSUMP-OPA.10)

3.2.5

Ground Domain assumptions

This section focuses on the assumptions that are made for the Ground Domain as defined in Figure 1.1.

- There is no specific requirement on the ground CNS. (ASSUMP-OSD.9)
- The ATSA-AIRB application does not change roles or responsibilities for controllers in comparison with existing operations. (ASSUMP-OSD.16)
- The surveillance means for ATC considered in the main OSA is radar surveillance only and does not include ADS-B surveillance. (ASSUMP-OSA.4)

NOTE: *The safety assessment for the ATSA-AIRB application was originally conducted assuming radar surveillance only. Appendix C.2 was included at a later stage of the SPR development process. This is the reason the assessment for environments with ADS-B based ground surveillance have been included in a separate appendix and not the main OSA. Appendix C.2 shows that ATSA-AIRB operations in airspace where ground surveillance is based on ADS-B are acceptable.*

- In airspace where ATC service is provided based on surveillance but some flights are not being controlled, or in airspace where ATC service is not provided based on surveillance (i.e. procedural control), it is assumed that the controller cannot detect an unsafe manoeuvre or a reduction in Safety Margins. (ASSUMP-OSA.7)

3.3

OPERATIONAL REQUIREMENTS

Operational Requirements specify the procedural elements of the ATSA-AIRB application associated with the operators. These Operational Requirements identify and define the necessary procedural steps, tasks and actions that must be performed by these operators for proper execution of the application. In the case of the ATSA-AIRB application, all the Operational Requirements are defined for the flight crew of the AIRB Aircraft.

The Operational Requirements are specified in Table 3.1 below and are accompanied by references to the corresponding Operational Requirements defined in the OSD (0). These Operational Requirements are used to define the proper use of the AIRB equipment. These Operational Requirements are not meant to be used as part of the certification of AIRB equipment. Table 3.1 simply states the assumed use of the AIRB application and related procedures by the flight crew on which the rest of the requirements found in this section are derived to assure safe and proper use of the ATSA-AIRB application.

NOTE: *Some Operational Requirements defined in the OSD are more functional requirements than operational requirements and therefore, they are listed in Table 3.3 “Functional Requirements for AIRB Equipment”.*

As described in the OSED (Annex A), the ATSA-AIRB application includes two phases:

- “Building of enhanced traffic situational awareness”: the flight crew scans the Traffic Display to identify any Traffic of Interest among the AIRB Traffic, correlates the Traffic Display information with any other available sources of information (i.e. out the window and/or radio communication) to check consistency, collects missing information if deemed necessary and assesses the traffic situation based on all available information. The flight crew can also look at the Traffic Display to try to identify if a known traffic (e.g. following visual acquisition or traffic information from the controller) is displayed. Then, they correlate the various sources of information for this traffic.
- “Enhanced flight operations”: After building this enhanced traffic awareness, the flight crew uses the information and knowledge acquired to operate the aircraft as in existing operations (according to the flight rules and class of airspace) but having an enhanced traffic situational awareness.

As an illustration, these phases correspond to the two tasks of the “see-and-avoid” procedure. The first action (i.e. “see”) consists in achieving visual acquisition on another aircraft and in determining whether this aircraft is a threat. With ATSA-AIRB, the flight crew will be supported by the Traffic Display in addition to the out the window information to determine whether an avoiding manoeuvre is needed. Then, the second action (i.e. “avoid”) consists in manoeuvring safely to avoid this threat. With ATSA-AIRB, the flight crew will be supported by the Traffic Display in addition to the out the window information to better assess the traffic situation while manoeuvring.

Table 3.1 lists the Operational Requirements for each of the two phases and when appropriate, for the specific tasks.

TABLE 3.1: OPERATIONAL REQUIREMENTS

Phase (Task)		Operational Requirement	Source
Building of enhanced traffic situational awareness	Traffic Display Scan	SPR.1 If the flight crew detects a Traffic Display failure, the flight crew shall disregard the Traffic Display.	OR.20
	Consistency check of the Traffic Display	SPR.2 Whenever visual conditions permit, the flight crew shall check consistency between the Traffic Display information on a AIRB Traffic first identified on the display and the out the window information when visual contact is achieved.	OR.9
		SPR.3 If the flight crew detects AIRB Traffic on the Traffic Display with displayed information not consistent with out the window, the flight crew shall disregard the inconsistent piece of information for this AIRB Traffic provided by the Traffic Display and use the out the window information.	OR.10
		SPR.4 Whenever information is available by radio communications, the flight crew shall check consistency between the traffic information provided by the controller or the AIRB Traffic flight crew and the Traffic Display information.	OR.11

Phase (Task)		Operational Requirement	Source
		SPR.5 If the flight crew detects Traffic of Interest on the Traffic Display with displayed information not consistent with radio communication information and if the flight crew wants to use the displayed information, the flight crew shall cross-check with the controller in controlled airspace or the Traffic of Interest flight crew in uncontrolled airspace for confirmation. <i>NOTE: When assessing the consistency between Traffic Display information and information provided by the controller, the flight crew should take into account the evolution of the traffic situation; the displayed information is continuously updated and it can vary from the information received from the controller, which is based on a past situation. In case of doubt and when necessary from a safety perspective, the flight crew may decide to ask confirmation from the controller.</i>	OR.12
Flight Operations		SPR.6 Within the ATSA-AIRB application, the flight crew shall not undertake any manoeuvres relative to Traffic of Interest based solely on the Traffic Display that would lead to either a deviation from or a non-execution of an ATC clearance or instruction. <i>Note: The flight crew must comply with existing ICAO SARPS, for instance Annex 2 - Rules of the Air, Chapter 3 - General Rules, Section 3.6 - Air Traffic Control Service, paragraph 3.6.2 - Adherence to Flight Plan.</i>	OR.13
		SPR.7 As in existing operations, for AIRB Aircraft also equipped with an ACAS II, if an RA is triggered when using the ATSA-AIRB application, the flight crew shall apply the ACAS procedure for flight crews described in ICAO PANS-OPS Doc 8168.	OR.14
		SPR.8 As in existing operations, for AIRB Aircraft also equipped with a separate ACAS II Traffic Display, if a TA is triggered when using the ATSA-AIRB application, the flight crew shall reference the ACAS II Traffic Display for assistance in visual acquisition of the traffic that generated the TA.	OR.15
		SPR.9 As in existing operations, when alerted to a hazard by the controller, the flight crew shall, without delay, take appropriate measures to ensure the safety of the operations.	OR.16
		SPR.10 As in existing operations, upon out the window visual detection of a hazard, the flight crew shall, without delay, take appropriate measures to ensure the safety of the operations.	OR.17
		SPR.11 As in existing operations, before any manoeuvre, and visual conditions permitting, the flight crew shall perform a visual scan to check if the area they want to manoeuvre towards is free of traffic.	OR.18
		SPR.12 As in existing operations, if ATC service is provided and air/ground communications are reliable the flight crew shall, time permitting, announce to ATC any intentions to manoeuvre before undertaking the manoeuvre.	OR.19
Both		SPR.13 Flight crews shall be trained on the ATSA-AIRB application. <i>NOTE: Some training considerations identified by the OSA are consolidated in §3.7.</i>	OR.21

3.4 AIRB EQUIPMENT REQUIREMENTS

To be able to perform the ATSA-AIRB application, the AIRB Aircraft has to be equipped with an AIRB Equipment, which meets the requirements listed in this section.

TABLE 3.2: EQUIPMENT REQUIREMENT

Item	Interface	Equipment Requirement	Source
AIRB Equipment	D&B2 → G1	SPR.14 The AIRB Aircraft shall be equipped with an AIRB Equipment, which includes in particular ADS-B IN capability and a graphical Traffic Display providing the flight crew with at least the required information on AIRB Traffic.	OR.1

3.4.1 Functional requirements for AIRB Equipment

Functional requirements represent high-level information requirements and behavioural attributes that are placed on system functions (refer to Figure 3.1). The following table specifies the functional requirements for the AIRB Equipment.

NOTE: *In terms of hierarchy, functional requirements generally flow down from operational considerations identified in the OSED (Annex A). Functional requirements are often further decomposed in Safety and Performance analyses (i.e. OSA and OPA), where they result in more specific Safety and Performance Requirements. Thus functional requirements serve as bridge requirements between Operational Requirements and specific Safety and Performance Requirements imposed on the system.*

TABLE 3.3: FUNCTIONAL REQUIREMENTS FOR AIRB EQUIPMENT

Item	Interface	Functional Requirement	Source
Displayable information	G1	SPR.15 The AIRB Equipment shall be able to display the following information for AIRB Traffic to the flight crew: Relative horizontal position (i.e. distance and relative bearing).	OR.2
	G1	SPR.16 The AIRB Equipment shall be able to display the following list of information to the flight crew for AIRB Traffic if these pieces of information are available and meet associated requirements derived in the OPA: - Altitude (Relative altitude is required. Pressure altitude and barometric-corrected pressure altitude are optional); - Vertical tendency; and - Direction (i.e. ground track). NOTE: <i>It is expected that these three pieces of information should be available and therefore displayed to the flight crew along with the information included in OR.2. In non-nominal situations where a piece of information included in OR.3 is not available or does not meet any associated requirements derived in the OPA, an AIRB Traffic is displayed without this information.</i>	OR.3

Item	Interface	Functional Requirement	Source
	F1	SPR.17 The AIRB Equipment shall enable the flight crew to select the following list of information for AIRB Traffic to be displayed, if these pieces of information are available and meet associated requirements derived in the OPA: • Aircraft Identification; and • Speed information (i.e. ground speed). <i>NOTE: Indicated Air Speed can further enhance the traffic situational awareness of the flight crew in some traffic situations (e.g. in trail) but this information is not a minimum requirement (see §3.6).</i> <i>NOTE: Predictive time-based vector can further enhance the traffic situational awareness of the flight crew, in particular to better assess the evolution of traffic situations but this information is not a minimum requirement (see §3.6).</i>	OR.4
	B2	SPR.18 The following data items shall be provided to the AIRB Equipment by on-board sensors in the Receive Aircraft Domain: • Horizontal Position; • Altitude; • Horizontal Velocity; • Horizontal Position Accuracy; and • Horizontal Velocity Accuracy. <i>Note: Depending on implementation, if no comparison is made to own data to derive ground speed differential, the Receive Aircraft Domain data items; Aircraft Horizontal Velocity and/or Horizontal Velocity Accuracy may not be required.</i> <i>Note: Horizontal Position Accuracy may be derived from other information available to the AIRB Aircraft (e.g. Horizontal Position Integrity Containment Bound). It is expected that for any implementation employing such techniques, an equivalency analysis will be performed and demonstrated</i>	PR.1
AIRB Aircraft data	E1 → G1	SPR.19 When the parameters listed in SPR.15, SPR.16 and SPR.17 are received by the AIRB Aircraft and if they meet associated requirements derived in the OPA and OSA, they shall be computed and displayed or made available for display.	OR.5
Data processing	E1 → G1	SPR.20 If the AIRB Equipment is deriving the vertical tendency based on received pressure altitude, then the AIRB Equipment shall filter the altitude data in order to limit noise in the vertical tendency computation and display.	PR.16
	G1	SPR.21 The AIRB Equipment shall enable the flight crew to determine whether the AIRB Aircraft is currently qualified to use the ATSA-AIRB application.	OR.6
Traffic Display	G1	SPR.22 The Traffic Display shall present clear and uncluttered information to the flight crew. <i>NOTE: It is not the objective of this document to define specific requirements on the Traffic Display performances to address this Operational Requirement. These requirements will be defined in lower level specifications (e.g. MOPS).</i>	OR.7
	G1	SPR.23 The AIRB Equipment shall enable the flight crew to filter AIRB Traffic to be displayed on the Traffic Display using different ranges and altitude bands. <i>NOTE: The values of ranges or altitude bands vary depending on the operations. For instance, a 5 NM range would be largely sufficient for a VFR pilot but irrelevant for a jet aircraft in cruise flight.</i>	OR.8

Item	Interface	Functional Requirement	Source
	G1	SPR.24 Relative horizontal position derived by the AIRB Equipment from the horizontal position data of AIRB Aircraft and surveillance reports received from AIRB Traffic shall be displayed graphically and with a resolution consistent with other onboard display standards.	PR.2
	G1	SPR.25 The AIRB Equipment shall enable the flight crew to estimate the relative range between the AIRB Aircraft and the Traffic of Interest as well as other AIRB Traffic on the Traffic Display. <i>Note: The AIRB Equipment should also enable the flight crew to estimate the relative range between any two AIRB Traffic on the display.</i>	PR.3
	G1	SPR.26 Altitude shall be displayed with an increment not greater than 100 ft.	PR.9
	G1	SPR.27 The displayed altitude information for traffic depicted on the Traffic Display shall all have the same altitude reference or a clear indication to the altitude reference.	PR.10
	G1	SPR.28 The Traffic Display shall be capable of providing the Aircraft Identification of Traffic of Interest. <i>Note: This requirement would be met by an implementation that displays Aircraft Identification for all AIRB Traffic. In fact user preference have been expressed to be able to display Aircraft Identification for all AIRB Traffic, however, the minimum requirement is for the system to be able to display Aircraft Identification for Traffic of Interest</i>	PR.11
	G1	SPR.29 The direction information shall be provided for AIRB Traffic to the flight crew by the AIRB Equipment with a resolution of +/- 5 degrees or better.	PR.12
	G1	SPR.30 Vertical tendency shall be, at a minimum, conveyed to the flight crew with an up or down indication representing climbing traffic or descending traffic.	PR.14
	G1	SPR.31 The AIRB Equipment shall indicate the vertical tendency of any AIRB Traffic that is determined to be climbing or descending with a vertical rate of 500 feet per minute or greater. <i>Note: TCAS uses 500 fpm for this indication; therefore this limit has been maintained for consistency. If a specific implementation is independent from other Traffic displays that display vertical tendency (such as TCAS) a smaller threshold may be used but not a greater one.</i>	PR.15
	G1	SPR.32 The resolution for display of speed information shall be 10 knots or better. <i>Note: A higher resolution of speed information than 10 knots (e.g. 1 knot) is preferred under the condition that the implementation is such that the readability of speed information is not impaired e.g. due to flickering digits and not misleading considering conveyed accuracy versus actual accuracy.</i>	PR.17
	G1	SPR.33 A target shall be removed from the Traffic Display if there is no update, at interface D, of position or velocity for 25 seconds.	PR.4

3.4.2 Safety and Performance Requirements for AIRB Equipment

This section states the Safety and Performance Requirements of the AIRB Equipment within the Receive Aircraft Domain.

This section is divided as follows:

- System reliability and integrity requirements (i.e. the likelihood of not corrupting); and
- Timing requirements.

3.4.2.1 System reliability and integrity requirements

The following Safety and Performance Requirements apply to the AIRB Aircraft and Transmitting Traffic systems. These requirements specify the reliability with which on the one hand the onboard avionics will not corrupt data or display incorrect data and on the other hand the Transmitting Traffic system integrity will not corrupt the ADS-B data. The requirements in this subsection are drawn from the OSA (Annex C) and are needed to meet the Safety Objectives of specific Operational Hazards.

TABLE 3.4: SYSTEM RELIABILITY AND INTEGRITY REQUIREMENTS

Item	Interface	Safety and Performance Requirement	Source
Transmitting Traffic	D	SPR.34 Transmitting Traffic shall only be considered qualified for the ATSA-AIRB application (i.e. displayed as an AIRB Traffic) if the probability of a system integrity failure leading to ADS-B data corruption is no more than 1.0E-03 per flight hour. <i>Note: It is expected that the lowest Design Assurance level of one system in the data transmission chain defines the integrity level.</i>	SR.2
AIRB Aircraft	D/A2 → G1	SPR.35 The probability of an AIRB Aircraft system integrity failure leading to AIRB data corruption shall be no greater than 1.0E-03 per flight hour. <i>Note: It is expected that the lowest Design Assurance level of one system in the data transmission chain defines the integrity level.</i>	SR.1

NOTE: For systems transmitting system integrity (or system design assurance) as defined in ED-102A/DO-260B SPR.34 equates to a System Design Assurance, SDA =1 or better.

NOTE: For systems transmitting system integrity (or system design assurance) as defined in DO-242A (DO-260A) SPR.34 equates to a Surveillance Integrity Level, SIL=1 or better.

NOTE: For DO-242 (ED-102/DO-260) systems or DO-286B systems not transmitting system integrity (or system design assurance) it is generally assumed that such systems meet the 1.0E-03 per flight hour system integrity requirement defined in SPR.34.

NOTE: Some Regulation Authorities may require a more stringent system design assurance requirement, e.g. 1.0E-05.

3.4.2.2 Timing requirements

There are two key aspects to timing requirements considered: total latency and uncompensated latency. The total latency of both horizontal position and horizontal velocity of an AIRB Traffic is considered, defined from the time of applicability of data at Interface B1 to the time of observation of that data at Interface G1. It is comprised of three components:

- Transmitted total latency in the Transmit Aircraft Domain (Interface B1 to D);
- Update interval of horizontal position and horizontal velocity data (Interface E1); and

NOTE: *The update interval is the time within which the probability of successfully receiving both position and velocity information is at least 95%, for at least 95% of the aircraft.*

- Onboard total latency in the Receive Aircraft Domain (Interface D to G1).

Assumptions are made on the first two components (ASSUMP-OPA.13 and ASSUMP-OPA.14) and requirements levied for the third. A further assumption is made on the frequency with which horizontal position and velocity measurements are provided by the navigation sensors to Interface B1 (ASSUMP-OPA.12).

Uncompensated latency only relates to horizontal position data and it is that portion of the total latency that is not compensated for. The uncompensated latency of the Transmitting Traffic data is defined from the time of applicability of the position measurement at Interface B1 to the time of observation at Interface G1. Uncompensated latency of AIRB Aircraft's data is defined similarly, but starting from the time of applicability of the position measurement at Interface B2.

NOTE: *The measurement of latency ends at the time of observation by the flight crew. In particular, the amount of time between when the position is rendered on the Traffic Display and when the flight crew observes the position is considered to contribute to total latency and not to be compensable. While flight crew training can mitigate this, the analysis employs a conservative approach.*

The Performance Requirements related to timing are listed in Table 3.5.

TABLE 3.5: ATSA-AIRB TIMING REQUIREMENTS

Item	Interface	Safety and Performance Requirement	Source
Total latency	D → G1	SPR.36 The Receive Aircraft Domain total latency of horizontal position and velocity data between interfaces D and G1 shall be less than 4 seconds, 95%. <i>Note: These requirements are defined on Receive Aircraft Domain total latency from the time of applicability at reception (at interface D) to the time of observation by the flight crew (at interface G1) (conservatively assumed to be at the end of the display refresh cycle). It is therefore necessary to consider the refresh rate of the Traffic Display as one of the components of onboard total latency in the Receive Aircraft Domain.</i>	PR.20
Uncompensated latency	D → G1	SPR.37 The onboard uncompensated latency of an AIRB Traffic's horizontal position, from the time of applicability at interface D to the time of observation by the flight crew at interface G1 shall be less than 2.5 seconds, 95%. <i>Note: The maximum uncompensated latency at G1, at any instant, is measured from time of applicability of the horizontal position data (TOA) to the end of the display refresh cycle.</i>	PR.8

Item	Interface	Safety and Performance Requirement	Source
	B2 → G1	SPR.38 The uncompensated latency of the AIRB Aircraft's horizontal position from the time of applicability at interface B2 to the time of observation by the flight crew at interface G1 shall be less than 1.6 seconds, 95%. <i>Note: The uncompensated latency of the AIRB Aircraft's horizontal position is defined from the time of applicability of the horizontal position data at interface B2 to the time of observation of the data at interface G1 (conservatively assumed to be at the end of the display refresh cycle). In particular, the amount of time between when the position is rendered on the Traffic Display and when the flight crew observes the position is considered not to be compensated for.</i>	PR.7

3.5

AIRB DATA REQUIREMENTS

This section specifies the minimum data quality needed from ownship (i.e. Receive Aircraft Domain) for it to perform the ATSA-AIRB application and from data received from Transmitting Traffic (i.e. Transmit Aircraft Domain) to qualify them as AIRB Traffic.

NOTE: *The requirements specified in this section place requirements on the use of received data from Transmitting Traffic. These requirements should not be interpreted as levying requirements on Transmitting Traffic to guarantee the broadcast of data that meets these requirements. If transmitted data (e.g. horizontal velocity) does not meet these requirements nor can be assured to do so, then the AIRB Aircraft must not consider that data. In the case that the unqualified data is horizontal position data, the AIRB Aircraft must not consider the Transmitting Traffic from which that unqualified data was received as AIRB Traffic for the ATSA-AIRB application.*

The data quality requirements focus on two parameters:

- Horizontal Position:** Inaccuracies in the position data of the AIRB Traffic and AIRB Aircraft results in errors in the relative bearing and range of the AIRB Traffic on the Traffic Display compared to the 'out the window view'. This difference can lead the flight crew of the AIRB Aircraft to build an incorrect traffic situational awareness. Then, this incorrect traffic picture can result in situations where the flight crew does not change the flight path in a timely manner by executing a "see-and-avoid" manoeuvre or requesting and executing a revised ATC clearance when appropriate. Horizontal position accuracy of 0.5 NM, 95% for the Transmitting Traffic is the required minimum to be considered qualified for ATSA-AIRB (i.e. an AIRB Traffic). Horizontal position accuracy of 0.5 NM, 95% for the AIRB Aircraft is also the required minimum to be able to perform the ATSA-AIRB application. Additionally, in the Fault Trees of the ASOR in the Operational Safety Assessment (Annex C) the likelihood that the Transmitting Traffic and AIRB Aircraft horizontal positions are incorrect and larger than a 1 NM error bound is assigned to be 1.0E-03 per flight hour when reported as valid.
- Horizontal Velocity:** Inaccuracies in the reported velocities of the AIRB Traffic and AIRB Aircraft can result for instance in inappropriate decisions to delay a "see-and-avoid" manoeuvre or a request for a revised ATC clearance due to a degradation in the flight crew's traffic situational awareness. Horizontal velocity accuracy of 10 m/s (19.4 knots), 95% is required to be considered qualified for ATSA-AIRB.

TABLE 3.6: AIRB DATA QUALITY REQUIREMENTS

Data	Interface	Safety and Performance Requirement	Source
Horizontal position	D	SPR.39 Transmitting Traffic shall only be considered qualified for the ATSA-AIRB application (i.e. displayed as an AIRB Traffic) if it has a horizontal position accuracy of 0.5 NM, 95% or better. <i>Note: See below the table.</i>	PR.5 SR.4
	B2	SPR.40 In order to use the ATSA-AIRB application the AIRB Aircraft shall have a horizontal position accuracy of 0.5 NM, 95% or better. <i>Note: See below the table.</i>	PR.6 SR.3
Horizontal velocity	D	SPR.41 AIRB Traffic speed information shall only be considered qualified for the ATSA-AIRB application if it has a horizontal velocity accuracy of at least 19.4 knots, 95%.	PR.18
	B2	SPR.42 AIRB Aircraft speed information shall only be considered qualified for the ATSA-AIRB application if it has a horizontal velocity accuracy of at least 19.4 knots, 95%. <i>Note: AIRB Aircraft velocity is used in the case that ground speed differential is provided to the flight crew. If only AIRB Traffic ground speed is displayed, the AIRB Aircraft velocity is not required to meet this minimum velocity accuracy requirement.</i>	PR.19
Direction	D	SPR.43 Direction information for AIRB Traffic shall only be displayed to the flight crew if it has an accuracy of +/- 25 degrees, 95% or better. <i>Note: When direction is calculated from velocity, lower ground speeds reduce the direction accuracy while higher speeds increase the direction accuracy. With a ground speed of 47 knots, the direction accuracy of +/- 25 degrees is satisfied for the worst case as long as the velocity accuracy is at least 19.4 knots. The characteristics of using the velocity information for directionality also results in that the direction accuracy at 500 knot ground speed, with the same velocity accuracy, will in the worst case be in the order of 2 degrees.</i>	PR.13

NOTE: The OSA has established that the maximum acceptable failure rate that the horizontal position source data when reported as valid exceeds 1.0 NM position error is $1.0E-03$ per flight hour (SR.3 and SR.4). It is observed that this acceptable integrity failure rate ($1.0E-03$) is greater than the expected GPS signal in space (SIS) failure rate, which is conservatively assumed to be $1.0E-04$ per hour.

The OPA established a minimum accuracy requirement that bounds the maximum acceptable position error for ATSA-AIRB to 0.5 NM (95%) per sample. A single Gaussian distribution is used to represent the error in the misleading direction resulting in a distribution with $0.5/2.4477 \cdot 1.96 = 0.4$ NM (95%) per sample accuracy, where the $(1.96 / 2.4477)$ conversion factor converted from a circular Gaussian distribution in the horizontal plane to a single Gaussian distribution in the misleading direction. By studying the same single Gaussian accuracy curve at 1.0 NM, which is the established not to exceed limit, it is identified that the position error probability is no more than $9.8E-07$ per sample in the hazardously misleading direction.

The decorrelation time for GPS SIS is conservatively assumed to be two minutes, which results in 30 samples per hour. Converting the HFOM per sample figure to an per hour figure using the 30 samples per hour and adding the SIS failure rate ($1.0E-04$ per hour) gives the probability of the position error in the hazardously misleading direction $P(\text{pos error misleading}) = 1.3E-04$ per flight hour.

As seen the required nominal accuracy (0.5 NM), as identified in the OPA scenarios above, will not generate a misleading position error more frequent than $1.3E-4$ per flight hour. As stated above the OSA requires a misleading position error to occur no more than $1.0E-03$ per flight hour when reported as valid. It can therefore be concluded that the ATSA-AIRB required accuracy is also sufficient to avoid that the misleading horizontal position error occurs more frequently than accepted by the OSA.

NOTE: The requirements specified in Table 3.6 are stated in terms of specific numeric values and not corresponding values of the associated ADS-B parameters. Techniques could be used within the Receive Aircraft Domain such as correlation or tracking to increase data accuracy to the required levels specified in the table. For data received by certified ADS-B systems compliant to DO-242A or newer standards (e.g. DO-260B/ED-102A), the requirements correspond to following ADS-B values:

- SPR.39: $NAC_p \geq 5$ (0.5 NM, 95%); and
- SPR.41 and SPR.43: $NAC_v \geq 1$ (10 m/s or 19.4 knots)

NOTE: For a table of accepted conversions from NAC_p to NUC_p , see Appendix B.2.

NOTE: Due to the inability of some early installations of ADS-B and some GPS receivers to transmit quality indicators for velocity accuracy (i.e. NUC_v , NAC_v), the required speed information may be derived or validated using other equivalent means, e.g. using position information to determine or validate the speed information (i.e. ground speed) in support of ATSA-AIRB.

NOTE: These requirements do not imply that an individual assessment of each performance parameter is carried out by the flight crew.

3.6

RECOMMENDATIONS AND DESIGN CONSIDERATIONS

In addition to the Interoperability Recommendations provided in Chapter 4, this section provides some recommendations and design considerations identified in the Operational Performance Assessment (see §B.6).

TABLE 3.7: RECOMMENDATIONS AND DESIGN CONSIDERATIONS

Parameters	Recommendations / Design Considerations
Availability	Availability is an indication of the ability of the system to provide usable service. Availability is expressed in terms of the probability of the system being available at the beginning of the intended operation. While defined here for completeness, there are no availability requirements specified for AIRB Equipment as they are viewed to be driven more by business case considerations rather than technical considerations. <i>Note: Availability with respect to received data quality, e.g. sufficient quality of horizontal position, is expected to be supported in the vast majority of the time.</i>
Continuity	Continuity is the probability that the system will perform its required function without unscheduled interruption, assuming that the system is available when the procedure is initiated. Continuity is expressed per unit of time, e.g. per flight hour or per operation. While defined here for completeness, there are no continuity requirements specified for AIRB Equipment as they are viewed to be more driven by business case considerations rather than technical considerations. <i>Note: Continuity with respect to received data quality, e.g. sufficient quality of horizontal position, is expected to be supported in the vast majority of the time.</i>
Coverage volume	Operational inputs estimate that this detection volume, which corresponds to the coverage volume or the ADS-B surveillance, should be no less than 10 NM in range and +/- 3,500 ft vertically of AIRB Aircraft. For AIRB use in less dense airspace the Traffic of Interest may be much further away, for example in large procedural airspace's the separation may be in the order of 80 NM. <i>Note: RTCA DO-242A ADS-B MASPS Table 3-4a provides high-level guidance on acquisition range for various ASAS applications.</i>
Tracking of aircraft	Coverage volume, density of the traffic environment and percentage of ADS-B OUT transmitting aircraft determine the number of aircraft that may be received by the AIRB Aircraft. The AIRB Equipment should have the ability to acquire and maintain a sufficient number of tracks to ensure that all relevant traffic is available for display on the Traffic Display.

Parameters	Recommendations / Design Considerations
Display of traffic	To support a rapid and accurate mental integration of available traffic information, it is important to be able to display all relevant qualified aircraft in the coverage volume. In addition, the OSED requires that the flight crew shall be presented with clear and uncluttered information on the Traffic Display. The OPA process has identified the complexity in displaying all relevant traffic while providing non-cluttered information in different environments. The design decision becomes an optimization between a number of factors such as number of aircraft displayed, symbol design, Traffic Display size, range settings, area of interest, type of operations etc. One implementation could for example display all AIRB Traffic in the coverage volume while others apply a specific logic to display relevant aircraft (the word relevant is not intended to be precise but rather imply the use of some logic for selection of which aircraft to display). In this trade-off it is also important to consider that the introduction of ATSA-AIRB will have an impact on the flight crew's awareness of the consequences of their own intended manoeuvres. Even though this document does not define a minimum number of traffic symbols that the AIRB Equipment is required to display it is noted that other documents have such numbers, e.g. to comply with (DO-317 ASAS MOPS EVAcq) the AIRB Equipment is expected to be able to display a minimum of 16 aircraft. <i>Note: Flight crews should use the most appropriate Traffic Display range for the current operation. Use of large display range settings can result in excessive display clutter if there are several nearby aircraft and it can degrade the quality of the displayed information (e.g. the size of the symbol can be 1 or 2 NM).</i>
Traffic Display design considerations	<u>Predictive time-based vector</u> While not a requirement for ATSA-AIRB, a desirable capability is the use of a predictive time-based vector depicting projected traffic position for selected displayed aircraft. Potential prediction times, such as 30 seconds, 60 seconds, 90 seconds or other values should be considered in design of the Traffic Display. <u>Indicated Air Speed / Heading</u> In addition to ground-referenced velocity (i.e. ground speed, ground track) to depict target aircraft, pilot operational feedback also expressed a desired capability to provide Indicated Air Speed / Heading for depicted traffic. Pilots fly their aircraft using Indicated Air Speeds (IAS) and not Ground Speeds. The provision of AIRB Traffic IAS on the Traffic Display would allow pilots to easily compare their speed with the AIRB Traffic speed without any conversion. This is of particular interest when the AIRB Aircraft is following the AIRB Traffic. Furthermore, the ATC speed instructions also refer to Indicated Air Speeds and it would be easier to correlate the radio communication information with the displayed information. <i>Note: Indicated Air Speed / Heading will generally not be available from 1090 MHz transmissions of ADS-B OUT. The current link protocol (ED-102A/DO-260B) supports the data but only as a back-up to the ground speed data which has priority.</i>

Parameters	Recommendations / Design Considerations
	<u>Display of altitude</u> The minimum required altitude information for ATSA-AIRB is the relative altitude (relative to AIRB Aircraft). The need and usability of the optional altitudes, pressure altitude and barometric-corrected pressure altitude, is context dependent. Pressure altitude is the altitude relative to a standard pressure reference (1013.25 hPa), while the barometric-corrected pressure altitude represents the altitude in relation to the pressure reference used by the flight crew. Workshops have identified a clear preference for displaying altitudes using the same pressure reference as the flight crew. It has also been acknowledged that specific display formats, such as indications of Flight Level using 'F' or 'FL', reduces the ambiguity in having different altitude pressure references displayed. It is recommended that the implementer consider the use and display format of the altitudes in the cockpit especially considering AIRB Aircraft's position in relation the Transition Altitude and/or Transition Level.
	<u>Display of vertical tendency</u> The threshold for display of vertical tendency was set to no more 500 feet per minute (fpm) considering current vertical trackers (supporting TCAS) thresholds established on observed performance in relation avoiding nuisance indication of the vertical trend indicator. It is acknowledged that a threshold of 500 fpm may not be satisfying considering descent rates for smaller aircraft. It was therefore clarified in an accompanying note that systems independent from TCAS indication of vertical trend could benefit from using another threshold, lower than 500 feet per minute (but not higher). Further, operational experts recommend that such systems designed to frequently be used in the vicinity of smaller aircraft may consider using a threshold of no more than 300 fpm if nuisance indications can be avoided.

3.7

TRAINING CONSIDERATIONS

In addition to SPR.13 requiring that flight crews must be trained on the ATSA-AIRB application, this section provides some training considerations identified during the SPR process.

Although specific detailed training requirements are not within the scope of a SPR document, several considerations concerning training have been identified during the Operational Safety Assessment (see §C.4.4). Several aspects which should be addressed in training include overreliance on the Traffic Display to the detriment of other sources of information, excessive head-down time, awareness of latency issues and operation in a partial ADS-B equipage environment.

- It is important to provide appropriate training for the flight crews to use and understand the Traffic Display and how the information is presented on it. (See §C.5.4.1.1)
- Training on the use of the ATSA-AIRB application should emphasize the use of the Traffic Display as supplemental information to existing sources of information, so as to avoid overreliance on the ATSA-AIRB application to the detriment of other sources or interference with existing procedures. (See §C.5.1.2 and §C.5.4.2.1)
- Flight crews, especially if flying VFR, should be trained to avoid excessive head-down time to the detriment of regular out the window scans. (See §C.5.1.2)
- Training should address the evolution of the traffic situation, considering that the displayed information is continuously updated and can vary from the information received from the controller, which is based on a past situation. (See §C.5.4.1.1)

- Training should ensure flight crews are aware that the traffic picture displayed may be incomplete, due to a partial equipage situation, or filtering of poor quality data. (See §C.5.3.6.1 and §C.5.4.2.1)
- Periodic refresher training on the proper use of the ATSA-AIRB application should be provided to prevent flight crew complacency when using the Traffic Display as a supplemental source of traffic information. (See §C.5.3.6.1)

Additionally, the following training consideration should also be taken into account:

- Training should also be provided on the hazard of misinterpreting the AIRB Traffic Display and manoeuvring inappropriately because the display provides only partial information and is based upon a moving reference. Examples of potential misinterpretations of a traffic display are provided in the EUROCONTROL ACAS Safety Bulletin # 6, titled "Incorrect Use of the TCAS Traffic Display". [8]
- Training should ensure flight crews are aware of the need to reference the TCAS Traffic Display for assistance in the visual acquisition of traffic when a Traffic Advisory is generated by TCAS and TCAS traffic is shown on a separate display.

Also, special attention should be given to training for General Aviation (GA) flight crews regarding the appropriate uses of the ATSA-AIRB application. Some expected means of providing this information and emphasizing the appropriate uses and limitations of displayed AIRB Traffic to the GA community include, but are not limited to the following: Airplane Flight Manual Supplements (AFMS), training material supplied directly from the avionics manufacturer, specific training during bi-annual Flight Reviews, and direct instructions from fixed-base operators during any rental checkout procedures.