



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 VISUAL SEPARATION ON APPROACH (ATSA-VSA)

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FOREWORD

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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 (ATSA) for “Enhanced Visual Separation on Approach” (VSA). The ATSA-VSA 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.” [7]. It provides the minimum ATSA-VSA 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. The system here includes ground and airborne elements.

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-VSA 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 specification is also written to support system specific standards (e.g. MOPS, TSOs, etc.) which will be required for many airspace regulators.

In addition, this document also 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-VSA application.

The ATSA-VSA SPR and INTEROP are 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 avionics systems to assure that all subsystems perform their intended functions adequately for these applications.

1.1.1 ATSA-VSA application

Clearances to maintain own visual separation on approach are used in current operations. The objective of the ATSA-VSA application is to safely perform approach procedures with the flight crew of the Succeeding Aircraft while maintaining own visual separation from the Preceding Aircraft. This is for both single and parallel runway operations so that it is more efficient, safer, and on a more regular basis.

NOTE 1: *In the context of this document, the aircraft ahead is referred to as “the Preceding Aircraft” and the aircraft performing the application and maintaining own visual separation from the Preceding Aircraft is referred to as “the Succeeding Aircraft”.*

The Traffic Display will support flight crews in the visual search of the Preceding Aircraft in addition to the traffic information provided by the controller. Also the Traffic Display will support flight crews in maintaining visually a safe distance from the Preceding Aircraft.

NOTE 2: *In the context of this document, the term “Traffic Display” is consistently used as a graphical cockpit display of traffic information, often referred as a CDTI.*

NOTE 3: *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-VSA are applicable to both single and multiple pilot operations.*

The controller will provide traffic information to the flight crew of the Succeeding Aircraft as in current operations. On reception of this traffic information, the flight crew of an aircraft suitably equipped to support the ATSA-VSA application, will look both out the window and at the Traffic Display to identify the Preceding Aircraft. If the Traffic Display depicts a traffic corresponding to the Preceding Aircraft qualified for the ATSA-VSA application and if the flight crew assesses that the relevant Traffic Display, controller and out the window information are consistent, the flight crew can then decide to use the ATSA-VSA application. If there is no corresponding and qualified displayed traffic or if the Traffic Display information is not assessed consistent with the other sources of information, the flight crew must not use the Traffic Display as a support and must apply current visual procedures.

Information provided by the Traffic Display is not a substitute to out the window information and flight crews must maintain visual contact with the Preceding Aircraft throughout the ATSA-VSA application.

The ATSA-VSA application includes two procedures:

- The “Basic Procedure” is based on current ATC procedures. Flight crew’s procedures are only changed to include the use of the Traffic Display. Controllers do not know if the flight crew is applying the ATSA-VSA “Basic Procedure” or current visual procedure.
- The “Advanced Procedure” defines new procedures for both the controller and the flight crew of the Succeeding Aircraft related to the use of the aircraft identification of the Preceding Aircraft by the flight crew using a modified phraseology.

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 application of ATSA-VSA.

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.

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-VSA application.

Aircraft and avionics system designers should consider any additional specifications that may enhance the system supporting the ATSA-VSA application in view of other future Airborne Surveillance Applications (ASA) so that systems designed for ATSA-VSA 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-VSA application and the operational, safety, performance and interoperability requirements for using the application.

NOTE 1: *Requirements that provide protection against intentional behaviour causing harm or sabotage are beyond the scope of this document.*

NOTE 2: *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-VSA context

This document considers ATSA-VSA 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-VSA application do not necessarily satisfy others.

ATSA-VSA 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 and future SPR/INTEROP documents such as ADS-B-NRA (EUROCAE ED-126/RTCA DO-303 [11]) and ADS-B-RAD. This document has therefore been developed in coordination with ADS-B-NRA.

ATSA-VSA 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 [5]. 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.

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 (ASA) 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-S&M Enhanced sequencing and merging operations

NOTE 1: ADS-B-RAD is a combination of 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 I.

NOTE 2: ATSA-AIRB has been combined with the Package I definition of ATSA-S&A ("Enhanced Visual Acquisition for See-and-Avoid").

NOTE 3: Enhanced Crossing and Passing Operations (ASPA-C&P), as defined in Package I has been dropped from the RFG work plan by RTCA SC-186 and EUROCAE WG-51.

Separate publication of the SPR and INTEROP specifications 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 below 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.

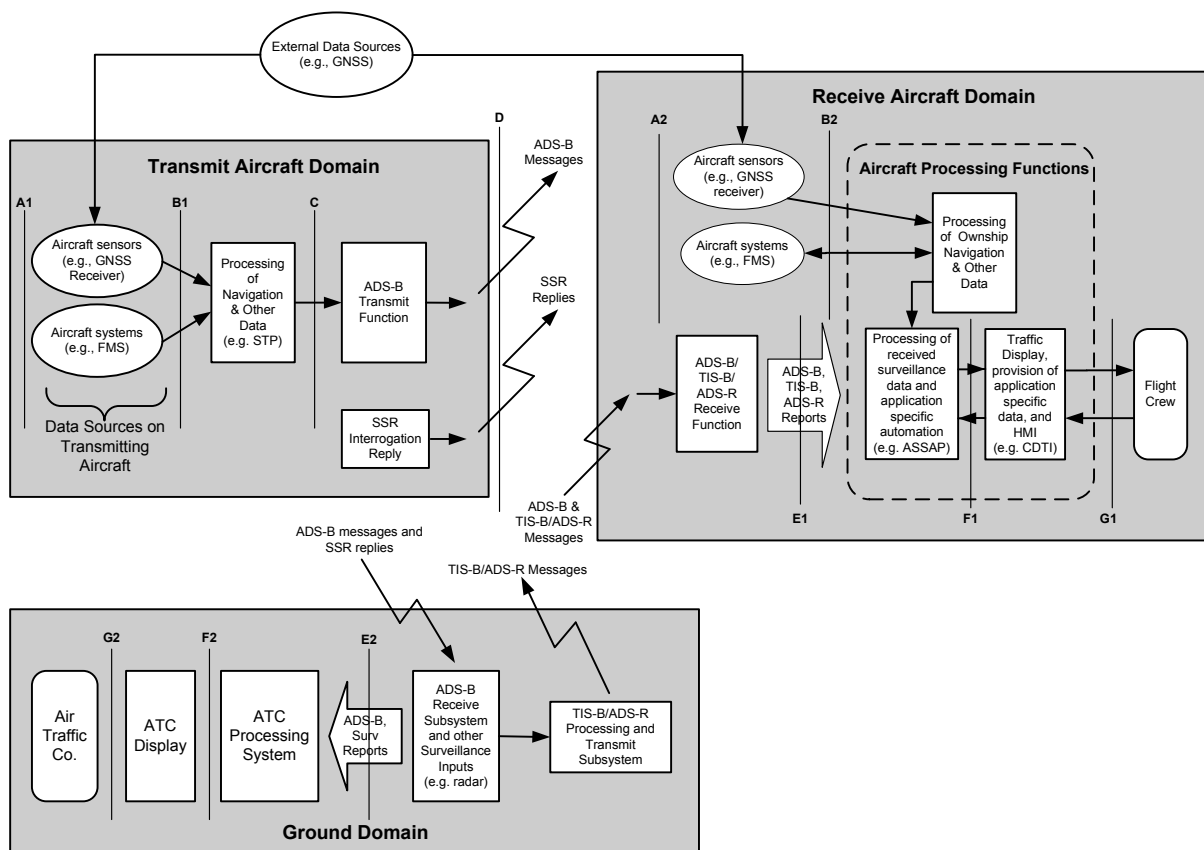


FIGURE 1.1: SURVEILLANCE FUNCTIONAL ARCHITECTURE

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, etc) to which the Safety and Performance Requirements (SPR) are allocated. These interfaces are referenced throughout the document where requirements are provided.

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 (by the ADS-B Receive Function) and, where applicable, surveillance data processing, ownship sensor data processing, and applications-specific processing (represented by the Airborne Surveillance and Separation Assistance Processing Function, ASSAP). 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.
- Requirements allocated to the Receive Aircraft Domain are measured from the time of transmission (interface D) through the conveyance of needed information to the flight crew (interface G1).

NOTE 1: *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. 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).
- Requirements allocated to the Transmit Aircraft Domain are measured from:
 - the time of measurement of sensor data (interface A1 for positioning data);
 - sensor outputs and pilot 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 2: *This document uses the term “Succeeding Aircraft” for the aircraft which is cleared to maintain own visual separation. The Succeeding Aircraft is represented in **Figure 1.1** as the Receive Aircraft Domain. For ATSA-VSA the Transmit Aircraft Domain is represented by the “Preceding Aircraft”, which is the aircraft from which the Succeeding Aircraft is maintaining own visual separation. The surveillance functional architecture supporting the ATSA-VSA application is described in §3.1.3.*

NOTE 3: *While no ADS-B information is required to be received by the Ground Domain for ATSA-VSA, it is assumed that the Ground Domain will have access to a source for aircraft identification information that is periodically updated in order to better facilitate controller comparison between aircraft identification verbally communicated by flight crews and that on the ATC display.*

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: Accuracy describes 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. 'ADS-B IN' 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 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: An ADS-B Report is one of the data reports specifically defined in the ADS-B MASPS (either RTCA DO-242 [8] or DO-242A [9]). A report can contain information from multiple messages.

ADS-B Surveillance Report: An 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 3 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 1: *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.

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 time).

Integrity (data): Data Integrity indicates 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): System integrity is the probability per operating 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 measured data to a new time of applicability in order to reduce the effects of latency on reported position, thus reducing the amount of uncompensated latency of the position data.

Preceding Aircraft: The aircraft to be visually acquired and from which own visual separation will then be maintained by the Succeeding Aircraft.

Qualified ADS-B Data: Received ADS-B data that meet the accuracy and integrity requirements determined to be required for the ATSA-VSA application.

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.

Succeeding Aircraft: The aircraft that is cleared to maintain own visual separation from the Preceding 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.

Traffic Display function: Appropriate flight deck tools and data to support the flight crew in the tasks of visual acquisition and maintaining own visual separation from the Preceding Aircraft. The objective of this document is not to specify any specific implementation method or format for the Traffic Display.

Uncompensated Latency: The difference between the position information's time of applicability and the time of use.

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

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

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-VSA application, and the SPR and INTEROP materials 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-VSA application. It also includes the key assumptions made for the ATSA-VSA application.
- Chapter 4 introduces the data-link independent Interoperability Requirements applicable to the ATSA-VSA application.
- Annex A is the Operational Services and Environment Definition (OSD) for ATSA-VSA. This describes the services, intended functions, and associated procedures of the ATSA-VSA 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; providing relevant ICAO provisions and illustrations of possible ATSA-VSA operations.
- Annex B is the Operational Performance Assessment (OPA). This determines minimum Performance Requirements for the surveillance data (received and ownship), 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, providing the details of the mathematical analysis and the 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 [7]. The Annex also presents the detailed tables of results of the Safety Assessment itself. It includes two appendices, providing the Hazard Classification matrix 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 14, Aerodromes, Volume 1, Fourth Edition, July 2004

1.5.2 EUROCONTROL

- [5] Description of a First Package of GS/AS Applications, CARE/ASAS Ref. CA-02-040 (2.2), version 2.2, September 30, 2002
- [6] EUROCONTROL Safety Regulatory Requirement – ESARR 4: Risk Assessment and Mitigation in ATM, Edition 1.0

1.5.3 EUROCAE/RTCA

- [7] EUROCAE ED-78A/RTCA DO-264: Guidelines for Approval of the Provision and Use of air Traffic Services Supported by Data Communications, March 2002
- [8] DO-242, Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS B)
- [9] DO-242A, Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS B)
- [10] DO-242A, Change 1, Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS B)
- [11] ED-126/DO-303, Safety, Performance and Interoperability Requirements Document For ADS-B-NRA application, December 2006
- [12] ED-12B/DO-178B, Software Considerations in Airborne Systems and Equipment Certification
- [13] DO-208, Minimum Operational Performance Standards for Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS), RTCA Inc., July 1991
- [14] DO-229D, Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment, RTCA Inc., Issued 13th December 2006
- [15] DO-253A, Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment
- [16] ED-80/DO-254, Design Assurance Guidance for Airborne Electronic Hardware
- [17] DO-302, Minimum Operational Performance Standards for Surveillance Transmit Processing (STP), 13 December 2006
- [18] DO-310, Minimum Operational Performance Standards for GPS Ground-based Regional Augmentation System Airborne Equipment, Issued 13th March 2008
- [19] Pending European Standard on Process for Specifying Risk Classification Scheme and Deriving Safety Objectives in ATM “in compliance” with ESARR 4, 3 November 2007

1.5.4**Other**

- [20]** "System Safety for the 21st Century", Updated and Revised Edition of System Safety 2000, Richard A. Stephans, 2004
- [21]** "Bearing inaccuracies in ADS-B", DSNA/DTI/R&D/NT07-731/MIQUEL Thierry, CHABERT Stephan, 2007

CHAPTER 2

APPROACH AND METHODOLOGY

2.1 DOCUMENT DEVELOPMENT PROCESS

This document was developed in accordance with the ED78A/DO-264 guidelines for the definition of operational, safety, performance, and interoperability requirements [7].

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 stages.

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-VSA 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-VSA 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) characterising the application to be assessed.

The OSED was developed to enhance existing procedures for maintaining own visual separation on approach defined in ICAO Doc 4444 [1].

The ATSA-VSA application is broken into phases. These are: "Visual acquisition", "Clearance for maintaining own visual", "Maintaining own visual separation on the approach" and "Termination". For each of these phases, detailed descriptions and phase diagrams are provided in Annex A.

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

2.2.2 Safety and Performance Requirements (SPR)

The OSED (Annex A) provides the description of the services and the environment of the ATSA-VSA application. Based on this description, two assessments were performed to derive the requirements needed to assure proper and safe execution of the ATSA-VSA 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-VSA application under nominal conditions. The OPA is found in Annex B;
- The OSA derives Safety Requirements (SR) by considering unique Operational Hazards introduced by ATSA-VSA or existing Operational Hazards that the application of ATSA-VSA might adversely affect. These Operational Hazards are examined in order to control their likelihood and their effects. The OSA is found in Annex C.

NOTE 1: *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 process also apportions the requirements between the relevant domains. For the ATSA-VSA application, these requirements are placed on the Receive Aircraft (see **Figure 1.1** and **Figure 3.1**).

NOTE 2: *“Transmit” and “Receive” Aircraft Domains are terms used when allocating requirements. For operational aspects or explanatory text, the terms “Preceding” and “Succeeding” Aircraft are respectively used through 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-VSA application does not forbid aircraft, regardless of the level of their ADS-B equipage, from flying in airspace where ATSA-VSA operations are conducted. Generally, assumptions are made about the Transmit Aircraft, and requirements are levied on the Receive Aircraft. This includes, for example, stating requirements such that the Receive Aircraft is only permitted to use the ATSA-VSA application against Transmitting Aircraft from which suitably qualified ADS-B data is received. This does not place data quality requirements on all aircraft transmitting ADS-B data in the airspace, but rather qualifies when the Receive Aircraft may conduct an ATSA-VSA 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-VSA 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-VSA application are defined as the minimum interface needed between the Transmit Aircraft Domain and Receive Aircraft Domain (i.e. Preceding Aircraft and Succeeding 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 [8] and DO-242A [9] compliant systems where appropriate.

As mentioned above, the Interoperability Requirements are worded such that the burden of the levied requirements on the minimum data set and minimum quality of transmitted ADS-B data is allocated to the Receive Aircraft Domain by specifying permitted usage of the data only when the minimum requirements are met.

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-VSA application and have 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 and 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-VSA application. The use of the word "shall" indicates a mandated criterion or requirement; i.e. compliance with the criterion is mandatory and no alternative may be applied;
- The use of the word "**should**" indicates that although the criterion is regarded as the preferred option, alternative criteria may be applied. In such cases, alternatives should be identified in appropriate approval plans and agreement sought from the approval authority. Criteria indicated using the word "**should**" serve as recommendations for system designers; 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-VSA in a given TMA, 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 (Annex C). They correspond to minimum quantitative or functional requirements that are defined on the VSA 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, VSA Equipment requirements and ATSA-VSA 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-VSA 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).

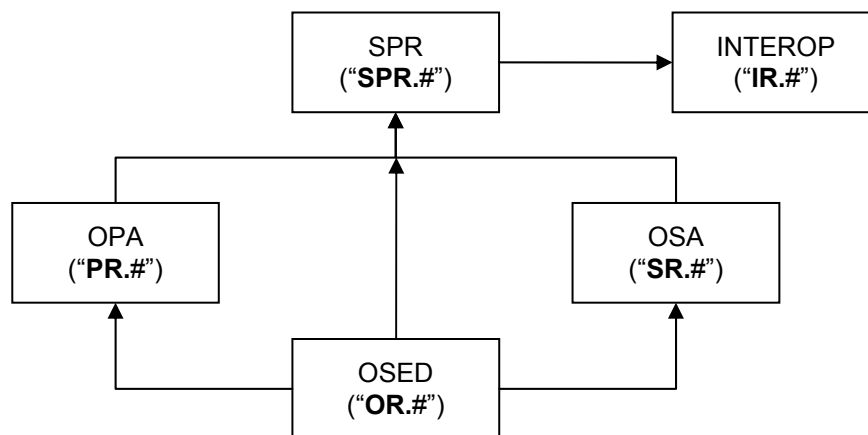


FIGURE 2.1: TRACEABILITY SCHEME

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-VSA application as defined in the OSED. While these requirements consider ATSA-VSA as an isolated application, it is recognized that other ADS-B applications are likely to be performed by both aircraft and ground systems. Therefore, this document also proposes many recommendations, primarily in the INTEROP (Chapter 4). These recommendations are not minimum requirements for ATSA-VSA but are optional capabilities or desired performance levels above the minimum required. Many of these recommendations are made to ensure development of robust ATSA-VSA 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-VSA application. These requirements were developed based on the process defined in EUROCAE ED-78A/RTCA DO-264 [7]. 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-VSA application under nominal conditions. The OPA is found in Annex B.

3.1.1.1 Operational objectives

The OPA studies the needs of the application as defined in the OSED and establishes operational objectives that should be met during fault-free ATSA-VSA 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 VSA Equipment to support their operational needs and to provide operational benefit. 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 VSA Equipment. For example, when controllers provide traffic information in current operations relative range is provided in whole miles. Additionally, pilots can judge distances visually accurate to about 1 NM in this phase of flight. If the VSA Equipment provides this information accurately to 0.5 NM, there is a considerable operational benefit to be derived. The operational objective that relative distance be within 0.5 NM 95% of the time is employed. To achieve this objective, a positional accuracy of better than 0.3 NM must be available for both the Transmit and Receive Aircraft horizontal position data and uncompensated latency at the display must be less than 1.6 seconds, 95%. The detailed analysis of each operational objective can be found in Annex B and Appendix B.1.

3.1.1.2 Data and display requirements

Throughout the analysis, PR's are set and assumptions are made on the system. Requirements and assumptions are generally placed around the minimum data set and the display of information derived from that data. Performance Requirements are set both on the quality of data used by the VSA Equipment, and on the display of derived information to the flight crew.

3.1.1.3 Design considerations

Some consideration is given to certain aspects of the design of the VSA Equipment, but no requirements are derived. As issues relevant to the design process are discovered during the SPR process, and as requirements set forth in higher level documents support aspects of ATSA-VSA operations, they are discussed at the end of Annex B.

3.1.2 OSA process

The OSA derives Safety Requirements (SR) by considering unique Operational Hazards introduced by ATSA-VSA or existing Operational Hazards that the application of ATSA-VSA 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

There are three Operational Hazards studied in the OSA, visually identifying the Wrong Target Aircraft, manoeuvring incorrectly while maintaining own visual separation, and the workload hazard associated with miscommunication/misinterpretation of aircraft identification. Each Operational Hazard is analyzed for both the Basic Procedure and Advanced Procedure when applicable. It is important to note that while descriptively, the first two Operational Hazards exist in standard operations; the OSA considers exposure to Operational Hazards that are specifically related to the presence of the Traffic Display in the cockpit. For example, incorrect manoeuvres are only considered when the flight crew of the Succeeding Aircraft uses the Traffic Display.

3.1.2.2 Mitigation means

Mitigation Means are procedures, alerts, 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 are outside the application and that help reduce the impact of an Operational Hazard once it has occurred.

Other mitigations are internal to the application, and are therefore 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 constitute Operational Requirements if procedural. If technical, they correspond to Safety Requirements (see §2.3.3).

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-VSA 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 External Mitigation Means. The conditional probability of Operational Effects such as increased flight crew workload, wake vortex encounter, and collision, are estimated. These probabilities are compared to the appropriate Safety Targets (ST). For each Operational Hazard there is derived a Safety Objective (SO), the greatest frequency of the hazard such that the Safety Target is met for every Operational Effect.

Operational input is a critical facet of the Event Tree analysis. As there are many decades of experience with the application of own visual separation during approach, 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. Internal Mitigation Means 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 system integrity is at $1.0E-03$, the VSA Equipment will support the conduct of safe ATSA-VSA operations. In fact, it can be inferred from the analysis provided that ATSA-VSA operations provide a safety benefit in many cases against Operational Hazards that exist in today's operations.

The OSA does not derive requirements specific to the Advanced Procedure. Any considerations for the Advanced Procedure are therefore operational in nature and levy neither additional nor more stringent requirements on the avionics. ANSPs need to take the operational considerations detailed in this document into account before implementing the Advanced Procedure

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 VSA Equipment (see §3.4)

NOTE 1: 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 Annex C). 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), Functional Requirements (Table 3.2), system-related (Aircraft Domain) Performance Requirements (Table 3.3 and Table 3.4) and data-related requirements (Table 3.5). Each SPR.# is associated with at least one requirement from the OSED, OPA or OSA as noted in the tables.

NOTE 2: ATSA-VSA is necessarily focused on the Receive Aircraft Domain (i.e. the VSA Equipment and the data used by the VSA Equipment). While the data on the Preceding Aircraft 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.

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

Figure 3.1 replicates the Package I functional Architecture depicted in **Figure 1.1**, however the shaded areas illustrate the parts of each domain relevant to the ATSA-VSA application.

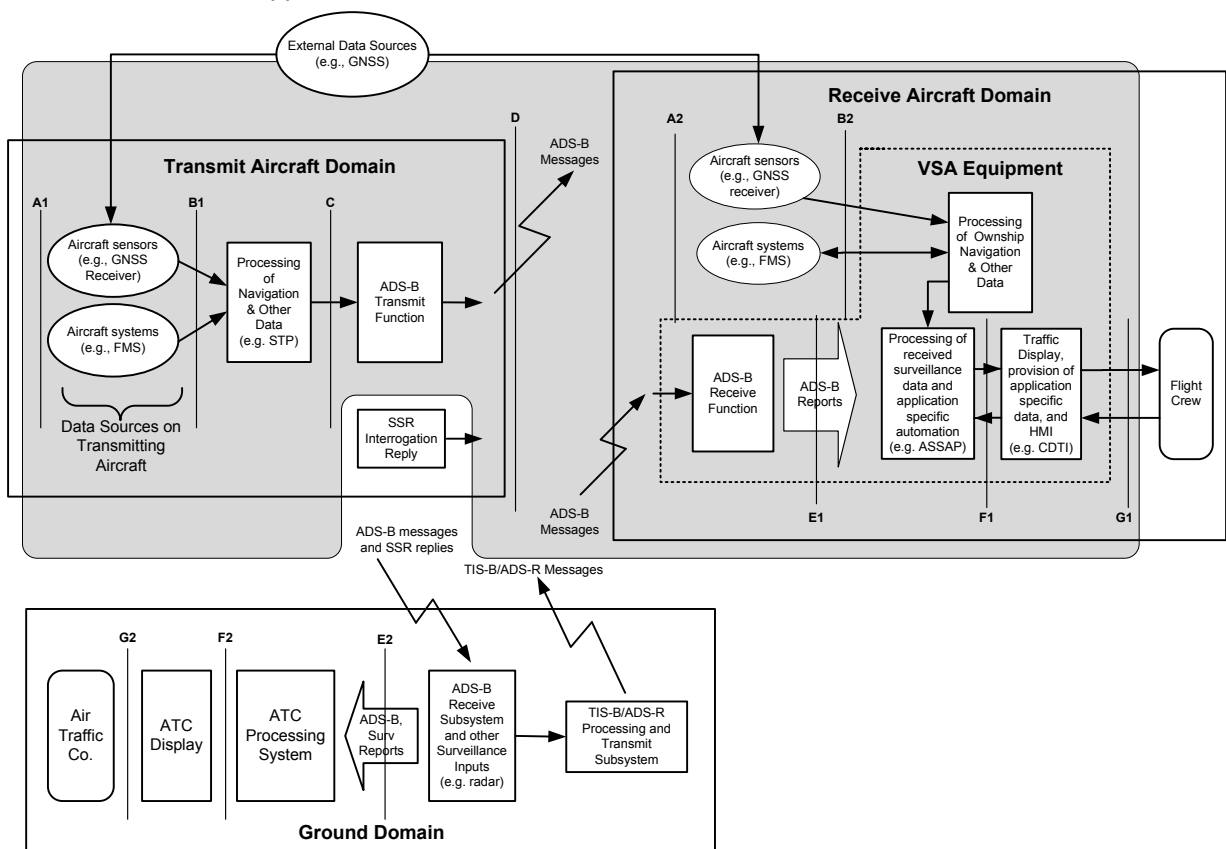


FIGURE 3.1: SURVEILLANCE FUNCTIONAL ARCHITECTURE FOR ATSA-VSA

- NOTE 3:** 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 “VSA Equipment” throughout this document.
- NOTE 4:** TIS-B and ADS-R are not required for the ATSA-VSA application. Therefore, references to TIS-B and ADS-R in the Receive Aircraft Domain that are included in **Figure 1.1** have been removed.
- NOTE 5:** The role of the ground domain for ATSA-VSA is captured in the OSED (Annex A). With the exception of a single ground domain assumption (ASSUMP-OSED.10), which states that for the Advanced Procedure the aircraft identification is provided to the ground domain by a source which periodically updates the information, no additional 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-VSA 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 an attempt to consolidate the major ideas into groupings. There are many more detailed assumptions that can be found in the various Annexes. All the assumptions in the SPR and the Annexes have to be considered and checked before implementing ATSA-VSA requirements provided in this document.

§3.2.1 describes a group of general assumptions, which provide the foundation for the ATSA-VSA application. Section §3.2.2 provides the assumptions about the environment in which the ATSA-VSA 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. The assumptions listed in these sections are mostly at a more detailed level than those in §3.2.1 and §3.2.2 but are derived from the same sources (Annex A, Annex B, and Annex C).

Full details of the assumptions described in this section can be found in the appropriate Annexes.

3.2.1

General assumptions

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

- Abuse or intentional misuse of information provided to the flight crew or the controller are out of the scope of the ATSA-VSA assessment. (ASSUMP-OSED.7) (ASSUMP-OSA.3) (ASSUMP-OPA.2)
- During the Visual Acquisition phase, the most demanding task is to correlate the Preceding Aircraft identified on the Traffic Display with the out the window view and the information provided by the controller. (ASSUMP-OPA.5)
- During the Maintaining Own Visual Separation phase, the most demanding tasks for the flight crew of the Succeeding Aircraft are assumed to be judging the distance to the Preceding Aircraft and detecting a sharp slowdown by the Preceding Aircraft. (ASSUMP-OPA.6)
- Security issues are out of the scope of this document. (ASSUMP-OSA.2)
- Functions such as an alerting function detecting excessive closure rate, use of TIS-B to supplement ADS-B ground surveillance, use of CPDLC, or provision of information regarding aircraft equipment capabilities to controllers are out of the scope of this document. (ASSUMP-OSED.8)

- The phases of the issuance of the own visual separation clearance and of maintaining own visual separation are identical for the Basic Procedure and Advanced Procedure. (ASSUMP-OSED.20)
- Safety nets, such as conflict alerts and TCAS, are not used as mitigation means. (ASSUMP-OSA.1)
- For the Safety Target and Safety Objective calculation, it is assumed that there is one ATSA-VSA operation per 10 flight hours. (ASSUMP-OSA.4)

3.2.2

Environmental assumptions

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

- All current requirements for maintaining own visual separation are still valid while performing an ATSA-VSA procedure. (ASSUMP-OSED.1)
- The ATSA-VSA application can be used by aircraft flying a visual or an instrument approach. (ASSUMP-OSED.2)
- The ATSA-VSA is applicable to single runway, independent parallel runways, dependent parallel runways and closely-spaced parallel runways. (ASSUMP-OSED.3)
- The ATSA-VSA application can only be conducted under VMC as defined by ICAO or as specified by the State. (ASSUMP-OSED.4)
- The ATSA-VSA application can be used by all suitably equipped aircraft during approach to any airports where own visual separation is used. (ASSUMP-OSED.5)
- The ATSA-VSA application does not raise any specific issues related to wake vortex limitations or runway occupancy time. (ASSUMP-OSED.6)
- The ATSA-VSA application is defined to be used in Terminal Airspace to support aircraft performing approach and landing operations. Air Traffic Control is provided by Approach Control and Tower Control services as today (i.e. there are no specific requirements). (ASSUMP-OSED.15)

NOTE 1: *The Tower Controller may utilize radar at airports where it is available. However, radar is not a minimum requirement to be able to conduct ATSA-VSA operations.*

- The airspace in which the ATSA-VSA application is used has VHF voice as means of communications between controllers and flight crews. (ASSUMP-OSED.16)
- The ATSA-VSA application can be applied in airspace of any traffic density. (ASSUMP-OSED.17)
- The ADS-B equipage (i.e. ADS-B OUT and ADS-B IN) within the deployment environment will be mixed. (ASSUMP-OSED.18)
- The minimum spacing between the Preceding Aircraft and Succeeding Aircraft during the Visual Acquisition phase is 3 NM. (ASSUMP-OPA.4)
- At a range of 5 NM, the 95% update interval for both horizontal position and horizontal velocity is assumed to be 3 seconds. (ASSUMP-OPA.20)

NOTE 2: *For the relationship of this assumption to other ADS-B documentation (e.g., RTCA DO-242A ADS-B MASPS [9]), the reader is referred to the notes following ASSUMP-OPA.20.*

3.2.3 Receive Aircraft Domain assumptions

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

- The Succeeding Aircraft is equipped with appropriate avionics systems, which includes ADS-B IN capability and graphical Traffic Display providing the flight crew with the required data. (ASSUMP-OSED.11)
- It is a decision of the flight crew to use the Traffic Display. The ATSA-VSA application only includes the situations where the flight crew uses the Traffic Display. (ASSUMP-OSED.19)
- The flight crew assesses the meteorological conditions as in current operations. (ASSUMP-OSED.22)
- The barometric altimetry system of the Receive Aircraft Domain is assumed to perform as well as or better than what is encountered during current operations. (ASSUMP-OPA.14)
- The likelihood that the flight crew misinterprets ATSA-VSA data provided by the controller is assumed to be less than $2.0E-02$ per operation. (ASSUMP-OSA.7)
- The likelihood that the flight crew misinterprets out the window data is assumed to be less than $3.4E-02$ per operation. (ASSUMP-OSA.8)
- The likelihood that the flight crew misinterprets Traffic Display data is assumed to be less than $1.0E-02$ per operation. (ASSUMP-OSA.9)
- The likelihood that flight crew fails to correctly correlate information from different data sources is assumed to be less than $1.0E-02$ per operation. (ASSUMP-OSA.11)
- The likelihood that the flight crew misreads or miscommunicates aircraft identification of the target identified on the Traffic Display is assumed to be less than $1.0E-04$ per operation. (ASSUMP-OSA.16)
- The likelihood that the flight crew unintentionally misuses the Traffic Display is assumed to be less than $2.0E-02$ per operation. (ASSUMP-OSA.10)

3.2.4 Transmit Aircraft Domain assumptions

This section places assumptions that are made for the Preceding Aircraft, i.e. the Transmit Aircraft Domain as defined in **Figure 1.1**.

- The Preceding Aircraft is equipped with ADS-B OUT transponders and broadcast ADS-B data meeting requirements to support the ATSA-VSA application. (ASSUMP-OSED.12)
- The aircraft equipped with ADS-B have an aircraft identification feature and transmit the aircraft identification entered in the aircraft system. (ASSUMP-OSED.13)
- The aircraft identification entered in the aircraft system of the Preceding Aircraft is that specified in Item 7 of the ICAO flight plan, or when no flight plan has been filed, the aircraft registration. (ASSUMP-OSED.14)

- The following data items are provided to the VSA Equipment via ADS-B OUT by the Transmit Aircraft Domain when available (ASSUMP-OPA.3).
 - Horizontal Position
 - Pressure Altitude
 - Horizontal Velocity
 - Aircraft identification
 - Horizontal Position Accuracy
 - Horizontal Position Integrity Containment Bound
 - Horizontal Velocity Accuracy

NOTE 1: *Vertical rate may also be transmitted by the Transmit Aircraft Domain and may also be received by the Receive Aircraft Domain to support determination of vertical tendency.*

- The 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.12)
- The total latency of horizontal position and velocity data between interfaces B1 and D is less than 1.5 seconds, 95% (ASSUMP-OPA.16, ASSUMP-OPA.18)
- The navigation sensor in the Transmit Aircraft Domain provides measurements of horizontal position data and horizontal velocity data to interface B1 at a rate of at least once per second (ASSUMP-OPA.17, ASSUMP-OPA.19)
- The ADS-B barometric altimetry and reporting system of the Transmit Aircraft Domain is assumed to perform as well as or better than what is encountered during current operations. (ASSUMP-OPA.13)
- The likelihood that a Transmitting Aircraft transmits erroneous State Vector information or that the information is corrupted during transmission is less than 1.0E-03 per flight hour. (ASSUMP-OSA.12)
- The likelihood that an aircraft transmits incorrect aircraft identification data to be used as a Preceding Aircraft for the ATSA-VSA application is assumed to be less than 1.0E-04 per operation. (ASSUMP-OSA.17)
- The likelihood that an aircraft identification that is different from item 7 of the ICAO flight plan is used in the encoding of a transmitted ADS-B message is assumed to be less than 1.0E-03 per operation. (ASSUMP-OSA.18)

3.2.5

Ground Domain assumptions

This section focuses on the assumptions that are made for the ground domain.

- For the Basic Procedure there is no specific requirement on the ground CNS above what is currently available in airspace where own visual separation on approach is used. (ASSUMP-OSD.9)
- For the Advanced Procedure, an updated aircraft identification is available to the controller to support the comparison of the aircraft identification reported by the flight crew of the Succeeding Aircraft and that provided by the surveillance display. (ASSUMP-OSD.10)

NOTE 1: *The aircraft identification available to the controller to support the Advanced Procedure has to be consistent with the aircraft identification that actually is available to the Succeeding Aircraft. Based on the current design and knowledge of the consistency between flight plan aircraft identification and transmitted aircraft identification, the flight plan information alone is not considered sufficient to support the Advanced Procedure. It has also been identified that it is recommended to base the aircraft identification presented to the controller on the same data as the aircraft identification available to the Succeeding Aircraft.*

- The controller is provided with the meteorological condition information as in current operations. (ASSUMP-OSD.21)
- With the exception of the Advanced Procedure assumption ASSUMP-OSD.10, the performance of the current Ground Domain is sufficient to perform the Basic Procedure and Advanced Procedure of ATSA-VSA. (ASSUMP-OPA.1)
- The likelihood that the controller provides erroneous data in the traffic information is assumed to be less than $4.2E-03$ per operation. (ASSUMP-OSA.5)
- The likelihood that the controller fails to detect a mismatch between aircraft identification transmitted by a flight crew and the one expected is assumed to be less than $1.0E-03$ per operation. (ASSUMP-OSA.13)
- The likelihood that an incorrect aircraft identification provided by Transmitting Aircraft is not detected before a ATSA-VSA operation is assumed to be less than $5E-01$ per operation. (ASSUMP-OSA.15)
- The probability that the controller misunderstands an aircraft identification communicated by flight crew is assumed to be less than $1.0E-04$ per operation. (ASSUMP-OSA.19)

3.3 OPERATIONAL REQUIREMENTS

Operational Requirements specify the performance elements of the ATSA-VSA application associated with the operators, i.e., the flight crew of the Succeeding Aircraft and the controller. These Operational Requirements identify and define the necessary procedural steps, tasks and actions that must be performed by the operators – in this case the flight crew of the Succeeding Aircraft (i.e. the Receive Aircraft Domain) and the controller (i.e. the Ground Domain) – for proper execution of the ATSA-VSA application.

NOTE 1: *These Operational Requirements (i.e. required procedures, tasks or actions) are not to be interpreted as requirements on airborne or ground systems and are therefore not part of any equipment certification.*

The Operational Requirements are specified in Table 3.1 below and are supported by the following explanatory text. Table 3.1 also references the Operational Requirements defined in the OSD (Annex A) and the Internal Mitigation Means in the OSA (Annex C).

3.3.1 ATSA-VSA phases

The current own visual separation procedure is comprised of four successive phases:

- Visual Acquisition;
- Clearance for Maintaining Own Visual Separation;
- Maintaining Own Visual Separation on the Approach; and
- Termination.

3.3.1.1 Visual Acquisition phase

As specified in the OSED (Annex A), the objective of this phase is that, at the end:

- the flight crew of the Succeeding Aircraft has:
 - detected the Preceding Aircraft on the Traffic Display;
 - visually acquired the Preceding Aircraft and visual contact can be maintained;
 - checked consistency of the Traffic Display, out the window and controller information; and
 - reported visual contact on the Preceding Aircraft to the controller;
- the controller has assessed the applicability of providing a clearance for maintaining own visual separation.

This phase includes two procedures.

- The “Basic Procedure” is based on current ATC procedures. Flight crew’s procedures are only changed to include the use of the Traffic Display.
- The “Advanced Procedure” defines, in addition, new procedures for both the controller and the flight crew of the Succeeding Aircraft related to the use of the aircraft identification of the Preceding Aircraft by the flight crew using a modified phraseology.

3.3.1.2 Clearance phase

After the flight crew of the Succeeding Aircraft has explicitly reported having the Preceding Aircraft in sight, the controller provides the flight crew with the clearance to maintain own visual separation from the Preceding Aircraft. The flight crew decides to either accept or refuse this clearance and reports the decision to the controller. If the clearance is accepted, the ATSA-VSA application moves to the maintaining phase. If it is not, the controller continues to provide separation to the Succeeding Aircraft by issuing clearances and instructions.

3.3.1.3 Maintaining Own Visual Separation phase

In this phase, the responsibility of the flight crew is to maintain own visual separation from the Preceding Aircraft. In addition to the out the window information, the flight crew of the Succeeding Aircraft also uses the information provided by the Traffic Display to perform this task. In particular, the distance and speed information provided by the Traffic Display allows respectively for a better evaluation of the actual distance from the Preceding Aircraft and for an earlier detection of speed variations. The ATSA-VSA application modifies the decision process (e.g. the flight crew of the Succeeding Aircraft can decide that a speed reduction is required due to an excessive speed difference detected on the Traffic Display but that is not yet detectable visually) but it does not change the manoeuvre: any manoeuvre shall be undertaken with visual reference to the Preceding Aircraft.

The procedure in case of abnormal modes is identical to the current visual procedure (i.e. without the support of the Traffic Display).

3.3.1.4 Termination phase

In nominal conditions, the clearance for own visual separation ends when the Preceding Aircraft lands.

NOTE 1: *Under specific circumstances (e.g. under FAA procedures), the application ends when the Preceding Aircraft clears the runway.*

3.3.2 Operational Requirements

Table 3.1 lists the Operational Requirements for each of the phases described in §3.3.1.

TABLE 3.1: OPERATIONAL REQUIREMENTS

Phase	Domain	Operational Requirement	Source
Visual acquisition	Flight crew of the Receive Aircraft	SPR.1 If the flight crew detects a target on the Traffic Display corresponding to the Preceding Aircraft but with ADS-B data not qualified for ATSA-VSA, the flight crew shall apply the current procedure for own visual separation.	OR.4
		SPR.2 When performing an ATSA-VSA procedure, the flight crew shall report to the controller that the Preceding Aircraft is in sight only after having checked that the relevant Traffic Display, controller and out the window information are consistent.	OR.5
		SPR.3 If the relevant Traffic Display, controller and out the window information are not consistent, the flight crew shall apply current procedure for own visual separation and disregard the Traffic Display.	OR.6
		SPR.4 Flight crews shall be trained on the use of the Traffic Display within the ATSA-VSA application.	OR.7
		SPR.5 In the Advanced Procedure, the flight crew shall report the aircraft identification of the target aircraft on the Traffic Display.	OR.8
		SPR.6 In the Advanced Procedure, the flight crew shall explicitly inform the controller when visual acquisition on the Preceding Aircraft is achieved, if the flight crew has first reported having identified the Preceding Aircraft only on the Traffic Display.	OR.10
		SPR.7 In the Advanced Procedure, flight crews shall be trained on the modified phraseology including the Preceding Aircraft identification and the associated procedures.	OR.11
	Controller	SPR.8 In the Advanced Procedure, the controller shall compare the aircraft identification used by the flight crew against the aircraft identification of the Preceding Aircraft provided by the surveillance display and shall take an appropriate action if the reported aircraft identification is incorrect.	OR.9
		SPR.9 In the Advanced Procedure, controllers shall be trained on the modified phraseology including the Preceding Aircraft identification and the associated procedures.	OR.12
Clearance	Controller	SPR.10 As in current operations, the controller shall only issue the clearance for maintaining own visual separation after the flight crew has explicitly reported having the Preceding Aircraft in sight.	OR.13
Maintaining own visual separation	Flight crew of the Receive Aircraft	SPR.11 As in current operations, the flight crew shall maintain visual contact with the Preceding Aircraft while maintaining own visual separation from it.	OR.15
		SPR.12 As in current operations, any manoeuvre by the flight crew while maintaining own visual separation shall be undertaken with visual reference to the Preceding Aircraft.	OR.16
		SPR.13 The flight crew shall apply current procedure for own visual separation if the target corresponding to the Preceding Aircraft disappears on the Traffic Display.	OR.17

Phase	Domain	Operational Requirement	Source
		SPR.14 As in current operations, the flight crew shall apply current contingency procedures if visual contact with the Preceding Aircraft is lost while maintaining own visual separation from it.	OR.18
		SPR.15 Flight crews shall be trained on the use of the Traffic Display to maintain own visual separation from the Preceding Aircraft on approach.	OR.19
		SPR.16 As in current operations, upon visual detection of a hazard or upon being alerted to a hazard by the controller, the flight crew shall , without delay, take appropriate measures to ensure the safety of the operations.	OR.20
	Controller	SPR.17 As in current operations, upon detection of a hazard, the controller shall issue appropriate instructions to the flight crew in order to ensure the safety of the operations.	OR.21
All	Controller	SPR.18 As in current operations, Tower and Approach Controllers shall issue clearances, instructions, safety alerts, and traffic advisories according to facility requirements and standard operating procedures.	OR.22
		SPR.19 As in current operations, the Approach Controller shall maintain separation between the Succeeding Aircraft and all other aircraft for which they have separation responsibility.	OR.23
		SPR.20 As in current operations, the Tower Controller shall observe traffic using visual means within visual range of the tower. <i>Note: The Tower Controller may utilize radar at airports where it is available. However, radar is not a minimum requirement to be able to conduct ATSA-VSA operations.</i>	OR.24

3.4 VSA EQUIPMENT REQUIREMENTS

3.4.1 Functional requirements for VSA Equipment

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

NOTE 1: *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 3.2: FUNCTIONAL REQUIREMENTS FOR VSA EQUIPMENT

Data	Interface	Functional Requirement	Source
Available data	G1	SPR.21 The following list of parameters shall be displayed to the flight crew for qualified airborne traffic to support the visual acquisition of the Preceding Aircraft: - Relative horizontal position (i.e. distance and relative bearing); - Altitude (relative altitude required. Barometric corrected pressure altitude and absolute pressure altitude optional); - Direction (ground track); and - Vertical tendency.	OR.1
	F1	SPR.22 The following surveillance parameter shall be available to display to the flight crew for qualified airborne traffic to support the visual acquisition of the Preceding Aircraft: Aircraft identification.	OR.2
	G1	SPR.23 In addition to the list of parameters to support visual acquisition, the following parameter for the Preceding Aircraft shall be displayed to the flight crew to support maintaining own visual separation from this traffic: Speed information (ground speed or ground speed differential).	OR.14
Ownship data		SPR.24 The following data items shall be provided to the VSA Equipment by on-board sensors in the Receive Aircraft Domain: - Horizontal Position - Pressure Altitude - Horizontal Velocity (*) - Horizontal Position Accuracy (**) - Horizontal Position Integrity Containment Bound - Horizontal Velocity Accuracy (*) (*) Depending on implementation, if no comparison is made to own data to derive ground speed differential, the ownship Horizontal Velocity and/or Horizontal Velocity Accuracy may not be required. (**) It does not preclude the possibility of deriving Horizontal Position Accuracy from other information provided from the ownship sensors (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.	PR.3
Qualification	G1	SPR.25 The VSA Equipment shall provide the flight crew with the capability to determine whether ownship and a target on the Traffic Display are qualified for ATSA-VSA	PR.1, PR.2, OR.3
Traffic Display	G1	SPR.26 Relative horizontal position derived by the VSA Equipment from the horizontal position data of ownship and received surveillance reports shall be displayed graphically and with a resolution consistent with other onboard displays.	PR.4

Data	Interface	Functional Requirement	Source
	G1	SPR.27 The minimum resolution for display of altitude information shall be 100 feet.	PR.11
	G1	SPR.28 The Traffic Display shall be capable of providing the aircraft identification of the transmitting aircraft.	PR.12
	G1	SPR.29 The direction information shall be provided to the flight crew by the VSA Equipment with a resolution of 15 degrees or better.	PR.13
	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.15
	G1	SPR.31 The minimum resolution for display of speed information shall be 10 kts.	PR.17
Data Performance	D → G1	SPR.32 Errors in the direction information shall be less than 15 degrees, 95%.	PR.14
	D → G1	SPR.33 The VSA Equipment shall , at a minimum level of performance, determine if a qualified aircraft is climbing or descending to a nominal, tracked vertical rate threshold equal to 500 feet per minute, with an allowable tolerance of +/- 200 feet per minute around the nominal threshold.	PR.16

3.4.2 Performance Requirements for VSA Equipment

This section states the Performance Requirements of the VSA Equipment within the Receive Aircraft Domain.

This section is divided as follows:

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

3.4.2.1 System reliability and integrity requirements

The following Performance Requirements apply to the VSA Equipment within the Receive Aircraft Domain. These requirements specify the reliability with which the onboard avionics will not corrupt data or display incorrect data. All of the requirements in this subsection are drawn from the OSA in Annex C and are needed to meet the Safety Objectives of specific Operational Hazards.

TABLE 3.3: SYSTEM RELIABILITY REQUIREMENTS

Data	Interface	Performance Requirement	Source
ADS-B State Vector	D → G1	SPR.34 The likelihood that the VSA Equipment corrupts ADS-B State Vector data it receives and processes or information derived from the State Vector it displays shall be less than 1.0E-03 per flight hour. <i>Note: The State Vector contained the following ADS-B data:</i> ▪ horizontal position and related integrity and accuracy; ▪ altitude; ▪ vertical tendency; ▪ ground speed and related accuracy; and ▪ ground track.	SR.1
Ownship state data	B2 → G1	SPR.35 The likelihood that an ownship state data error occurs shall be less than 1.0E-03 per flight hour. <i>The state data contained the following ownship data:</i> ▪ horizontal position and related integrity and accuracy; ▪ altitude; ▪ vertical tendency; ▪ ground speed and related accuracy; and ▪ ground track.	SR.2
Aircraft identification	D → G1	SPR.36 The likelihood that the VSA Equipment corrupts aircraft identification data it receives and processes or aircraft identification data it displays shall be less than 1.0E-04 per flight hour.	SR.4

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 ADS-B target 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 D)

NOTE 1: *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, 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.

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 aircraft 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 ownship's data is defined similarly, but starting from the time of applicability of the position measurement at Interface B2.

NOTE 2: *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 compensatable. While flight crew training can mitigate this, the analysis employs a conservative approach.*

The Performance Requirements related to timing are listed in Table 3.4.

TABLE 3.4: ATSA-VSA TIMING REQUIREMENTS

Data	Interface	Performance Requirement	Source
Total Latency	D → G1	SPR.37 The total latency of horizontal position data between interfaces D and G1 shall be less than 4 seconds, 95%.	PR.20
	D → G1	SPR.38 The total latency of horizontal velocity data between interfaces D and G1 shall be less than 4 seconds, 95%.	PR.21
Uncompensated Latency	D → G1	SPR.39 The onboard uncompensated latency of the target aircraft's 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%.	PR.10
	B2 → G1	SPR.40 The uncompensated latency of the ownship's position shall be less than 1.6 seconds, 95%.	PR.9

3.5

VSA DATA REQUIREMENTS

This section specifies the minimum data quality needed to perform the ATSA-VSA application. These requirements apply to data from both the Succeeding Aircraft (i.e. Receive Aircraft Domain), and data received from the Preceding Aircraft (i.e. Transmit Aircraft Domain).

NOTE 1: *The requirements specified in this section place requirements on the use of received data from transmitting aircraft. These requirements should not be interpreted as levying requirements on transmitting aircraft to guarantee the broadcast of data that meets these requirements. If transmitting data does not meet these requirements, then the Succeeding Aircraft must not consider the aircraft from which that non-qualified data was received as a Preceding Aircraft for the ATSA-VSA application.*

The data quality requirements focus on two parameters:

- **Horizontal Position:** Inaccuracies in the reported positions of the Preceding and Succeeding Aircraft result in a difference of the relative bearing and range of the Preceding Aircraft with respect to the position of the Succeeding Aircraft between the information provided by the Traffic Display and the out the window view. This difference can lead the Succeeding Aircraft to maintain own visual separation from the Wrong Target Aircraft or to inappropriate decisions to manoeuvre or not to manoeuvre while maintaining own visual separation from the correct Preceding Aircraft. Horizontal position accuracy of 0.3 NM, 95% for both the Preceding Aircraft and Succeeding Aircraft is the required minimum to be considered qualified for ATSA-VSA. To ensure that large errors do not behave worse than is modelled in the OPA, an integrity containment bound of 0.75 NM with an integrity level of 1.0E-03 applies to both the Preceding Aircraft's and the Succeeding Aircraft's position data. This requirement is used in the calculations of the Fault Trees in the ASOR, safety process of the Operation Safety Assessment, Annex C.
- **Horizontal Velocity:** Inaccuracies in the reported velocities of the Preceding and Succeeding Aircraft can result in inappropriate decisions to manoeuvre or not to manoeuvre while maintaining own visual separation. Horizontal velocity accuracy of 10 m/s (19.4 knots), 95% is required to be considered qualified for ATSA-VSA.

TABLE 3.5: VSA DATA QUALITY REQUIREMENTS

Data	Interface	Performance Requirement	Source
Horizontal Position	D → G1 B2 → G1	SPR.41 The ownship and target shall only be considered qualified for the ATSA-VSA application if they have a horizontal position accuracy of 0.3 NM, 95% or better.	PR.5 PR.6
	D → G1 B2 → G1	SPR.42 The ownship and target shall only be considered qualified for the ATSA-VSA application if they have a horizontal position integrity bound of 0.75 NM with an integrity of 1E-3, or better.	PR.7 PR.8 SR.3
Horizontal Velocity	D → G1 B2 → G1	SPR.43 The ownship and target shall only be considered qualified for the ATSA-VSA application if they have a horizontal velocity accuracy of 10 m/s, 95%.	PR.18 PR.19

NOTE 2: *The accuracy and integrity requirements specified in Table 3.5 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 integrity and/or accuracy to the required levels specified in the table. For data received by certified ADS-B systems compliant to DO-242A [9], the requirements correspond to following ADS-B values:*

- SPR.41: NACP ≥ 6 (0.3 NM);
- SPR.42: NIC ≥ 6 (0.6 NM) and SIL ≥ 1 (1.0E-03); and
- SPR.43: NACv ≥ 1 (10 m/s)

NOTE 3: *For a table of accepted conversions from NIC and NACp to NUCp, see Appendix B.2.*

NOTE 4: *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 identifies some Recommendations and design considerations identified in the Operational Performance Assessment (see §B.6).

TABLE 3.6: RECOMMENDATIONS AND DESIGN CONSIDERATIONS

Parameters	Recommendations
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. This document does not specify any availability requirements for the ATSA-VSA application. They are viewed to be driven more by business case considerations rather than technical considerations.
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 time, e.g. per flight hour or per operation. This document does not specify any continuity requirements for the ATSA-VSA application. They are viewed to be driven more by business case considerations rather than technical considerations.
Coverage volume	To support the visual acquisition of the Preceding Aircraft, the flight crew of the Succeeding Aircraft should be provided with information on all qualified aircraft within the detection volume. Operational inputs estimate that this detection volume, which corresponds to the coverage volume or the ADS-B surveillance, should be of 10 NM in range and +/- 3,500 ft vertically of ownship. <i>Note: RTCA DO-242A ADS-B MASPS [9] Table 3-4a provides high-level guidance on acquisition range for various ASAS applications. It is expected that future MOPS level documents (e.g. ASAS MOPS) will address this parameter in greater detail to fully specify the coverage volume for the ADS-B surveillance link.</i>
Minimum number of aircraft tracked	The VSA 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. <i>Note: RTCA DO-242A ADS-B MASPS [9] Table 2-8 and Table 2-9 provide some guidance on anticipated traffic levels. It is expected that future MOPS level documents (e.g. ASAS MOPS) will address this parameter based on assumed Environmental Conditions.</i>
Minimum number of aircraft displayed	To support the flight crew of the Succeeding Aircraft in visually acquiring the Preceding Aircraft, it is important to be able to display all the qualified aircraft in the coverage volume that are in the visual field of the flight crew (typically between 9 o'clock and 3 o'clock). <i>Note: Flight crews should use the most appropriate Traffic Display range for the current operation (e.g. visual acquisition). 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.</i> When maintaining own visual separation, there is only one relevant aircraft, i.e. the Preceding Aircraft. Nevertheless, the other qualified aircraft can also be displayed.

Parameters	Recommendations
Traffic Display design considerations	<u>Selection / Highlighting</u> Some pilots expressed a desire for some of the below Traffic Display capabilities to be included in the ATSA-VSA application as part of operational workshop discussions: ▪ Ability for selection and highlighting of an aircraft of interest, e.g. the Preceding Aircraft; and ▪ Ability to display the selected aircraft horizontal velocity (i.e. speed and direction) to provide trend information.
	<u>Predictive Time-Based Vector</u> A desirable capability for the Visual Acquisition phase of ATSA-VSA is the use of a predictive, time-based vector depicting projected traffic position for all displayed aircraft. This was deemed to be particularly beneficial in preventing potential misidentification of the traffic-to-follow during the Visual Acquisition phase. 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> A desired capability as expressed by pilots for depicting target aircraft on the Traffic Display is the use of Indicated Air Speed / Heading as an alternate view to ground speed / ground track. Indicated Air Speed is available from Air Referenced Velocity (ARV) transmissions of ADS-B OUT.
	<u>Display of altitude</u> The minimum required altitude information for ATSA-VSA is the relative altitude (relative to ownship). The need and usability of the optional altitudes, pressure altitude and correct barometric altitude, is context dependent. Pressure altitude is the altitude relative to a standard pressure reference, 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, i.e. barometric corrected pressure altitude. However 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 further noted that the traffic information provided by the controller for acquisition typically uses barometric corrected pressure altitude. It is therefore considered useful for the flight crew to have this information available during the acquisition phase
	<u>Non-qualified traffic</u> The issue of whether non-qualified traffic is displayed, and the manner in which it may be displayed, is left to the discretion of the implementer as part of the airworthiness approval of the ATSA-VSA application

CHAPTER 4

INTEROPERABILITY REQUIREMENTS

4.1 PURPOSE OF INTEROPERABILITY REQUIREMENTS

This chapter specifies the minimum set of Interoperability Requirements and allocations necessary to provide assurance that the elements of the CNS/ATM system are compatible with each other and will perform their intended function for ATSA-VSA. As depicted in Figure 1.1, the CNS/ATM system is divided into the aircraft (transmit and receive) and ground domains.

NOTE 1: *This set of Interoperability Requirements is meant to specify the required exchange of data between aircraft, and between aircraft and ground domains, for the proper operation of the ATSA-VSA application. These requirements are not intended to contain detailed Operational Requirements for avionics and/or ground equipment. Such requirements can be found in specialised documents such as MOPS and Interface Control Documents.*

4.2 SCOPE OF INTEROPERABILITY REQUIREMENTS

The Interoperability Requirements found in this Chapter specify technical exchange of data between all relevant domains for the ATSA-VSA application. This exchange of data focuses on the ADS-B surveillance data and therefore does not include data that is communicated over voice.

NOTE 1: *Specific ADS-B link technology requirements are not addressed in the INTEROP specification. Requirements are specified at the ADS-B system (i.e. MASPS) level.*

This Chapter provides the minimum INTEROP requirements needed to satisfy the SPR requirements stated in Chapter 3. Also included are recommendations for further requirements or means on how requirements are best met.

4.2.1 ATSA-VSA domains

The ATSA-VSA functional components represent a subset of the components required for the general Airborne Surveillance Applications and Ground Surveillance Applications system. For the purpose of this document, an indication of the main functional components used for the ATSA-VSA application is provided in **Figure 3.1** of this document. The domains to be considered for interoperability allocation within the context of this document are:

- The Transmit Aircraft Domain;
- The Receive Aircraft Domain; and
- The Ground Domain.

The following subsections briefly discuss the relevant domains.

4.2.1.1 Transmit Aircraft Domain

In the Transmit Aircraft Domain the following capabilities are taken into consideration for interoperability:

- The ability to process and store information from systems on board the aircraft, for amalgamation into surveillance data (e.g. using a Surveillance Transmit Processing, STP, function); and
- The ability to format and transmit surveillance data as ADS-B signals in compliance with the specifications of the implemented link technology.

4.2.1.2 Receive Aircraft Domain

In the Receive Aircraft Domain the following capabilities are taken into consideration for interoperability:

- The ability to process and store information from systems on board the aircraft, for amalgamation into ownship surveillance data (e.g. using an STP);
- The ability to receive ADS-B signals and assemble them into surveillance data in compliance with the specifications of the implemented link technology and the airborne system;
- The ability to process and associate received surveillance data from transmitting aircraft with ownship surveillance data in preparation for presentation to the flight crew (e.g. using an ASSAP); and
- The ability to present surveillance data to the flight crew via a Traffic Display (e.g. a Cockpit Display of Traffic Information and control panel).

4.2.1.3 Ground Domain

In the Ground Domain for the ATSA-VSA application (for both the Basic Procedure and Advanced Procedure), responsibilities with respect to separation provision are the same as for current own visual separation clearances: the controller is responsible for providing separation services until an own visual separation clearance is provided to and has been accepted by the flight crew of the Succeeding Aircraft against the Preceding Aircraft. Ground Domain requirements are the same as for current visual operations, utilizing VHF voice communications between the controller and flight crews, and using radar surveillance by the Approach Control services. Tower Control services are provided, at a minimum, using visual observations of aircraft on approach and landing.

NOTE 1: *The Tower Controller may utilize radar at airports where it is available. However, radar is not a minimum requirement to be able to conduct ATSA-VSA operations.*

Since there are no ADS-B or new radar surveillance aspects associated with this application, there are no Interoperability Requirements levied on the Ground Domain for both the Basic Procedure and Advanced Procedure.

NOTE 2: *While no new radar surveillance aspects and no new Interoperability Requirements are levied on the Ground Domain for ATSA-VSA, there is an assumption in the OSED ASSUMP-OSED.10: For the Advanced Procedure, an updated aircraft identification is available to the controller to support the comparison of the aircraft identification reported by the flight crew of the Succeeding Aircraft and that provided by the surveillance display..*

In future iterations of the ATSA-VSA application, ground traffic surveillance may also be provided using ADS-B RAD or ADS-B NRA. In these future surveillance environments further enhancements in the use and role of aircraft identification in communications between the controller and flight crews in conducting ATSA-VSA operations are expected.

4.2.1.4 ATSA-VSA domain summary

Unless the Air Navigation Service Provider has regulated the airspace so that all aircraft must be fully compliant with minimum ADS-B installations that will meet these requirements, it is possible for noncompliant systems to exist. It is the responsibility of the Receive Aircraft Domain to identify such aircraft and prohibit using such aircraft in performing the ATSA-VSA application.

This document primarily defines requirements for the input of the Receive Aircraft Domain and the output of the Transmit Aircraft Domain. Each requirement may levy requirements on the subsystem or function of the given domain; e.g. integrity requirements for an ADS B message impose requirements on Data Source components of the Transmit Aircraft Domain.

NOTE 1: *The indicated subsystems or capabilities of each of the above domains are not intended to imply a physical architecture. The intent is to describe functional blocks to ease reader understanding of the requirements.*

NOTE 2: *From an interoperability perspective the physical architecture of the VSA Equipment does not need to be specified.*

4.3 ATSA-VSA INTEROPERABILITY REQUIREMENTS

4.3.1 Minimum data

ATSA-VSA Interoperability Requirements are derived from ASSUMP-OPA.3 which identifies the data items that are provided to the VSA Equipment (i.e. Receive Aircraft Domain) via ADS-B OUT provided by the Transmit Aircraft Domain:

- Horizontal Position
- Pressure Altitude
- Horizontal Velocity
- Aircraft identification
- Horizontal Position Accuracy
- Horizontal Position Integrity Containment Bound
- Horizontal Velocity Accuracy

IR.1 In order to be considered a Preceding Aircraft for ATSA-VSA, the Transmit Aircraft Domain **shall** transmit the following ADS-B parameters.

- Identity;
- Horizontal position;
- Vertical position;
- Horizontal velocity;
- Surveillance quality indicators.

More specific requirements on each data parameter are specified in the following subsections.

IR.2 The Receive Aircraft Domain **shall** be able to receive, from an eligible Transmit Aircraft Domain, ADS-B messages containing at least the elements which enable the avionics to format the required ADS-B surveillance reports and associate the surveillance data with ownship surveillance data to support ATSA-VSA.

IR.3 The Receive Aircraft Domain **shall** be able to determine the time of applicability for all received ADS-B data.

4.3.2 Identity

The ATSA-VSA application has a requirement for the Receive Aircraft Domain to be able to identify qualified aircraft from received ADS-B “OUT” transmissions (OR.1).

4.3.2.1 24 bit aircraft address

IR.4 In order to be considered a Preceding Aircraft for ATSA-VSA, the Transmit Aircraft Domain **shall** transmit the 24 bit aircraft address within each ADS-B message.

4.3.2.2 Aircraft identification

IR.5 In order to be considered a Preceding Aircraft for ATSA-VSA, the Transmit Aircraft Domain shall transmit an ADS-B identification message containing the aircraft identification (OR.1).

IR.6 As per ICAO Doc. 4444, PANS-ATM [1] the following definitions **shall** be applied by the Receive Aircraft Domain:

- (Chapter 1, Definitions) Aircraft identification is ‘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’,
- (Appendix 2, 2.2) one of the following aircraft identifications, not exceeding 7 characters:
 - the ICAO designator for the aircraft operating agency followed by the flight identification (e.g. KLM511, NGA213, JTR25) when in radiotelephony the call sign to be used by the aircraft will consist of the ICAO telephony designator for the operating agency followed by the flight identification (e.g. KLM511, NIGERIA 213, HERBIE 25); or
 - the registration marking of the aircraft (e.g. EIAKO, 4XBCD, N2567GA).

4.3.3 Horizontal position

Horizontal position is indicated using latitude and longitude and has its quality characterized using position quality indicators.

4.3.3.1 Horizontal position (latitude and longitude)

IR.7 In order to be considered a Preceding Aircraft for ATSA-VSA, the Transmit Aircraft Domain **shall** transmit horizontal position information (i.e. latitude, longitude) referenced to WGS-84, consistent with the associated quality indicators.

NOTE 1: *Horizontal position information may be transmitted with equivalent quality to that received from the positioning source, or alternately the aircraft may transmit position information with lower quality than that received from the positioning source, provided that the quality indicators correctly indicate the transmitted position quality.*

IR.8 The Receive Aircraft Domain **shall** interpret received horizontal position information (i.e. latitude, longitude) as referenced to WGS-84.

4.3.3.2 Position quality indicators

NOTE 1: *Position Quality Indicators are used by the Receive Aircraft Domain to determine whether the ADS B surveillance report (and therefore the derived Transmit Aircraft Domain position) can be used to support the ATSA-VSA application.*

NOTE 2: *In the following material the term Horizontal Protection Limit (HPL) represents an integrity containment parameter on horizontal position derived from a Global Navigation Satellite System (GNSS) source or an equivalent containment for horizontal position provided from other sources providing GNSS equivalent position integrity.*

IR.9 In order to be considered a Preceding Aircraft for ATSA-VSA, the Transmit Aircraft Domain **shall** transmit an appropriate indication of quality for the horizontal position information.

IR.10 The indicators of position quality used **shall** be Navigation Integrity Category (NIC), Navigation Accuracy Category for Position (NACp), or Surveillance Integrity Level (SIL) as specified in DO-242A, or Navigation Uncertainty Category for Position (NUCp) as specified in DO-242.

NOTE 3: *DO-242A [9] and DO-242 [8] also define the relationship between these parameters and the HPL and Horizontal Figure of Merit (HFOM) indicators when the parameters are derived from a GNSS source.*

NOTE 4: *When HPL (or equivalent integrity containment bound indications) is not available, NIC or NUCp are set to 0 (i.e. integrity bound is unknown).*

IRec.1 As opposed to a single quality parameter, the Transmit Aircraft Domain **should** transmit accuracy and integrity as independent items (as defined per DO-242A).

IR.11 When NACp and NIC are transmitted, the Transmit Aircraft Domain **shall** determine NACp based upon HFOM (or equivalent) and NIC based upon on HPL (or equivalent) in order to be considered a Preceding Aircraft for ATSA-VSA.

IR.12 When NUCp is transmitted, the Transmit Aircraft Domain **shall** determine NUCp based upon HPL or equivalent in order to be considered a Preceding Aircraft for ATSA-VSA.

IRec.2 When the position data source is GNSS, the use of DO-208 [13] RAIM (Receiver Autonomous Integrity Monitoring) calculations to determine HPL is acceptable as a minimum. However, NUCp/NIC values **should** be determined using HPL values based on DO-229D [14], DO-253A [15], or DO-310 [18] GNSS receivers or equivalent when feasible.

IRec.3 When the position data source is GNSS, the NACp values **should** be determined using the HFOM value output from DO-208 [13], DO-229D [14], DO-253A [15], or DO-310 [18] GNSS receivers or equivalent.

IR.13 In order to be considered a Preceding Aircraft for ATSA-VSA, the Transmit Aircraft Domain **shall** establish a value of SIL per DO-242A, change 1 [10]. The value of SIL **shall** be set to 1 for position sources with software design assurance of at least Level D per ED-12B/DO-178B [12] and hardware design assurance of at least Level D per ED-80/DO-254 [16], or else SIL **shall** be set to 0.

IR.14 A distinction between NUCp and NIC/NACp/SIL airborne implementations **shall** be provided by the Transmit Aircraft Domain (e.g. a link-specific defined version number).

NOTE 5: *Airborne implementations based on DO-242 do not broadcast an explicit ADS B version number. Such implementations can be identified based on their lack of version number, interpreted as version 0.*

4.3.4 Vertical position

Vertical position sent by a Transmit Aircraft Domain is used by the Receive Aircraft Domain to establish the altitude of the transmitting aircraft. The vertical position is based upon pressure altitude.

NOTE 1: *Pressure altitude is the indicated altitude which corresponds to the pressure in the International Standard Atmosphere; ISO 2533:1975.*

4.3.4.1 Pressure altitude

IR.15 In order to be considered a Preceding Aircraft for ATSA-VSA, the Transmit Aircraft Domain **shall** transmit pressure altitude.

IRec.4 Neither Gilham altitude encoders nor altitude sources with a resolution less than or equal to 7.62 m (25 ft) **should** be used by aircraft implementations.

4.3.5 Horizontal velocity

4.3.5.1 Horizontal geometric velocity

Horizontal geometric velocity is used by the Receive Aircraft Domain to establish the directionality or ground track of the transmitting aircraft and is also used in computing the speed information (ground speed or ground speed differential).

IR.16 In order to be considered a Preceding Aircraft for ATSA-VSA, the Transmit Aircraft Domain **shall** transmit horizontal geometric velocity as specified in DO-242 and DO-242A.

IR.17 In order to be considered a Preceding Aircraft for ATSA-VSA, the Transmit Aircraft Domain **shall** reference all horizontal geometric velocity elements to a local level plane that is tangent to the WGS-84 ellipsoid and is vertically displaced such that it contains its surveillance reference point.

IRec.5 In order to enable the possibility of providing Indicated Air Speed (IAS) and associated heading information (also referred to as 'Air Referenced Velocity (ARV)') to the Traffic Display as a Design Consideration for ATSA- VSA, the Receive Aircraft Domain **should** be capable of receiving the ARV as defined in Section 2.1.2.7 in DO-242A."

NOTE 1: *Any implementation using the ARV must be coordinated with the transmit requirements of other ADS-B applications utilizing ARV, e.g. ADS-B RAD, to ensure transmission rate compatibility.*

4.3.5.2 Velocity quality indicators

IR.18 In order to be considered a Preceding Aircraft for ATSA-VSA, the Transmit Aircraft Domain **shall** transmit an associated quality indicator (i.e. Navigation Accuracy Category for Velocity (NACv) or Navigation Uncertainty Category for Velocity (NUCr) as specified in DO-242A and DO-242, respectively) for the transmitted geometric velocity.

4.3.6 Vertical rate

Vertical rate may be used by the Receive Aircraft Domain to establish the vertical tendency of the transmitting aircraft. Vertical rate is either the pressure altitude rate (referred to as barometric altitude rate in DO-242 and DO-242A) or the geometric vertical velocity.

IRec.6 The Transmit Aircraft Domain **should** transmit vertical rate as specified in DO-242 and DO-242A, where the vertical rate is either pressure altitude rate or geometric vertical velocity with an appropriate indication.

IRec.7 The Receive Aircraft Domain may receive vertical rate as specified in DO-242 and DO-242A from qualified aircraft to determine the vertical tendency of other aircraft.

4.3.7 Surveillance quality indicators

Surveillance quality indicators include the position quality and velocity quality indicators. The position quality indicators include NIC, NACp and SIL as specified in DO-242A or NUCp as specified in DO-242. The velocity quality indicators include NACv or NUCr as specified in DO-242A and DO-242, respectively.

IR.19 In order to be considered a Preceding Aircraft for ATSA-VSA, the Transmit Aircraft Domain **shall** establish and transmit surveillance quality indicators directly from the outputs of onboard aircraft sensors (i.e. NACp, NACv, etc) without including latency effects, which are addressed as separate requirements.

NOTE 1: *Total latency and uncompensated latency requirements and assumptions for the Transmit Aircraft Domain and Receive Aircraft Domain are provided separately from the Surveillance Quality Indicators and are found in §3.4.2.2 of the SPR and in Annex B.*

4.3.8 Transmit Aircraft Domain design assurance

The Transmit Aircraft Domain will need to meet acceptable levels of design assurance to support the ATSA-VSA application.

IR.20 In order to be considered a Preceding Aircraft for ATSA-VSA, the Transmit Aircraft Domain **shall** have software design assurance of at least Level D per ED-12B/DO-178B [12] and hardware design assurance of at least Level D per ED-80/DO-254 [16] associated with all functions that impact the integrity of the ADS-B OUT elements required to support the ATSA-VSA application.

NOTE 1: *SIL characterizes the Surveillance Integrity Level of the ADS-B OUT position source without addressing other functions within the Transmit Aircraft Domain that may impact the integrity of the transmitted information.*

4.3.9 ADS-B emitter category

ADS-B Emitter Category describes the category of aircraft that ADS-B OUT traffic represents. This is potentially beneficial information during the Maintaining Own Visual Separation phase of ATSA-VSA, indicating the category of Preceding Aircraft that is being followed. The ADS-B Emitter Category is as specified in DO-242A.

IRec.8 Aircraft implementations **should** consider the use of ADS-B Emitter Category as potentially useful additional information to be conveyed via ADS-B OUT as part of the Transmit Aircraft Domain, and being received and processed by ADS-B IN as part of the Receive Aircraft Domain.