ICAO

Doc 9994

Manual on Airborne Surveillance Applications

Second Edition, 2020

Approved by and published under the authority of the Secretary General

INTERNATIONAL CIVIL AVIATION ORGANIZATION

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AMENDMENTS

Amendments are announced in the supplements to the *Products and Services Catalogue;* the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

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FOREWORD

Airborne surveillance is rapidly evolving with a number of new capabilities planned for introduction into the flight deck. The ICAO *Global Air Navigation Plan (GANP)* (Doc 9750) requires that these be interoperable in order to allow aircraft to achieve the same levels of safety and efficiency globally. Airborne surveillance represents a shift in surveillance functionality from traditional ground-based sensors to a comprehensive suite of avionics which will support a range of new, demanding surveillance capabilities and applications. Aircraft position and other airborne parameters are/will be provided by the basic airborne surveillance capability, known as ADS-B OUT. This information is/will be used directly by other aircraft equipped with an advanced capability, known as ADS-B IN, to support both existing applications, and some yet to be developed.

This manual describes several airborne surveillance capabilities such as Basic Airborne Situational Awareness (AIRB), visual separation on approach (VSA), Basic Surface Situational Awareness (SURF) and ADS-B traffic awareness system (ATAS). It also describes the in-trail procedure (ITP) application and the interval management (IM) application, which were introduced in the Aviation System Block Upgrades (ASBUs) supporting GANP.

The ASBUs contain modules which rely on ADS-B Standards, both for ADS-B OUT (ASUR-B0/1: automatic dependent surveillance – broadcast (ADS-B)) and for ADS-B IN, which are the key enablers for airborne surveillance. Their evolution is described in specific threads related to airborne surveillance applications (ASA) (CSEP-B1/1: AIRB to CSEP-B4/1: airborne separation) as well as airborne collision avoidance (ACAS-B1/1: ACAS improvements and ACAS-B2/1: new collision avoidance system).

Future airborne ADS-B IN applications which involve separation minima less than current radar separation standards may require changes in the airborne collision avoidance system (ACAS). Therefore, implementations of various airborne ADS-B IN applications may be dependent on the availability for implementation of a new collision avoidance system.

This manual also provides initial material regarding cockpit display of traffic information (CDTI) and assisted visual separation (CAVS) capabilities. CAVS is explained in Chapter 3 as specific implementation, since there are operational implementations of these capabilities only in one country as of 2020.

For surface applications, it is pointed out that SURF and SURF-IA (SURF-B1/2: Comprehensive pilot situational awareness on the airport surface and SURF-B2/3: conflict alerting for pilots for runway operations) are expected to complement A-SMGCS levels 1 and 2 and A-SMGCS levels 3 and 4.

This manual was initially developed by the Airborne Surveillance Task Force (ASTAF) that was established by ICAO in 2010 as a multidisciplinary team of experts for the timely development of ICAO provisions to ensure global uniformity and interoperability of operations based on the use of ADS-B on the flight deck. Three main objectives of this manual are as follows:

a) to support the implementation of ASA and the initial airborne surveillance capabilities, for which some industrial solutions are already available and in operational use;

b) to present guidance material and references related to the standards and recommended practices (SARPs), the procedures for air navigation services (PANS) and relevant industry standards documents, i.e. safety, performance and interoperability requirements (SPR) and minimum operational performance standards (MOPS);

c) to summarize and recapitulate within an ICAO document the main results of the airborne surveillance work carried out in the air traffic management (ATM) community supported by ADS-B, which is recognized as an essential enabler of the ICAO global concept of operations as a promoter of the related ASBU threads.

The manual will be updated with the support of the Surveillance Panel (SP) to incorporate additional ASA when they are made available to the global ATM community.

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GLOSSARY

ABBREVIATIONS

ABP	Achieve-by point
ACAS	Airborne collision avoidance system
ACID	Aircraft identification
ADS-B	Automatic dependent surveillance–broadcast
AIRB	Basic Airborne Situational Awareness
ANSP	Air navigation services provider
ASA	Airborne surveillance application(s)
ASBU	Aviation System Block Upgrade
ASG	Assigned spacing goal
ASSAP	Airborne surveillance and separation assurance processing
ASTAF	Airborne Surveillance Task Force
ATAS	ADS-B traffic awareness system
ATC	Air traffic control
ATM	Air traffic management
ATS	Air traffic services
ATSA	Air traffic situational awareness
CAA	Civil aviation authority
CAVS	CDTI assisted visual separation
CDTI	Cockpit display of traffic information
CPDLC	Controller-pilot data link communications
CRM	Crew resource management
EASA	European Union Aviation Safety Agency
EUROCAE	European Organization for Civil Aviation Equipment
FIM	Flight-deck interval management
FMS	Flight management system
FUA	Flexible use of airspace
GNSS	Global navigation satellite system
GBAS	Ground-based augmentation system
HF	High frequency
HMI	Human-machine interface
ICAO	International Civil Aviation Organization
IFR	Instrument flight rules
IM	Interval management
IMC	Instrument meteorological conditions
ITP	In-trail procedure
MLAT	Multilateration (systems)
MOPS	Minimum operational performance standards
NAC	Navigation accuracy category
NIC	Navigation integrity category
NUC	Navigation uncertainty category
OEM	Original equipment manufacturer
OSA	Operational safety assessment
OTW	Out-the-window
PCP	Planned cancellation point
RA	Resolution advisory

RSI	Runway status indication
SESAR	Single European Sky ATM Research
SIL	Source integrity level (ADS-B version 2)
SIL	Surveillance integrity level (ADS-B version 1)
SOP	Standard operating procedure
SPR	Safety, performance and interoperability requirements
SSR	Secondary surveillance radar
SBAS	Satellite-based augmentation system
SURF	Basic Surface Situational Awareness
TA	Traffic advisory
TIS-B	Traffic information service–broadcast
TLS	Target level of safety
VFR	Visual flight rules
VHF	Very high frequency
VMC	Visual meteorological conditions
VSA	Visual separation on approach
WAM	Wide area multilateration

DEFINITIONS

Airborne surveillance and separation assurance processing (ASSAP). The processing of surveillance and other data in support of ASA. ASSAP function that processes surveillance data using ADS-B reports from the ADS-B receive function, and performs application-specific processing.

Airborne surveillance application (ASA). A set of operational procedures for controllers and pilots that makes use of the capabilities of airborne surveillance to meet a clearly defined operational goal.

Airborne surveillance capability. An installation into a flight deck that receives/processes surveillance data. and displays relevant information to the pilot.

Airborne surveillance system. An airborne surveillance system provides the position of participating aircraft and vehicles in the vicinities and other related information to pilots and on-board systems. In most cases, the system provides knowledge of “who” is “where” and “when”. Other information may include horizontal and vertical speed data, identifying characteristics or intent.

Airborne traffic situational awareness applications. These applications are aimed at enhancing the pilots’ knowledge of the surrounding traffic situation, both in the air and on the airport surface, and thus improving the pilots’ decision process for the safe and efficient management of their flight.

Aircraft address. A unique combination of 24 bits available for assignment to an aircraft for the purpose of air-ground communications, navigation and surveillance.

Aircraft identification (ACID). 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.

Assigned spacing goal. The time or distance interval between the IM aircraft and target aircraft assigned by the air traffic controller as part of the IM operation. The assigned spacing goal is determined by the air traffic controller issuing the IM clearance and the type and value(s) of the assigned spacing goal are selected to achieve the air traffic controller's goal of establishing an efficient flow while maintaining separation from all traffic.

Automatic dependent surveillance–broadcast (ADS-B) OUT. A function on an aircraft or vehicle that periodically broadcasts its state vector (position and velocity) and other information derived from on-board systems in a format suitable for ADS-B IN capable receivers.

Automatic dependent surveillance–broadcast (ADS-B) IN. A function that receives surveillance data from ADS-B OUT data sources.

Closing ground speed. The difference between the ITP aircraft's ground speed and a reference aircraft's ground speed, used to determine the reduction in ITP distance.

Closing Mach speed. The difference between the ITP aircraft's Mach speed and a reference aircraft's Mach speed, used to determine the reduction in ITP distance.

Cockpit display of traffic information (CDTI). The pilot interface portion of the aircraft surveillance applications system. This interface includes traffic display(s) and all the controls that interact with such a display.

Conflict. A predicted violation of parameterized minimum separation criteria for adverse weather, aircraft traffic, special use airspace, other airspace, turbulence, noise sensitive areas, terrain and obstacles, etc.

Essential traffic. Essential traffic is that controlled traffic to which the provision of separation by ATC is applicable, but which, in relation to a particular controlled flight is not, or will not be, separated from other controlled traffic by the appropriate separation minimum.

Free text message element. Part of a message that does not conform to any standard message element in the PANS-ATM (Doc 4444).

Ground speed. The speed of an aircraft or vehicle relative to the ground.

Hazard. Any real or potential condition that can cause injury, illness, or death to people; damage to or loss of a system, equipment, or property; or damage to the environment.

Horizontal velocity. The horizontal component of velocity relative to a ground reference.

IM aircraft. An aircraft approved by the State of the Operator that is equipped with FIM Equipment that is instructed to perform an IM Operation.

Interval. The horizontal along-path spacing between the IM and target aircraft. The interval may be specified in time or distance.

ITP aircraft. An aircraft approved by the State of the Operator to conduct in-trail procedure (ITP).

ITP distance. The distance between the ITP aircraft and a reference aircraft as defined by:

a) for aircraft on the same track, the difference in distance to an aircraft calculated common point along a projection of each other's track; or

b) for aircraft on parallel tracks, the distance measured along the track of one of the aircraft using its calculated position and the point abeam the calculated position of the other aircraft.

Note.— Reference aircraft refers to one or two aircraft with ADS-B data that meet the ITP criteria described in paragraph 5.4.2.7 in the Procedures for Air Navigation Services — Air Traffic *Management (PANS ATM) and are indicated to ATC by the ITP aircraft as part of the ITP clearance request.*

ITP equipment. All avionics which are involved in the execution of ITP functions needed to support or perform the ADS-B in-trail procedure (ITP).

ITP separation minimum. As described in 5.4.2.7.3 in the PANS-ATM, longitudinal separation between a climbing or descending ITP aircraft and reference aircraft shall be applied in accordance with paragraphs 5.4.2.7.3.1, 5.4.2.7.3.2 and 5.4.2.7.3.3 in the *PANS-ATM* (Doc 4444).

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

Partial equipage. An environment where not all aircraft are equipped with avionics system which is certified to support the airborne surveillance applications / capabilities under consideration.

Performance requirements**.** Minimum requirements needed for the application to function properly under nominal (no fault) conditions, and are generally quantitative in nature.

Preceding aircraft. The aircraft ahead of the one performing the VSA.

Pre-formatted free text message element. A free text message element that is stored within the aircraft system or ground system for selection.

Procedural control. Term used to indicate that information derived from an ATS surveillance system is not required for the provision of air traffic control service.

Procedural separation. The separation used when providing procedural control.

Runway status indication (RSI). Runway Status Indications (RSIs) are provided if the flight crew should verify runway status prior to proceeding.

Safety requirement. A safety requirement is a risk mitigation means that when implemented will help the system meet the safety objective.

Secondary surveillance radar (SSR). A surveillance radar system which uses transmitters/receivers (interrogators) and transponders.

Separation. The generic term used to describe action on the part of ATC in order to keep aircraft, operating in the same general area, at such distances from each other that the risk of their colliding with each other is reduced.

Standardized free text message element. A message element that uses a defined free text message format, using specific words in a specific order.

Note.— Standardized free text message elements may be manually entered by the user or pre-formatted.

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

Succeeding aircraft. The aircraft performing VSA and maintaining own visual separation from the Preceding Aircraft.

Surveillance radar. Radar equipment used to determine the position of an aircraft in range and azimuth.
Target aircraft. A designated aircraft from which the IM aircraft achieves and/or maintains an assigned spacing goal.

Target level of safety (TLS). A generic term representing the level of risk which is considered acceptable in particular circumstances.

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

Traffic Display. The graphical plan-view (top down) traffic display of the CDTI.

Traffic indication (TI). Traffic indications are provided by SURF-IA if there could be a collision hazard in the immediate future.

Traffic information. Information issued by an air traffic services unit to alert a pilot to other known or observed air traffic which may be in proximity to the position or intended route of flight and to help the pilot avoid a collision.

Traffic information service – broadcast (TIS-B). A function on ground systems that broadcasts an ADS-B-like message that includes current position information of aircraft/vehicles within its surveillance volume.

Note.— This technique can be achieved through different data links. The requirements for Mode S extended squitters are specified in Annex 10, Volume IV, Chapter 5. The requirements for VHF digital link (VDL) Mode 4 and universal access transceiver (UAT) are specified in Annex 10, Volume III, Part I.

Traffic symbol. A depiction on the traffic display of an aircraft or vehicle other than the *own aircraft.*

Vertical direction. An indication whether the traffic is climbing, descending or maintaining the altitude/level.

PUBLICATIONS

(referred to in this document)

International Civil Aviation Organization (ICAO)

Annex 2 — *Rules of the Air*

Annex 10 — *Aeronautical Telecommunications*,
Volume III — *Communication Systems*
Volume IV — *Surveillance and Collision Avoidance Systems*.

Annex 14 — *Aerodromes*
Volume I — *Aerodrome Design and Operations*

Procedures for Air Navigation Services — Air Traffic Management (PANS ATM) (Doc 4444)

Procedures for Air Navigation Services — Aircraft Operations (PANS OPS) (Doc 8168)
Volume I — *Flight Procedures*

Global Air Navigation Plan (GANP) (Doc 9750)

Report of the Twelfth Air Navigation Conference (Doc 10007)

Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual (Doc 9830)

Airborne Collision Avoidance System (ACAS) Manual (Doc 9863)

Technical Provisions for Mode S Services and Extended Squitter (Doc 9871)

Aeronautical Surveillance Manual (Doc 9924)

In-Trail Procedure (ITP) Using Automatic Dependent Surveillance -Broadcast (ADS-B) (Cir 325)

Federal Aviation Administration (FAA)

Automatic Dependent Surveillance-Broadcast (ADS-B) Operations FAA AC 90-114 (latest revision)

RTCA Inc. /European Organization for Civil Aviation Equipment (EUROCAE)

Minimum Operational Performance Standards (MOPS) for Aircraft Surveillance Applications (ASA) System, RTCA DO-317A/EUROCAE ED-194

Minimum Operational Performance Standards (MOPS) for Aircraft Surveillance Applications (ASA) System, RTCA DO-317B/EUROCAE ED-194A

Minimum Operational Performance Standards (MOPS) for Aircraft Surveillance Applications (ASA) System, RTCA DO-317C/EUROCAE ED-194B

Safety, Performance and Interoperability Requirements Document for Enhanced Traffic Situational Awareness during Flight Operations (ATSA-AIRB), RTCA DO-319/EUROCAE ED-164

Safety, Performance and Interoperability Requirements Document for Enhanced Visual Separation on Approach (ATSA-VSA), RTCA DO-314/EUROCAE ED-160

Safety, Performance and Interoperability Requirements Document for ATSA-SURF Application, RTCA DO-322/EUROCAE ED-165

Safety, Performance and Interoperability Requirements Document for the In-Trail Procedure in Oceanic Airspace (ATSA-ITP) Application, RTCA DO-312/EUROCAE ED-159 and their supplement

Safety Performance and Interoperability Requirements Document for Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts (SURF IA), RTCA DO-323

Safety, Performance and Interoperability Requirements Document for Airborne Spacing - Flight deck Interval Management (ASPA-FIM), RTCA DO-328B/EUROCAE ED-195B

Safety, Performance and Interoperability Requirements Document for Traffic Situation Awareness with Alerts (TSAA), RTCA DO-348/EUROCAE ED-232

Safety and Performance Requirements Document for CDTI Assisted Visual Separation (CAVS), RTCA DO-354/EUROCAE ED-233

Minimum Operational Performance Standards for 1090 MHz Automatic Dependent Surveillance – Broadcast (ADS-B), RTCA DO-260/EUROCAE ED-102

Note.— This refers to ICAO Extended Squitter Version 0.

Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance — Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B), RTCA DO-260A

Note.— This refers to ICAO Extended Squitter Version 1.

Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance — Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B), RTCA DO-260B/EUROCAE ED-102A with Corrigendum 1.

Note.— This refers to ICAO Extended Squitter Version 2.

Safety, Performance Standard for Baseline 2 ATS Data Communications (Baseline 2 SPR Standard), RTCA DO-350A/EUROCAE ED-228A

Interoperability Requirements Standard for Baseline 2 ATS Data Communications, Initial Release (Baseline 2 Interop Standard)”, RTCA DO-351A/EUROCAE ED-229A

Minimum Operational Performance Standards for Flight Deck Interval Management (FIM), RTCA DO-361A/EUROCAE ED-236A.

Chapter 1

AUTOMATIC DEPENDENT SURVEILLANCE —BROADCAST (ADS-B)

1.1 OVERVIEW

1.1.1 ADS-B is recognized as one of the most important enablers of global ATM operational concept for future trajectory-based air traffic management (refer to the *Report of the Twelfth Air Navigation Conference* (Doc 10007)). ADS-B data (ADS-B OUT) is already used by some ground ATM systems and by airborne ADS-B IN systems.

1.1.2 ADS-B is a surveillance technique that relies on an aircraft broadcasting its position (latitude and longitude), altitude, velocity, aircraft identification and other information. ADS-B is dependent upon a position source (e.g. global navigation satellite system (GNSS)) of required quality and requires additional information from other on-board systems. Every ADS-B message includes an indication of the quality of the position and velocity data. This allows recipients to determine whether the quality of the data is adequate to support the intended function.

1.1.3 ADS-B supports both ground and airborne surveillance. Because ADS-B OUT information is broadcast, any suitable receiver can process the received messages. Airborne surveillance applications (ASA)/airborne surveillance capabilities require aircraft to be equipped with ADS-B IN receivers to process the data from surrounding ADS-B OUT equipped aircraft. For most of these capabilities/applications, a traffic display is used to present traffic information graphically.

Note 1.— ADS-B is supported by different techniques and frequencies, namely 1090 MHz Extended Squitter, universal access transceiver (UAT) (978 MHz) and very high frequency (VHF) digital link (VDL) Mode 4 (118-137 MHz). The requirements for Mode S extended squitters are specified in Annex 10, Volume IV, Chapter 5. The requirements for VDL Mode 4 and UAT are specified in Annex 10, Volume III, Part I.

Note 2.— ADS-B OUT can be installed on surface vehicles for certain aerodrome applications.

1.1.4 Since ADS-B messages are broadcast, they can be received and processed by any suitable receiver. As a result, ADS-B supports both ground-based and ASA. Aeronautical surveillance ground stations are deployed to receive and process the ADS-B messages. In airborne applications, aircraft equipped with ADS-B receivers can process the messages from other aircraft to determine the location of surrounding traffic.

1.1.5 The 1 090 extended squitter (ES) was developed as part of the Mode S system. The ADS-B information is broadcast in separate messages, each of which contains a related set of information (e.g. airborne position and pressure altitude, surface position, velocity, aircraft ID and type, emergency information). Position and velocity are transmitted twice per second. Aircraft ID is transmitted every five seconds. The transmission of ADS-B messages is an integral part of many Mode S transponders, although it may also be implemented in a non-Mode S transponder device as well.

1.1.6 There are currently three versions of ADS-B with different levels of performance:

a) Version 0 provides basic ADS-B capability with position quality provided by a parameter called navigation uncertainty category (NUC). This was the initial version of ADS-B and there are a variety of Version 0 installations;

b) Version 1 provides, among other things, separate accuracy and integrity parameters, which replace the NUC, such as navigation integrity category (NIC), navigation accuracy category (NAC) and surveillance integrity level (SIL); the Version 1 message format also provides target state and status data; and

c) Version 2 provides, among other things, a renaming and new definition for source integrity level (SIL); includes several new message fields, such as system design assurance (SDA) and geometric vertical accuracy; removes vertical information from the NIC, NAC and SIL parameters; provides improved support of surface operations through changes to NIC encoding; supports non-diversity antenna options for smaller (general aviation) aircraft plus various other improvements.

Note.— Version 0 refers to RTCA DO-260 or EUROCAE ED-102, Version 1 refers to RTCA/DO-260A and Version 2 refers to RTCA DO-260B or EUROCAE ED-102A. The formats and update rates of each register are specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

1.1.7 The on-board architecture is discussed in sections 2.9 and 4.9. Partial equipage considerations for ADS-B OUT are discussed in section 2.5 and is also mentioned in section 2.4, with respect to Additional Information for Pilots.

Note 1.— ADS-B SARPs on 1090 MHz are in Annex 10, Volume IV. Additional guidance material on ADS-B is included in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871) and in the* Aeronautical Surveillance Manual *(Doc 9924).*

Note 2.— For more details, refer to the Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B) (RTCA DO-260B / EUROCAE ED-102A) and Minimum Operational Performance Standards (MOPS) for Aircraft Surveillance Applications (ASA) System*, RTCA DO-317B / EUROCAE ED-194A.*

1.2 INTERACTIONS OF ADS-B AND AIRBORNE COLLISION AVOIDANCE SYSTEM (ACAS)

1.2.1 ACAS is an airborne system based on SSR (transponder interrogation) technology, which is independent from air traffic control (ATC) separation standards but provides a last resort safety net function. Its purpose is to prevent collision when the primary means of separation provision has failed or no ATC separation was required (e.g. visual flight rules (VFR) flights in uncontrolled airspace).

1.2.2 At the operational level, the ASA have been designed in isolation of the ACAS procedure in order to maintain the independence of the airborne safety net.

1.2.3 At the technical level, system independence of the ACAS safety net has been preserved in the definition of the ASA on board the aircraft. However, some ASA equipment makes use of ACAS positional data to enhance the information received from ADS-B sources.

1.2.4 Hybrid surveillance is a technique within the ACAS surveillance function that takes advantage of ADS-B extended squitters to reduce the number of active interrogations. This technique is specified in Annex 10, Volume IV as an optional feature for TCAS version II compliant systems and a required feature for ACAS Xa.

Note.— The Airborne Collision Avoidance System (ACAS) Manual *(Doc 9863) contains operational and technical provisions on ACAS, including use of the hybrid surveillance technique.*

1.3 THE LIMITATIONS OF ADS-B

1.3.1 One of known limitations of ADS-B is that some of the benefits of ASA/airborne surveillance capabilities depend on the proper equipage of a large population of aircraft. Proper ADS-B equipage requires an installed and certified data source that is capable of supplying information (e.g. position/velocity) along with the necessary indication of the quality of that information.

1.3.2 Equipage

1.3.2.1 As described above, the benefits of ASA/airborne surveillance capabilities depend on the proper equipage of large population of aircraft. The equipage rate relates to both equipage for transmission of ADS-B data (ADS-B OUT) and equipage for reception of ADS-B data (ADS-B IN). Further considerations for partial equipage environment can be found in section 2.5.

1.3.2.2 ADS-B is available using different link technologies (e.g. 1090 MHz ES, UAT, VDL Mode 4) and different link versions (e.g. 1090MHz ES have 3 versions: version 0, 1 and 2). The link technologies are not automatically interoperable, while the link versions are generally interoperable. However, newer versions will be needed to support all envisioned operations.

1.3.2.3 The existence in parallel of different link versions (version 0, 1 and 2) requires ground and ADS-B IN systems to be able to mitigate for:

a) differences in broadcast data (e.g. quality indicators); and

b) data not available (e.g. selected altitude).

1.3.2.4 Several initiatives are on-going to mandate equipage of ADS-B OUT using the 1090 MHz as the global link technology. However, the minimum acceptable link version is different between regions and potentially between ADS-B IN applications. The initial ADS-B IN applications have been designed to use all link versions.

1.3.3 Loss of information

1.3.3.1 Currently ADS-B relies on GNSS for horizontal position and velocity. As a result, outages may be experienced when the performance or geometry of the satellite constellation is not adequate to provide the surveillance performance required for a given capability/application. Performance can also be degraded by the position and condition of the GNSS antenna.

1.3.3.2 It is noted that future systems that integrate GNSS information with data from other navigation sensors may overcome this limitation. In addition, the implementation of augmentation systems, such as satellite-based augmentation systems (SBAS), ground-based augmentation systems (GBAS) or airborne-based augmentation systems (ABAS) should improve GNSS performance.

1.3.3.3 Factors limiting the broadcasting range of ADS-B information are:

a) positions of the ADS-B transmitting antenna and receiving antennas;

b) power of the ADS-B transmitter;

c) receiver sensitivity;

d) extent of radio frequency interference; and

e) local traffic density.

Note.— Reception of the ADS-B signals is also related to the aircraft movements (e.g. banking during turns), shielding of the antennas due to buildings, terrain, etc.

1.3.4 Validity of the information

1.3.4.1 The broadcast information may need to be validated against errors. The requirements for validation will differ for each ASA/airborne surveillance capability.

Chapter 2

INITIAL AIRBORNE SURVEILLANCE CAPABILITIES AND IN-TRAIL PROCEDURE (ITP)

2.1 DESCRIPTION OF THE INITIAL AIRBORNE SURVEILLANCE CAPABILITIES

Note 1.— This section provides overall descriptions of airborne surveillance capabilities. Those technical standardization documents are already available and there are some operational implementations of those capabilities. Furthermore, an implementation timeline for the capability/application described in this section is given in the Global Air Navigation Plan (GANP) *(Doc 9750).*

Note 2.— In this document, Basic Airborne Situational Awareness *(AIRB),* visual separation on approach *(VSA) and* Basic Surface Situational Awareness (*SURF) are used as standard abbreviations for basic airborne traffic situational awareness, visual separation on approach and basic surface situational awareness accordingly, but abbreviations of ATSA-AIRB, ATSA-VSA and ATSA-SURF are sometimes used in the ASBUs and other documents in order to show that AIRB, VSA and SURF are airborne traffic situational awareness (ATSA) applications.*

2.1.1 Basic Airborne Situational Awareness (AIRB)

2.1.1.1 *Description of AIRB*

2.1.1.1.1 AIRB aims at enhancing traffic situational awareness for pilots, which is expected to improve flight safety and flight operations, through the provision of surrounding ADS-B traffic on an on-board display.

2.1.1.1.2 AIRB supplements the other available sources of information on traffic (i.e. visual scans and/or radio communications) and supports pilots having better awareness of the traffic in the vicinity, through the rapid and accurate mental integration of visual and radio communication information.

2.1.1.1.3 The following information is provided to the pilot:

a) relative horizontal position of surrounding traffic (distance and relative bearing); and

b) altitude and vertical direction.

2.1.1.1.4 The following information can be provided to the pilot on demand:

a) aircraft identification; and

b) speed information (ground speed).

2.1.1.2 *Operational environment for AIRB*

2.1.1.2.1 AIRB may be introduced in a partial equipage of ADS-B OUT, in which only some aircraft are equipped with ADS-B OUT.

2.1.1.2.2 In order to enhance the benefits of AIRB deployment, traffic information service –broadcast (TIS-B) may provide a more complete picture of nearby traffic. However, TIS–B is not a requirement for the deployment of AIRB.

Note.— TIS-B is described in section 2.5.2.

2.1.1.2.3 AIRB is defined for use by aircraft operating in any airspace, both controlled and uncontrolled (i.e. classes A to G), in which the traffic density can range from low to very high. AIRB is relevant to both instrument flight rules (IFR) and VFR traffic. Also it is applicable from the runway departure on take-off until touchdown on landing.

2.1.1.2.4 There are no specific requirements on ATM systems from communication, navigation and surveillance perspectives when AIRB is used. AIRB can be used in the same environments as in current operations.

Note.— For more information, refer to the Safety, Performance and Interoperability Requirements Document for AIRB, *RTCA DO-319/EUROCAE ED-164.*

2.1.1.3 *Benefits of AIRB*

2.1.1.3.1 Operational trials over several years have investigated the benefits of different implementation solutions of AIRB on board test aircraft and revenue flights. The conclusions prove the operational benefits of AIRB as follows:

a) AIRB application improves the traffic situational awareness regardless of the implementation on board (integrated on primary displays or auxiliary display outside of main instrument panel) without having a major impact on the pilot's workload;

b) the additional information available on board the aircraft e.g. aircraft identification (ACID) of nearby traffic improves the pilot's understanding of ATC clearances and turbulence reports; and

c) information on traffic conditions help the pilot plan for flight level change request and tactical routing.

Note.— As described in the definition, ACID 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. This definition is used in ICAO publications. There is confusion among call sign, aircraft identification and flight identification. The following are examples of call sign, aircraft identification and flight identification:

a) call sign is the telephonic identification of the aircraft, such as "Speedbird 123";

b) aircraft identification is used with respect to Item 7 of the ICAO Flight Plan and would appear as "BAW123"; and

c) what is broadcast by ADS-B is aircraft identification, which in some States is referred to as flight identification or FlightID.

The reader of this document should understand that what the pilot of an ADS-B IN equipped aircraft will see is (for example) 'BAW123" and would need to know that the telephonic reference (call sign) is "Speedbird123". This is not an issue with aircraft whose call sign is the registration marking, e.g., "F-AAAB".

2.1.1.3.2 The AIRB application can provide benefits in all types of operations. The benefits are dependent on several factors, including the operational environment and the estimated average fuel saving for the operation, which in turn depends on aircraft type and routing etc. It is important to note that the AIRB application does not require any ground involvement and benefits can be realized entirely from airborne equipment availability.

2.1.2 Visual separation on approach (VSA)

2.1.2.1 *Description of VSA*

2.1.2.1.1 The objective of VSA is to assist pilots in maintaining own separation during successive visual approach procedures.

2.1.2.1.2 In the context of this document, VSA is a situational awareness capability that offers a support tool for pilots to conduct existing procedures described in the PANS-ATM (sections 6.5.3.3. 6.5.3.4 and 6.5.3.5).

2.1.2.1.3 The air traffic controller will provide traffic information to the pilot of the succeeding aircraft as in current operations. On reception of this traffic information, the pilot of an aircraft suitably equipped for VSA can use the traffic display to support his visual scan and acquisition of the preceding aircraft during the approach procedure, if the preceding aircraft is transmitting ADS-B OUT surveillance data.

Note.— In this section, the aircraft ahead is referred to as the preceding aircraft and the aircraft performing VSA is referred to as the succeeding aircraft.

2.1.2.1.4 The following information is provided to the pilot:

a) relative horizontal position (i.e. distance and relative bearing);

b) altitude (relative altitude required. Barometric corrected pressure altitude and absolute pressure altitude optional);

c) direction (ground track);

d) vertical direction;

e) speed information (ground speed); and

f) aircraft identification on demand.

2.1.2.1.5 It is important to note that since information provided by the traffic display is not a substitute for visual contact, pilots are required to maintain continuous visual contact with the preceding aircraft during VSA.

Note.— For more information, refer to the Safety, Performance and Interoperability Requirements Document for VSA, *RTCA DO-314/EUROCAE ED-160.*

2.1.2.2 *Operational environment for VSA*

2.1.2.2.1 VSA may be introduced in a partial equipage of ADS-B OUT environment, in which only some aircraft are equipped with ADS-B OUT.

2.1.2.2.2 In order to enhance the benefits of VSA deployment, TIS-B may provide a more complete picture of nearby traffic. However, TIS–B is not a requirement for the deployment of VSA.

Note.— TIS-B is described in 2.5.2.

2.1.2.2.3 VSA is defined to support aircraft performing successive visual approach and landing operations. VSA is applicable for all types of runway configurations where successive visual approaches are in use.

2.1.2.2.4 There are no new requirements on ATM systems from communication, navigation and surveillance perspectives when VSA is used. VSA can be used in the same environments as current operations.

2.1.2.2.5 VSA can be used in airspace of any traffic density.

2.1.2.2.6 VSA can only be operated under visual meteorological conditions (VMC). VSA does not modify the approach procedure under VMC.

2.1.2.3 *Benefits of VSA*

2.1.2.3.1 VSA is expected to improve the efficiency and safety of arrival traffic at airports during visual approach operations.

2.1.2.3.2 It is expected that the safety of the operation will be improved through the provision of accurate data to the pilots (e.g. preceding traffic ground speed) allowing them to better predict the evolution of the traffic.

2.1.3 Basic surface situational awareness

2.1.3.1 *Description of SURF*

2.1.3.1.1 SURF is an airborne surveillance capability which provides situational awareness in support of airport surface operations and is supported by the air-to-air link. It has been designed to provide identity information and position of surrounding traffic together with the own aircraft position overlaid on an aerodrome map.

2.1.3.1.2 The information provided by the on-board display is designed to enhance the traffic situational awareness on the aerodrome surface. The available information is supplemental to the current information relative to the traffic on the surface provided by pilot's visual scan or through ATC radio communication. The main benefit provided by SURF is the provision of improved traffic (aircraft and ground vehicles) situational awareness in the vicinity of own aircraft during aerodrome surface operations.

2.1.3.1.3 SURF does not modify current pilot and air traffic controller responsibilities or the use of visual information as the primary basis of aerodrome surface operations. As in today's operations, the pilot is required to continue to maintain visual contact with other traffic on the aerodrome surface, by looking out the window to verify their position, and should not rely solely on displayed traffic information. Surface navigation and own separation is to be based on visual information assisted by radio communications. The on-board traffic display should only be used as tools to assist visual scan.

2.1.3.1.4 The following data are provided to the pilot:

a) absolute (i.e. geo-referenced to a surface map) horizontal position;

b) own absolute position;

c) altitude, if airborne;

d) direction if available;

e) aircraft (or vehicle) identification on demand;

f) ground speed on demand;

g) aircraft emitter category, or wake vortex category, on demand; and

h) vertical direction (if altitude is being displayed) on demand.

Note.— For more information, refer to the Safety, Performance and Interoperability Requirements Document for SURF, *RTCA DO-322 / EUROCAE ED-165.*

2.1.3.2 *Operational Environment for SURF*

2.1.3.2.1 SURF has been developed to be used by aircraft conducting operations on or near aerodrome surface (e.g. on final) at the range of aerodromes of code 3 and 4, as specified by Annex 14, Volume I. SURF utilizes an aerodrome mapping database (AMDB) that should be current and compliant with relevant standards.

2.1.3.2.2 SURF applies to operations at both controlled and uncontrolled aerodromes. There are no specific requirements for communications and surface ground surveillance capability when SURF is used. SURF may be introduced in a partial equipage of ADS-B OUT environment, in which only some aircraft and ground vehicles are equipped with ADS-B OUT.

2.1.3.2.3 In order to enhance the benefits of SURF deployment, TIS-B may provide a more complete picture of nearby traffic. However, TIS–B is not a requirement for the deployment of SURF.

Note.— TIS-B is described in section 2.5 2.

2.1.3.2.4 SURF is designed to be used in all visibility conditions without modifying the air traffic controller/pilot responsibilities and procedures under current operations. (For movement guidance, see *Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual* (Doc 9830)).

2.1.3.2.5 Surveillance data for SURF is based on ADS-B information received directly from ADS-B OUT equipped aircraft or from other available surveillance sources such as TIS-B and Surveillance Movement Radar.

2.1.3.3 *Benefits of SURF*

2.1.3.3.1 SURF improves the safety and efficiency of surface operations by allowing pilots to better understand the traffic situation on the surface. The expected benefits are as follows:

a) a safety improvement on runway;

b) a safety improvement on taxiways; and

c) an efficiency improvement in conditional clearances.

2.1.3.3.2 In the case of receiving a conditional clearance, pilots who use the information provided by SURF are expected to better anticipate the traffic intentions, which has the potential to enhance the efficiency during taxi operations.

2.1.4 ADS-B traffic awareness system (ATAS)

2.1.4.1 *Description of ATAS*

2.1.4.1.1 ATAS is intended to reduce the number of mid-air collisions and near mid-air collisions involving general aviation aircraft by providing indications of nearby airborne traffic in support of the pilot's see-and-avoid responsibilities. ATAS provides ADS-B-based traffic alerts for aircraft without ACAS.

2.1.4.1.2 ATAS provides voice annunciations to pilots to draw their attention to nearby airborne traffic and adds visual cues to the underlying basic traffic situational awareness application (e.g. AIRB) in installations with a traffic display.

2.1.4.1.3 The ATAS capability does not change the roles or responsibilities of pilots, who remain responsible for the safe and efficient control and navigation of their aircraft in all airspace.

2.1.4.1.4 ATAS does not provide Resolution Advisories and is therefore similar to ACAS traffic advisories, though based solely on ADS-B information.

2.1.4.1.5 The pilot will only use the ATAS capability as a supplement to existing traffic avoidance procedures (e.g. see-and-avoid, radio communications). The pilot should not undertake any manoeuvres relative to another aircraft based solely on the ATAS alert or indication.

Note.— ATAS is referred to as traffic situational awareness with alerts (TSAA) in the RTCA/EUROCAE ASA MOPS (RTCA DO-317C/EUROCAE ED-194B) and the Safety, Performance and Interoperability Requirements, *RTCA DO-348 / EUROCAE ED-232 for this capability.*

2.1.4.1.6 The following information is provided to the pilot about airborne traffic:

a) relative horizontal position (i.e. distance and relative bearing);

b) altitude (relative altitude required. Barometric corrected pressure altitude and absolute pressure altitude optional);

c) direction (ground track);

d) vertical direction;

e) alerting information; and

f) aircraft identification and ground speed on demand.

Note.— For more information, refer to RTCA DO-348/EUROCAE ED-232.

2.1.4.2 *Operational environment for ATAS*

2.1.4.2.1 ATAS may be introduced in a partial equipage of ADS-B OUT environment, in which only some aircraft are equipped with ADS-B OUT.

2.1.4.2.2 In order to enhance the benefits of ATAS deployment, TIS-B may provide a more complete picture of nearby airborne traffic. However, TIS–B is not a requirement for the deployment of ATAS.

Note.— TIS-B is described in section 2.5.2.

2.1.4.2.3 There are no new requirements on ATM systems from communications, navigation and surveillance perspectives when ATAS is used. ATAS can be used in the same environments as current operations.

2.1.4.2.4 ATAS can be used in airspace of any traffic density.

2.1.4.3 *Benefits of ATAS*

2.1.4.3.1 Since most aircraft equipped with ATAS do not have an ACAS system installed, the safety of the operation will be improved through the provision of accurate traffic data to the pilots (e.g. alerts of nearby conflicting airborne traffic).

2.2 IN-TRAIL PROCEDURE (ITP)

2.2.1 Description of ITP

2.2.1.1 Aircraft identification, altitude, position and ground speed of reference aircraft provided by ADS-B are assessed by the ITP aircraft's on-board equipment (on-board decision support system) to determine whether an ITP climb or descent is possible. Based on the processed ADS-B data from the reference aircraft, a pilot can make an ITP climb or descent request to ATC. The ITP introduces specific separation minima to be applied between the ITP aircraft and suitable equipped aircraft.

2.2.1.2 ITP is described in detail in the *Procedures for Air Navigation Services – Air Traffic Management (PANS-ATM* (Doc 4444). Its Appendix contains the related controller-pilot data link communications (CPDLC) message set.

2.2.1.3 Pilots are responsible for using the on-board equipment to evaluate the situation and provide the required information to the controller. The controller maintains separation responsibility at all times between aircraft as dictated by the airspace class in which the operations occur.

Note.— Additional information related to ITP may be found in In-Trail Procedure (ITP) Using Automatic Dependent Surveillance — Broadcast (ADS-B) (Cir 325).

2.2.2 Operational environment for ITP

2.2.2.1 ITP is designed to be applied in the en-route airspace, where separation is provided according to Chapter 5 of the *Procedures for Air Navigation Services – Air Traffic Management* (PANS ATM) (Doc 4444).

2.2.2.2 As specified in section 5.4.2.7.3 of PANS-ATM, ITP is designed to be used when both the ITP aircraft and reference aircraft are either on:

a) same identical tracks and any turn at a waypoint shall be limited to less than 45 degrees; or

b) parallel tracks or same tracks with no turns permitted during the manoeuvre.

2.2.2.3 ITP requests and clearances shall be communicated via a CPDLC message exchange and in accordance with the appropriate message elements in Appendix 5 of the *Procedures for Air Navigation Services – Air Traffic Management (PANS ATM)* (Doc 4444).

Note.— Satellite or high frequency (HF) voice communications have not been evaluated as a means of communications for ITP.

2.2.3 Benefits of ITP

2.2.3.1 The use of ITP would facilitate climb and descent of aircraft during the en-route phase to enable better use of optimal flight levels in environments, where a procedural airspace requires large separation standards.

2.2.3.2 The benefits of ITP are fuel savings and corresponding environmental benefits. Furthermore, it may increase passenger comfort, as ITP allows the pilot to more readily achieve an operationally desirable flight level. As such, it may also reduce the risk of injuries in situations where long periods of turbulence exist at a given altitude along the planned route of flight.

2.3 ADDITIONAL INFORMATION FOR ATC

2.3.1 Overview

2.3.1.1 This section provides air traffic controllers with some general information about the operation and interaction with aircraft that have airborne surveillance systems with initial capabilities (such as ADS-B traffic displays or cockpit display of traffic information (CDTI)). The information provided in this section supplements the air navigation services provider (ANSP) considerations described in section 2.6.

2.3.1.2 This section describes two kinds of ASA as follows:

a) airborne surveillance capabilities (AIRB, VSA, SURF and ATAS) which do not modify ATC procedures; and

b) the ITP application that requires specific ATC procedures.

2.3.2 Airborne surveillance capabilities - AIRB, VSA, SURF and ATAS

The availability of AIRB, VSA, SURF and/or ATAS on-board aircraft systems does not relieve the responsibility of either air traffic controllers or pilots from applying the procedures related to the provision of ATS, which include the issuance of traffic information. The requirement for traffic information, as well as its content to be passed to affected flights, remains unchanged (see *Procedures for Air Navigation Services – Air Traffic Management (PANS-ATM)* (Doc 4444)).

2.3.3 ITP

2.3.3.1 ICAO has developed procedures and ITP is described in Chapter 5 of the *Procedures for Air Navigation Services – Air Traffic Management (PANS-ATM)* (Doc 4444). Its Appendix 5 contains the related CPDLC message set.

2.3.3.2 ITP requests can only be made by appropriately equipped and authorized flights (aircraft and pilot(s) are approved). Additional information related to ITP is provided in *In-Trail Procedure (ITP) Using Automatic Dependent Surveillance – Broadcast (ADS-B)* (Cir 325).

Note.— ITP safety, performance and requirements are specified in the Safety Performance and Interoperability Requirements Document for the In-Trail Procedure in Oceanic Airspace (ATSA-ITP) Application, *RTCA DO-312/EUROCAE ED-159 , and its supplement. Detailed information on ITP equipment requirements can be found in* Minimum Operational Performance Standards (MOPS) for Aircraft Surveillance Applications (ASA) System, *RTCA DO-317A/EUROCAE ED-194.*

2.4 ADDITIONAL INFORMATION FOR PILOTS

Note 1.— The following sections provide general guidance on the use of ASA/airborne surveillance capability by pilots. Pilot procedures for the use of ADS-B traffic display to enhance the pilot's traffic situational awareness are included in section 8, of the Procedures for Air Navigation Services – Aircraft Operations (PANS OPS) *(Doc 8168), Volume III.*

Note 2.— The aircraft operator should refer the original equipment manufacturer (OEM) documentation for guidance on the exact standard operating procedures (SOPs) to apply.

2.4.1 Common considerations for AIRB, VSA SURF and ATAS

2.4.1.1 AIRB, VSA, SURF and ATAS do not change the roles or responsibilities of pilots under existing operations.

2.4.1.2 It is a pilot's decision whether to use the traffic display during flight operations. The scope of AIRB, VSA and SURF only includes situations where the pilot uses the traffic display. ATAS does not require a traffic display, though such a display will often help a pilot more quickly locate the alerted traffic in the out-the-window (OTW) view.

2.4.1.3 ACAS procedures are not affected by the use of AIRB, VSA, SURF and ATAS capabilities.

2.4.1.4 The pilot uses the traffic display as a tool for assisting but not replacing the visual scan for traffic.

2.4.1.5 The pilot should not regard the traffic display as providing a complete display of traffic of interest, due to partial equipage of ADS-B OUT or performance of ADS-B OUT transmission unqualified for display.

2.4.1.6 While pilots are building up their situational awareness and if information on displayed traffic of interest is available by visual contact or radio communications, the pilot is expected to check consistency between the information provided by the traffic display with the visual information and radio communications.

Note.— Inconsistency may come from partial equipage of ADS-B OUT or incorrect ADS-B transmissions.

2.4.1.7 The pilot should be aware that there is a possibility that the aircraft identification presented to the pilot on the on-board display may not necessarily be the same as the one displayed to the air traffic controller, due to differences in the source of information.

2.4.1.8 If the pilot detects an inconsistency between the information for traffic of interest on the traffic display and out the window, the pilot needs to use the visual information.

2.4.1.9 As described in PANS-OPS, Volume III, section 8, the use of the traffic display should not lead to a significant increase in radio communications.

2.4.1.10 The pilot should avoid making references to aircraft identification observed on the traffic display in their communication with ATC, directly or as a response to traffic information, except in cases where a reference to the observed aircraft identification would eliminate ambiguities with regard to essential traffic.

2.4.1.11 The displayed traffic information is not to be used by the pilot to anticipate ATC instructions or to self-separate in any class of airspace.

2.4.2 AIRB and ATAS

As described in PANS-OPS, Volume III, section 8, pilots shall not undertake any manoeuvres relative to traffic based solely on the ADS-B IN traffic display that would lead to either a deviation from, or the non-execution of, an ATC clearance or instruction unless exercising their emergency authority.

2.4.3 VSA

2.4.3.1 VSA uses the traffic display to support the visual scan and acquisition of the preceding aircraft during the approach procedure, if the preceding aircraft is transmitting ADS-B OUT surveillance data. VSA is comprised of three phases (i.e. visual acquisition, clearance for maintaining own separation and maintaining own separation on approach). The pilot will assess the meteorological conditions as in current operations and there is no change to the use of ICAO phraseology in Chapter 12 of the *Procedures for Air Navigation Services — Air Traffic Management (PANS ATM)* (Doc 4444).

2.4.3.2 Pilots should only report visual acquisitions to the air traffic controller. Any reference to aircraft identification observed on the traffic display is unnecessary.

2.4.4 SURF

2.4.4.1 It is a pilot's decision whether to use the traffic display during surface operations. SURF applies to operations at both controlled and uncontrolled aerodromes.

2.4.4.2 At a controlled aerodrome, the pilot would proceed according to current procedures and include the use of traffic display with their regular visual scan. Where relevant, the pilot would correlate the information displayed on the traffic display with visual information from the visual scan and/or information obtained from ATC voice communication. If the traffic depicted on the traffic display is considered to be an immediate threat to safety, the pilot may take any time-critical measures considered necessary and request information from ATC.

2.4.4.3 For a conditional clearance, if a clearance is given to proceed with relation to indicated traffic, the pilot will correlate the clearance with the information displayed on the traffic display with the visual information, identify the traffic visually and then proceed with the clearance based on the visual information.

2.4.4.4 At an uncontrolled aerodrome, the pilot would proceed according to current procedures and include the traffic display with the regular scan. Where relevant, the pilot would correlate the information displayed on the traffic display with the visual scan information and position reports of other aircraft broadcast on voice communications. If the traffic depicted on the traffic display is considered to be an immediate threat to safety, the pilot may take any time-critical measures considered necessary and will broadcast an information request with respect to the displayed traffic.

2.4.5 ITP

ITP requests can only be made by appropriately equipped and authorized flights (aircraft and pilot are approved). The ITP is described in detail in the *Procedures for Air Navigation Services — Air Traffic Management* (PANS ATM) (Doc 4444) and in *In-Trail Procedure (ITP) Using Automatic Dependent Surveillance — Broadcast (ADS-B)* (Cir 325).

Note 1.— Solely having an ADS-B traffic display can provide improved situational awareness, but it is not sufficient for the ITP climb or descent. The ITP requires on-board ADS-B IN with additional on-board processing so that the ITP aircraft can determine whether the necessary criteria can be met and, if so, allow the pilot to request air traffic controller approval to execute the desired flight level change using the ITP separation minimum between the reference aircraft.

Note 2.— See PANS-OPS Volume III, section 8 *on the use of information provided by ADS-B IN traffic displays.*

Note 3.— For more details on operational assumptions, refer to In-Trail Procedure (ITP) using Automatic Dependent Surveillance — Broadcast (ADS-B) (Cir 325)*.*

2.5 CONSIDERATIONS FOR PARTIAL EQUIPAGE ENVIRONMENT

2.5.1 Partial equipage of ADS-B OUT

2.5.1.1 Airborne surveillance function using ADS-B can provide enhanced traffic information only if the surrounding traffic provides it (see section 1.1). This means that aircraft without an ADS-B OUT function cannot be processed by an ADS-B IN system unless proper information on these aircraft is provided through other sources, such as TIS-B.

2.5.1.2 The ASA are designed to achieve operational objectives without any degradation of safety in a partial equipage of ADS-B OUT. However, efficiency benefits may be affected by the rate of aircraft equipped with ADS-B.

2.5.1.3 Partial equipage of ADS-B OUT has been considered a nominal environment assumption in the safety and performance requirements (SPR) document developed for each airborne surveillance application. For future applications, the safety impact of partial equipage of ADS-B OUT will have to be assessed.

2.5.1.4 From an airspace perspective, the situation with partial equipage of ADS-B OUT may exist for considerable time. A possible method of reducing the percentage of unequipped aircraft is to promulgate a mandate requiring ADS-B OUT capability with required performance to all aircraft in the designated airspace. This method should follow a full consultation and agreement by all airspace users and the timing of the mandate needs to be coincided with the readiness schedule of necessary ATC procedures and ground ATM infrastructures and system integrations. Any ADS-B performance requirement should be consistent with the safety requirements for the intended applications within the designated airspace. Overly demanding performance requirement will not only limit the participation rate but may also lead to unnecessary interruption of ADS-B operations.

2.5.1.5 However, there are cases where ADS-B OUT capability cannot be fitted to a given aircraft. For example, some classes of State aircraft cannot accommodate avionics for ADS-B OUT function due to specific technical constraints (e.g. fighters and special radio measurement platforms). Another reason for non-compliance is security: for example, some military operations, air policing, etc., are known cases where flight information is requested not to be broadcast.

2.5.1.6 When implementing ASA, the impact of partial equipage of ADS-B OUT will have to be considered to ensure that the benefits and safety objectives are achieved. It is pointed out that the partial equipage of ADS-B OUT does not prevent implementation of the capabilities/applications described in this manual.

2.5.1.7 Delivering efficiency benefits to early users has been proven as an effective way to encourage an increase in voluntary equipage. However, a balanced transition strategy, through a collaborative decision-making process with all stakeholders, needs to be developed to avoid unacceptable increase of workload for air traffic controllers.

2.5.1.8 To maximize the benefits provided by AIRB, VSA, SURF and ATAS, additional surveillance support may be required e.g. TIS-B. TIS-B provides the surveillance data from ground surveillance system such as SSR Mode S and Wide Area Multilateration (WAM) to all the ADS-B IN aircraft in the area.

2.5.2 Limitation of supplemental information by TIS-B

2.5.2.1 TIS-B may provide traffic information to fill in for aircraft not equipped with ADS-B OUT in some regions. It should be noted that even within TIS-B coverage, not all traffic may be displayed.

2.5.2.2 Consideration should be given to the level of security for each user before providing surveillance information with TIS-B. For example, certain class of surveillance information (typically, aircraft identity information) may be provided to ATC but not to public users with ADS-B IN.

2.6 STAKEHOLDERS CONSIDERATIONS

2.6.1 Air navigation services provider (ANSP)

2.6.1.1 *ANSP considerations for AIRB, VSA, SURF and ATAS*

2.6.1.1.1 By design, AIRB, VSA, SURF and ATAS have no direct impact on ANSP infrastructure or on the ATC procedures. These capabilities can be used in the same environments as current operations from the communication, navigation and surveillance perspectives and from ATM system perspectives. However, ANSPs should consider the merits of training air traffic controllers on these capabilities and the possible resulting pilot behaviour, such as pilot use of other aircraft's ADS-B identification in voice communications.

2.6.1.1.2 ANSPs may want to provide the information to the air traffic controller (i.e. whether the aircraft is ADS-B OUT and/or IN equipped) using the ADS-B capability field of the ICAO FPL format (item 10b (B1 and B2)), augmented by supplemental information contained in Field 18 after the "SUR/" indicator. The data may be used as an awareness of the aircraft equipage in the area of responsibility to allow ATC to better assess the capabilities of the traffic in the sector.

2.6.1.2 *ANSP considerations for ITP implementation*

2.6.1.2.1 ITP requires controller training. ANSP implementations may require changes to ATC automation.

2.6.1.2.2 *In-Trail Procedure (ITP) Using Automatic Dependent Surveillance — Broadcast (ADS-B)* (Cir 325) provides detailed guidance for ITP implementation and, in particular, the successive steps to be followed by all stakeholders.

2.6.1.2.3 System Requirements for ITP

2.6.1.2.3.1 For ITP operations, ICAO determined that the safest way to exchange information and clearances between pilots and air traffic controllers was through CPDLC, which allows the reference aircraft call sign to be referred to by the ITP aircraft and the air traffic controller without increasing the risk of confusion, unlike the case with conventional radios (VHF or HF). In addition, CPDLC provides the pilot with a "written" copy of the clearance which can be referred to just before or during the ITP climb or descent.

Note.— Satellite or HF voice communications have not been evaluated as a means of communications for ITP.

2.6.1.2.3.2 As described in section 2.2.2.3, CPDLC messages have been developed for ITP, which are included in *Procedures for Air Navigation Services Air Traffic Management (PANS ATM)* (Doc 4444) with examples described in section 2.3.14 of *In-Trail Procedure (ITP) using Automatic Dependent Surveillance — Broadcast (ADS-B)* (Cir 325). Bearing in mind the challenges and the costs related to the update of the aircraft message set, a series of standardized free text messages was developed. Until automation allows for the use of pre-formatted messages, ITP users will need to use standardized free text messages.

2.6.1.2.4 Training for air traffic controller

It will be up to the States, civil aviation authorities and air navigation services providers, who are responsible for implementing ITP, to determine in which part of its airspace, if any, ITP will be authorized. For those planning to use ITP, air traffic controller training on ITP will be required. The ITP application defines some new procedures for air traffic controllers. Therefore, specific training is required to be given to air traffic controllers in order to enable ITP. This training should include conditions to be met for the procedure, communications with the pilots and management and/or identification of abnormal situations (see Cir 325). Training will also be required on the format and use of standardized CDPLC messages related to ITP.

2.6.2 Aircraft operators

2.6.2.1 *Operational approvals*

2.6.2.1.1 There is no ICAO requirement for operational approvals of AIRB, VSA, SURF or ATAS.

2.6.2.1.2 The process and conditions for issuing ITP operational approval should be harmonized among States so that an approval issued by one State is automatically accepted by all other States unless explicitly forbidden.

Note.—More information on ITP operational approval can be found in Cir 325.

2.6.2.2 *Operator considerations for AIRB, VSA, SURF and ATAS*

2.6.2.2.1 For effective and safe employment of AIRB, VSA, SURF and ATAS, operators should develop guidance within the pilot's procedures because their capabilities may be used during critical phases of flight and there is the need to avoid excessive increases to the pilot's workload.

2.6.2.2.2 Operator's training programme for AIRB, VSA, SURF and ATAS

2.6.2.2.2.1 Operators must ensure that their pilots are trained to operate AIRB, VSA, SURF and ATAS in conformance with the provisions of the *Procedures for Air Navigation Services – Aircraft Operations (PANS OPS)* (Doc 8168) Volume III. The training materials may be developed by the operator or suggested by the OEM.

2.6.2.2.2.2 Recommended items for a pilot training programme include:

a) the supplementation nature of the displayed information.

b) avoidance of overreliance on the traffic display;

c) avoidance of excessive head-down time;

d) awareness of the why the traffic display may not include all aircraft and surface vehicles;

e) recognition of expected performance characteristics and limitations of the system;

f) operational concepts (ref to sections 2.1, 2.2 and 2.3);

g) pilot procedures, including appropriate responses to any alerts provided by ASA equipment (see section 2.4);

h) avoidance of radio communication using other aircraft identification; and

i) flight plan implications (ref to section 2.7).

2.6.2.2.2.3 Furthermore, additional training should be developed and given for the system functions, indications and interactions for each application/capability.

2.6.2.2.3 Documentation for AIRB, VSA, SURF and ATAS

Operators are required to update their documentation with regard to flight operations (e.g. Operations Manuals — Parts A, B, C and D) and maintenance. This documentation may be provided by the aircraft or avionics OEM.

2.6.2.3 *Operator considerations for ITP*

2.6.2.3.1 Before operating ITP, the civil aviation authority (CAA) of the operator needs to define the conditions required to operate ITP.

Note.— Details on operator considerations for ITP are included in In-Trail Procedure (ITP) Using Automatic Dependent Surveillance — Broadcast (ADS-B) *(Cir 325)*.

2.6.2.3.2 Operator's training programme for ITP

2.6.2.3.2.1 Operators must ensure that their pilots are trained to perform ITP in conformance with the provisions of the *Procedures for Air Navigation Services — Air Traffic Management (PANS ATM)* (Doc 4444) and local procedures. The training materials may be developed by the operator or suggested by the OEM. Recommended training items are given in *In-Trail Procedure (ITP) using Automatic Dependent Surveillance -Broadcast (ADS-B)* (Cir 325).

2.6.2.3.2.2 Operators also should ensure that their flight operations officers and dispatchers are familiarized with ITP operations.

2.6.2.3.3 Documentation for ITP

As described in PANS-OPS, Volume III, section 8, operators shall include in their Standard Operating Procedures (SOPs) specific guidance for using ADS-B IN to support ATC procedures specified in PANS-ATM (Doc 4444).

2.6.3 Regulatory responsibilities

2.6.3.1 *General considerations*

There is no ICAO requirement for operational approval of AIRB VSA SURF and ATAS.

2.6.3.2 *Operational approval for ITP*

Operational approval is required for the pilots and the aircraft to perform ITP. An operation manual or other appropriate material, as required by State regulations, is needed to permit the use of the ITP. State regulators should consider *In-Trail Procedure (ITP) using Automatic Dependent Surveillance -Broadcast (ADS-B)* (Cir 325) as the basis for such material.

2.7 FLIGHT PLANNING

2.7.1 All operators with ADS-B capability are expected to provide corresponding information on ADS-B OUT capability in the flight plan form (item 10) as defined in *Procedures for Air Navigation Services – Air Traffic Management (PANS ATM)* (Doc 4444).

2.7.2 All capabilities/applications described in sections 2.1 and 2.2 have no special requirements for flight plan information. However, operators can use the ADS-B IN descriptor (ICAO flight plan field 10b) or ADS-B-IN descriptive information (inserted after the ICAO flight plan Field 18's "SUR/" indicator) to provide ADS-B IN capability in anticipation of the dissemination of the information to the ATS units.

2.7.3 It is noted that the aircraft identification (item 7) is important for the consistency of the data on the traffic display. Operators are required to take appropriate steps to ensure that aircraft identification in the flight plan is identical to the one in the on-board systems for ADS-B for each flight. The format also needs to be identical to the filed flight plan, for example no leading zeros or spaces, nor any embedded spaces, per ICAO guidance on aircraft designators (refer to *Designators for Aircraft Operating Agencies, Aeronautical Authorities and Services (*Doc 8585)).

2.8 VALIDATION OF CAPABILITIES / APPLICATIONS

2.8.1 Several validation methodologies have been used for the capabilities/applications described in sections 2.1 and 2.2:

a) model-based simulations to support an evaluation of operational benefits and an impact assessment on the current operations and procedures;

b) real-time simulations which focus on both the pilot perspective and the ATC perspective, including air traffic controller/pilot cooperation and also acceptability issues; and

c) live operational evaluations (trials) in different traffic density environments (with different partial equipage rates of ADS-B OUT).

2.8.2 EUROCONTROL validation activities within the CRISTAL-ATSAW project were conducted for AIRB, VSA and SURF. The main outcomes were as follows:

a) The traffic display contributes to a better understanding of the traffic situation for pilots during flight and surface operations and it could decrease their stress;

b) The traffic display also contributes to better cooperation between air traffic controllers and pilots, thanks to the improved pilots' understanding of the traffic situation; and

c) If appropriately used, the traffic display should not have a major impact on the pilots' workload or on the air traffic controllers' activity.

2.8.3 FAA validation activities were conducted for ATAS. Several outcomes were similar to those described in section 2.8.2. Additional main outcomes were as follows:

a) For aircraft without a traffic display, ATAS aural alerts were adequate to call the pilot's attention to the appropriate OTW location for acquiring the alerted traffic; and

b) ATAS provides alerting performance that is generally better than an ACAS I system.

2.8.4 All validation activities are complete and AIRB, VSA, SURF and ATAS are operational.

2.9 ARCHITECTURE

2.9.1 Functional architecture

2.9.1.1 The functional architecture described in this section provides information on airborne surveillance systems enabling the ASA/capability. They can be grouped into three components as follows:

a) subsystems for ASA transmit participant;

b) subsystems for ASA receive participant; and

c) ground systems supporting TIS-B.

Note 1.— Two of them, a) and b), are essential to implement the air-to-air surveillance function as indicated in Figure 2-1. The third element, c), may be added to enhance the availability of air-to-air surveillance.

Note 2.— As shown in Figure 2-3, ASA needs other systems.

2.9.1.2 The subsystems for the ASA transmit participant are used to support the surveillance function by transmitting signals providing surveillance data such as aircraft position (latitude and longitude), altitude, velocity, aircraft identification and other information. The following subsystems are used for the transmit participant:

a) ADS-B transmit subsystem to generate and transmit the ADS-B signals; and

b) data sources to provide surveillance data.

2.9.1.3 On-board equipment to implement subsystems for transmit participant are listed in Table 2-1 and data flows are shown in Figure 2-2.

Table 2-1. On-board equipment for ASA transmit participant

Subsystem	*Function*	*Equipment*
ADS-B transmit subsystem	To transmit ADS-B signal with 1 090 MHz extended squitter	ATC transponder with 1 090 MHz extended squitter capability
On-board data source	To provide the aircraft or surface vehicle position and velocity (including ADS-B quality data)	GNSS receiver or other navigation sensors meeting performance requirements
	To provide the altitude and altitude rate	Air data sensors, e.g. barometric altimeter
	To provide aircraft or surface vehicle identification	FMS or direct input by pilot or surface vehicle driver

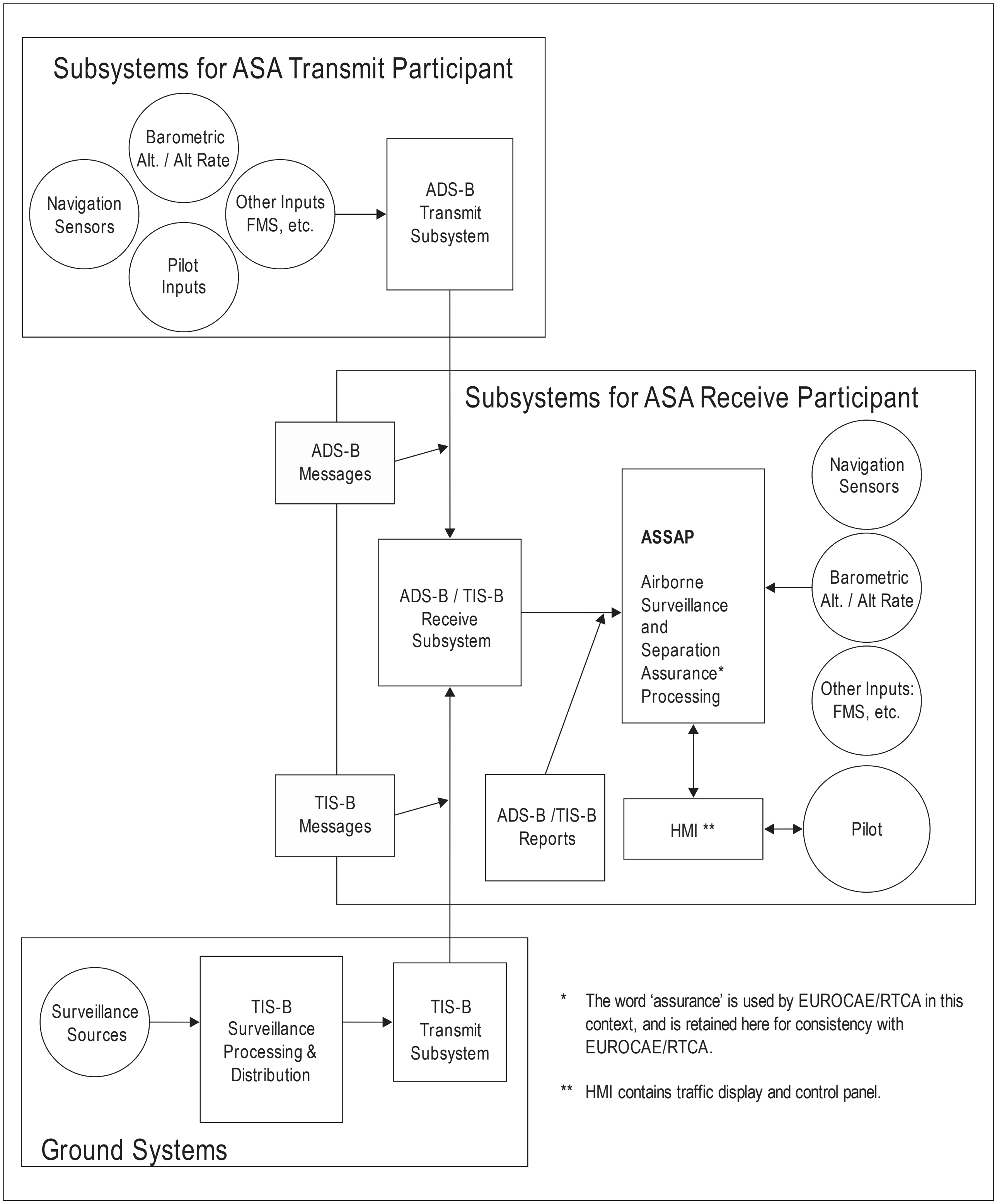

Figure 2-1. Airborne surveillance functional diagram

2.9.1.4 The subsystems for ASA receive participant are used to support the surveillance function by receiving signals, decoding surveillance data and processing it appropriately for each application/capability and to provide information to pilots. The following subsystems are used for the receive participant:

a) ADS-B/TIS-B subsystem to receive the signals and to decode the surveillance messages for extracting surveillance data;

b) Airborne surveillance and separation assurance processing (ASSAP) function to process received surveillance data from other aircraft and, if required, referring the surveillance data to own aircraft data for the intended application/capability;

c) Data sources on receiving aircraft to provide surveillance data measured by equipment on-board own aircraft or any other data required for intended application/capability; and

d) Human-machine interface (HMI), to provide display and control means for pilot.

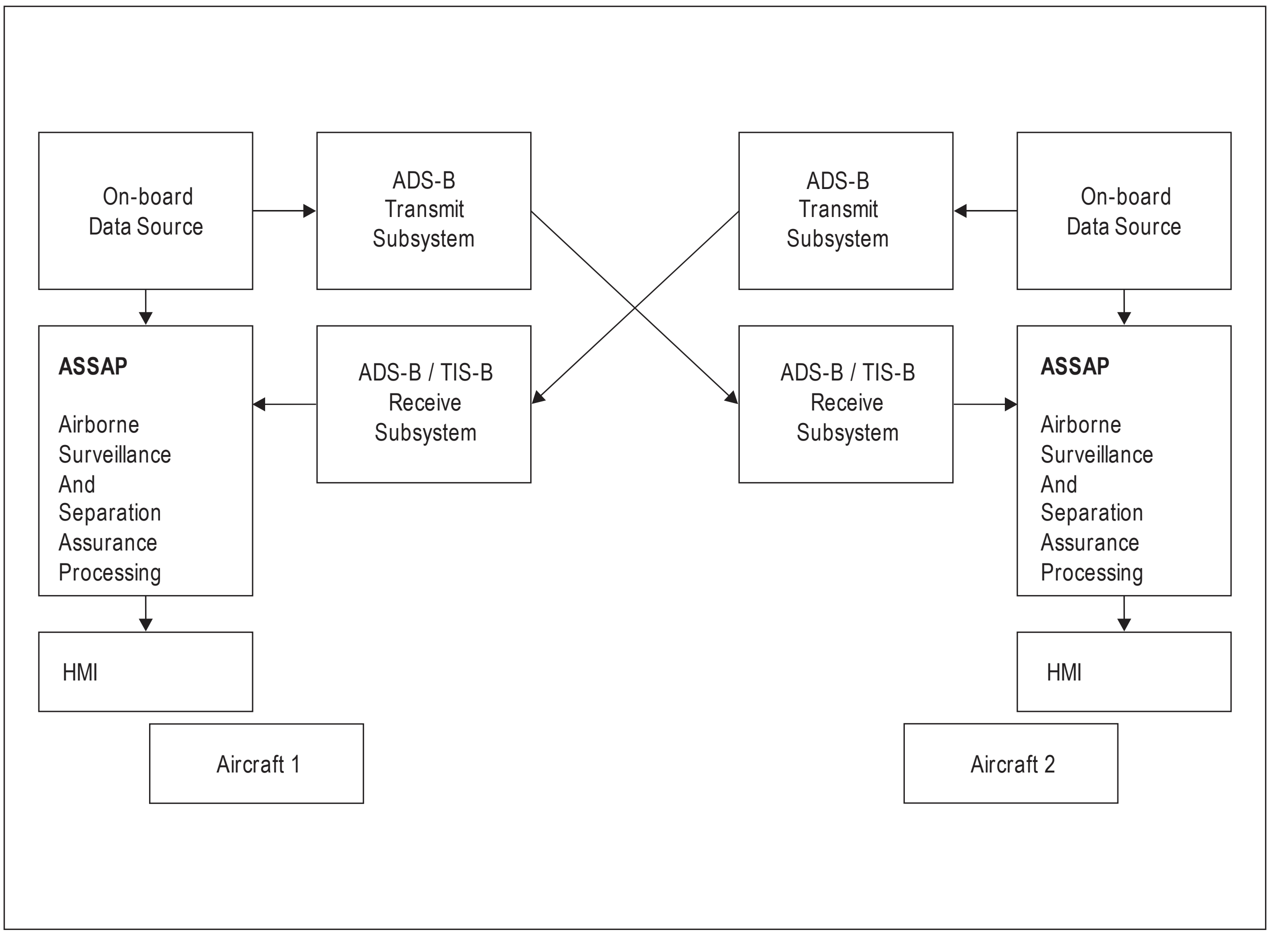

Figure 2-2. Data flows from on-board data sources

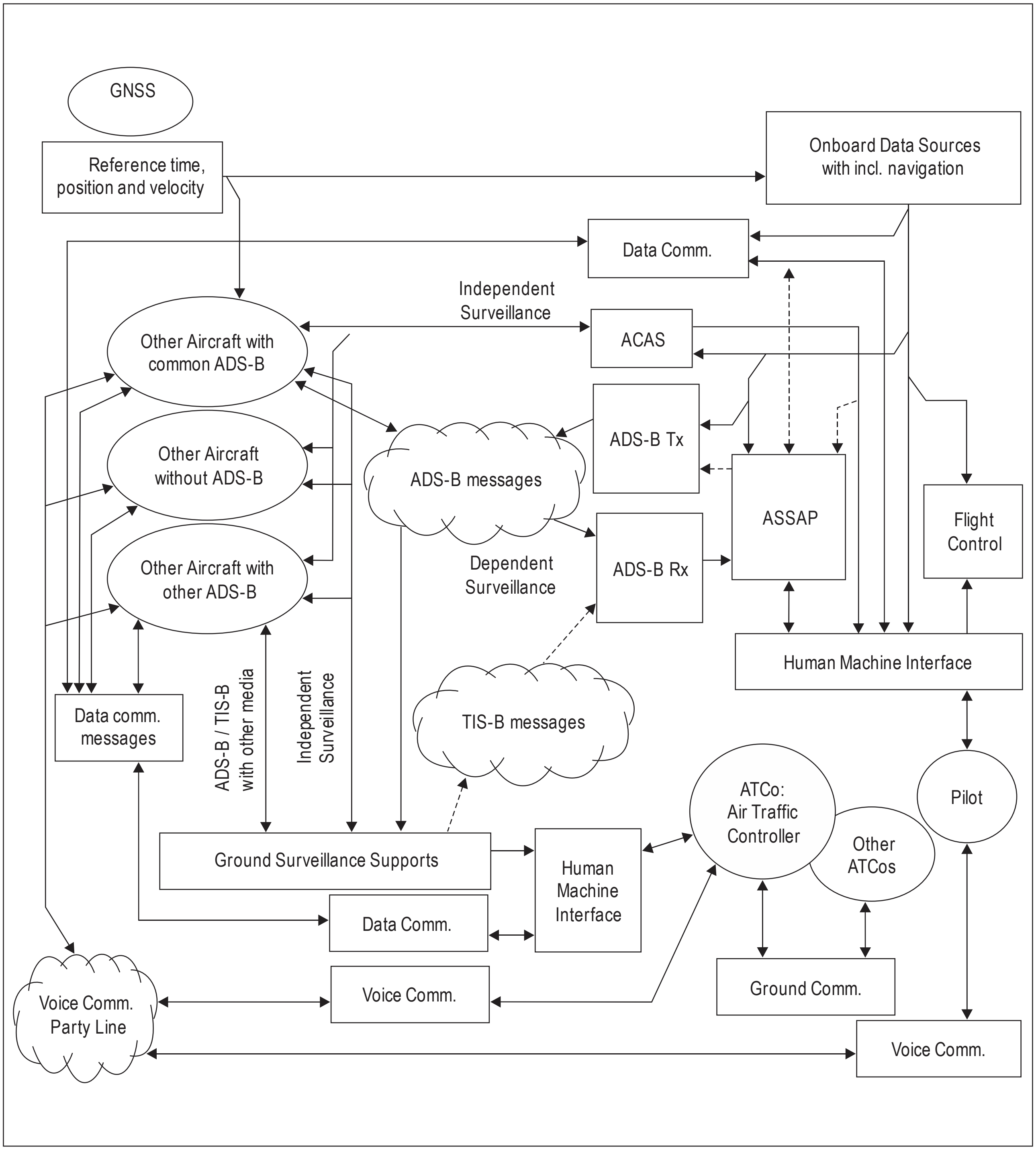

Figure 2-3. Interactions with other systems

2.9.1.5 On-board equipment to implement subsystems for the receive participant are listed in Table 2-2.

2.9.1.6 For some airborne surveillance capabilities, the ground systems can be used to support the airborne surveillance function by providing supplemental signals with encoded surveillance data for TIS-B. The following subsystems are used for the ground system:

a) TIS-B transmit subsystem to generate and transmit the TIS-B messages;

b) TIS-B surveillance processing and distribution function to generate TIS-B messages by choosing and encoding the surveillance data to be transmitted; and

c) Surveillance sources on the ground to measure and to provide surveillance data.

2.9.1.7 The equipment to implement ground systems are listed in Table 2-3.

Table 2-2. On-board equipment for ASA receive participant (ADS-B IN)

Subsystem	*Function*	*Equipment*
ADS-B/TIS-B receive subsystem	To receive ADS-B/TIS-B signals with 1 090 MHz extended squitter	Modified ACAS or independent receiver with antenna for 1 090 MHz extended squitter
ASSAP	To support for surveillance data processing and for airborne surveillance assurance processing	Computer in modified ACAS, in independent receiver for 1 090 MHz extended squitter or stand-alone processor.
On-board data sources	To provide the aircraft position and velocity (including ADS-B quality data)	GNSS receiver or other navigation sensors meeting performance requirements
	To provide the altitude and altitude rate	Air data sensors
	To measure the data for independent validation, which is required for some advanced applications and/or participants	Modified ACAS with output for independent surveillance data
	To synchronize to common time base	GNSS receiver or on-board time base
HMI	To provide the display for traffic situational awareness	Traffic display and other on-board displays as required
	To provide control means or dialogue method	Control panel, modified CDU for FMS or other suitable options

Note.— The receive participants with ADS-B need own position from an on-board data source to calculate traffic positions relative to own position, and relative speed as well. Figure 2-3 shows data flows from on-board data sources.

Table 2-3. Ground systems

Subsystem	*Function*	*Equipment*
TIS-B transmit subsystem	To transmit TIS-B signal with 1 090 MHz extended squitter	1 090 MHz extended squitter transmitter
TIS-B surveillance processing and distribution	To generate TIS-B messages	Surveillance data processor to support transmitter or transceivers above in this table
Surveillance sources	To provide the surveillance data with synchronized to common time base	SSR, WAM, MLAT, ADS-B by other media or any other appropriate surveillance sources

Note.— These systems are optional and not necessarily required for the applications discussed.

2.9.1.8 The interactions between the subsystem for ASA and other systems are described in Figure 2-3 with the following characteristics:

a) GNSS provides the time base to synchronize various systems, in addition to its positioning service;

b) Data link communication between air traffic controllers and pilots will support ASA by improving communication reliability in some airspace. The addressed data link message also reduces the misrecognition by an unintended receiver of ATC instructions. Voice communications between air traffic controllers and pilots will continue to support some applications/capabilities;

c) The HMI in the cockpit can support multiple functions and take different forms based on the function supported. All HMIs provide an organized means of operation of the ASA for pilots (and air traffic controllers when necessary). This operation relates to the display and processing of surveillance and communication data. In addition to this, it may also provide the pilots with control of the data from on-board surveillance/communications systems fed to the flight control systems. Alerting requirements would be dictated by the requirements of each application and the certification of the system;

d) The cooperative independent surveillance (systems such as WAM/Multilateration (MLAT) and SSR) provide surveillance data to validate or to supplement the surveillance data obtained with dependent surveillance systems such as ADS-B;

e) ACAS also has a cooperative independent surveillance subsystem to validate the surveillance information from ADS-B-IN onboard, especially, for the ASSAP with improved capability for applications such as ITP and interval management (IM); and

Note.— There are three surveillance system categories and the description of the independent cooperative surveillance systems is found in the Aeronautical Surveillance Manual *(Doc 9924).*

f) Other aircraft without ADS-B OUT may be covered by other ground surveillance systems. The surveillance data on these aircraft may also be processed and provided via TIS-B to on-board systems.

Note.— Dotted lines represent optional or provisional links.

2.9.2 Description of cockpit solutions

2.9.2.1 The current implementation of ASA/capability in the cockpit follows two main approaches:

a) Integrated display solution

These implementations are typically provided by the aircraft manufacturer. With these solutions, the traffic display and some of ASA/capability's key controls are integrated into the flight deck primary field of view (± 15 degrees from the pilot's normal line-of-sight); and

b) Auxiliary display solution

For implementations of this solution, the traffic display is provided on an avionics grade auxiliary display or displays.

2.9.2.2 Integrated display solutions

2.9.2.2.1 Integrated display solutions provide traffic information on a single display for:

a) collision avoidance; and

b) airborne surveillance applications/capabilities.

2.9.2.2.2 Benefits of integrated display solutions are:

a) graphical correlation of ACAS and ADS-B traffic information reduces mental burden for the pilots;

b) seamless handling of ACAS and ADS-B traffic information provides immediate reaction to ACAS SOPs when a traffic advisory (TA) or a resolution advisory (RA) is triggered;

c) display in the primary field of view increases ease of utilization of applications/capabilities and may limit head-down time; and

d) human factors assessment can be performed as early as the design phase, in parallel with the development of the operational procedure.

2.9.2.2.3 Taking into account human factors, considerations resulting from validation activities, use of an integrated display is preferred compared to an auxiliary traffic display.

2.9.2.3 *Auxiliary display solutions*

2.9.2.3.1 Auxiliary display solutions provide traffic information for ASA/capability on one or more auxiliary displays, which can be side mounted and/or in the primary field of view. It means that monitoring of the traffic for collision avoidance (both for TA and RA) remains on the currently used flight deck displays, while ASA/capability uses the auxiliary displays on either side of the flight deck and for some applications/capabilities in the primary field of view.

Note.— Human factors considerations indicate that the most effective location is in the primary field of view.

2.9.2.3.2 Side-mounted auxiliary display solutions may have operational limitations, such as:

a) restricted operational approval due to display location not being in the primary field of view;

b) terminal manoeuvring area operations restricted to VMC;

c) operations restricted to non-critical phases of flight; and

d) additional human factors evaluation needed on workload management, fatigue and unnecessary head-down time for the pilots.

2.9.2.3.3 Benefits of auxiliary display solutions are:

a) cost effectiveness: As integrated solutions require the latest generation flight deck displays (e.g. liquid crystal display) and related avionics, an auxiliary display solution may be the only viable option for some older aircraft with cathode ray tube (CRT) primary flight displays;

b) feasibility: an auxiliary display solution provides for a retrofit solution; and

c) auxiliary display solutions are available from a variety of manufacturers, with many choices to meet different operational needs.

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Chapter 3

SPECIFIC IMPLEMENTATIONS

3.1 COCKPIT DISPLAY OF TRAFFIC INFORMATION (CDTI) ASSISTED VISUAL SEPARATION (CAVS)

Note 1.— This chapter provides initial material regarding CAVS capabilities. Technical standardization documents are available and there are operational implementations of these capabilities only in the United States as of 2020. Operational provisions of CAVS, which are slightly different from ICAO provisions related to own separation, are used for operation of CAVS only in the United States.

Note 2.— Harmonized implementation and operational approval of CAVS are strongly encouraged.

3.1.1 Description of CAVS

3.1.1.1 The objective of CAVS is to assist pilots in maintaining own separation from an aircraft equipped with ADS-B OUT during successive visual approach procedures.

Note.— In this section, the aircraft ahead is referred to as the preceding aircraft and the aircraft performing CAVS is referred to as the succeeding aircraft.

3.1.1.2 The air traffic controller will provide traffic information to the pilot of the succeeding aircraft as in current operations. On reception of this traffic information, the pilot of a CAVS-equipped aircraft can use the traffic display to support visual acquisition of the preceding aircraft during the approach procedure, if the preceding aircraft is transmitting ADS-B OUT surveillance data. Once the preceding aircraft is initially identified on the traffic display, the pilot is, in contrast to VSA, allowed to use the traffic display to continue own separation approach procedures even if OTW visual contact with the preceding aircraft is lost (e.g., preceding aircraft is lost in city lights at night).

3.1.1.3 CAVS can only be operated under VMC. CAVS does not modify the approach procedure under VMC.

3.1.1.4 Aircraft installations compliant with RTCA DO-317C/EUROCAE ED-194B incorporate two alerting features: a caution level surveillance alert and an advisory level, pilot-selectable range indication. The pilot-selectable range indication is set in accordance with individual established company procedures and is intended to assist the pilot in maintaining an operationally desirable distance from the preceding aircraft. The caution level minimum range alert cannot be modified by the pilot and activates when the range from the preceding aircraft is less than 1.4 nautical miles, or, in some installations, when the CAVS system detects a predetermined excessive closure rate with the preceding aircraft. When the caution alert occurs, the pilot is no longer authorized to use the CAVS avionics as a substitute for OTW visual observation of the preceding aircraft.

Note.— The value of 1.4 NM is justified in the Safety, Performance and Interoperability Requirements Document for CAVS, *RTCA DO-354/EUROCAE ED-233.*

3.1.1.5 The following information about the preceding aircraft is presented to the pilot by the CAVS system:

a) relative horizontal position (i.e. distance and relative bearing);

b) altitude (relative altitude required. Barometric corrected pressure altitude and absolute pressure altitude optional);

c) direction (ground track);

d) vertical direction;

e) relative groundspeed information;

f) alerting information, as described in section 3.1.1.4; and

g) aircraft identification and ground speed on demand.

Note 1.— Relative groundspeed information enables the pilot to readily assess the closure rate.

Note 2.— For more information, see the Safety, Performance and Interoperability Requirements Document for CAVS, *RTCA DO-354/EUROCAE ED-233.*

3.1.2 Operational environment for CAVS

3.1.2.1 For maximum operational utility, CAVS should be introduced in an environment with full ADS-B OUT equipage. The preceding aircraft must be equipped with ADS-B OUT for use of CAVS.

3.1.2.2 Until data collection and analysis can justify it, TIS-B is not approved for use with CAVS (see more details in DO-354/ED-233).

3.1.2.3 CAVS is only approved to support aircraft performing successive visual approach and landing operations to the same runway. CAVS is applicable for all types of runway configurations where successive visual approaches are in use.

3.1.2.4 There are no new requirements on ATM systems from communications, navigation and surveillance perspectives when CAVS is used. CAVS can be used in the same environments as current operations.

3.1.2.5 CAVS can be used in airspace of any traffic density.

3.1.2.6 Some States require operational approval for use of the CAVS capability.

Note.— See FAA Advisory Circular 90-114 (latest revision) for example.

3.1.3 Benefits of CAVS

3.1.3.1 CAVS is expected to improve the efficiency of arrival traffic at airports due to the more frequent acceptance by pilots of visual separation.

3.1.3.2 It is expected that the safety of the successive visual approach and landing operation will be improved through the provision of accurate data to the pilots (e.g. relative groundspeed to the preceding traffic ground speed) allowing them to better predict the evolution of the traffic.

3.2 ADDITIONAL INFORMATION FOR ATC

3.2.1 The information provided in this section supplements the ANSP considerations described in section 2.6. This section describes CAVS which does not modify ATC procedures.

3.2.2 The availability of CAVS on-board aircraft systems does not relieve either air traffic controllers or pilots from applying the procedures related to the provision of ATS, which include the issuance of traffic information. The requirement for traffic information as well as its content to be passed to affected flights remains unchanged (see *Procedures for Air Navigation Services – Air Traffic Management (PANS-ATM)* (Doc 4444)).

3.3 ADDITIONAL INFORMATION FOR PILOTS

3.3.1 The information provided in this section supplements the additional information for pilots described in section 2.4.

Note 1.— The aircraft operator should refer to the OEM documentation for guidance on the exact SOPs to apply.

3.3.1.1 It is a pilot's decision whether to use the traffic display during flight operations. The scope of CAVS only includes situations where the pilot uses the traffic display.

3.3.1.2 ACAS procedures are not affected by the use of CAVS.

3.3.1.3 While pilots are building up their situational awareness, and if information on displayed traffic of interest is available by visual contact or radio communications, the pilot is expected to check consistency between the information provided by the traffic display with the visual information and radio communications.

3.3.1.4 The pilot should be aware that there is a possibility that the aircraft identification presented to the pilot on the on-board display may not necessarily be the same as the one displayed to the air traffic controller due to differences in the source of information.

3.3.1.5 If the pilot detects an inconsistency between the information for traffic of interest on the traffic display and the radio communication, and when necessary from a safety perspective, the pilot should cross-check with the air traffic controller in controlled airspace or the pilot of the traffic of interest in uncontrolled airspace for confirmation.

Note.— When assessing the consistency between information provided by the traffic display and by the air traffic controller, the pilot should take into account the evolution of the traffic situation, as the information displayed is continuously updated and it can slightly differ from the information received from the air traffic controller.

3.3.1.6 The pilot should avoid making references to aircraft identification observed on the traffic display in their communication with ATC, directly or as a response to traffic information, except in cases where a reference to the observed aircraft identification would eliminate ambiguities with regard to essential traffic.

3.3.1.7 Some States require operational approval for use of CAVS.

Note 1.— The United States requires operational approval for CAVS. See FAA Advisory Circular 90 -114 (latest version).

Note 2.— More information on operational approval for CAVS can be found in section 3.5.2.

3.3.1.8 CAVS use the traffic display to support the visual scan and acquisition of the preceding aircraft during the approach procedure, if the preceding aircraft is transmitting ADS-B OUT surveillance data. CAVS is comprised of four phases (i.e. visual acquisition, clearance for maintaining own separation, maintaining own separation on approach and termination). The pilot will assess the meteorological conditions as in current operations and that there is no change to the use of ICAO phraseology in Chapter 12 of the *Procedures for Air Navigation Services — Air Traffic Management (PANS ATM)* (Doc 4444).

3.3.1.9 Draft CAVS procedures

a) CAVS is an ADS-B IN application that assists the pilot in maintaining spacing from ADS-B Out-equipped aircraft for visual approaches. Traffic information from the CDTI is used to augment OTW visual contact with an aircraft a pilot is assigned to follow;

b) CAVS begins when the air traffic controller provides traffic information to the pilot of the succeeding aircraft as per current procedures. On reception of this traffic information and directed to maintain own separation, as described in Doc 4444, section 6.5.3, *Visual Approach*, the pilot of an aircraft (suitably equipped for CAVS) can use the traffic display to support visual acquisition of the preceding aircraft during the approach procedure, if the preceding aircraft is transmitting ADS-B OUT data;

c) use of CAVS equipment during successive visual approaches must be approved by the State of the Operator;

d) CAVS must not be used for dependent parallel runway operations;

e) it is a pilot's decision whether to use the traffic display. The pilot may use the traffic display to maintain spacing, even if visual OTW contact with the preceding aircraft is lost; and

f) ACAS procedures are not affected by the use of CAVS.

Note.— Details of the CAVS procedure are contained in Safety and Performance Requirements Document for CDTI Assisted Visual Separation (CAVS), *RTCA DO-354. Details of the CAVS equipment are specified in [E]TSO-C195b, which references* Minimum Operational Performance Standards (MOPS) for Aircraft Surveillance Applications System, *RTCA/EUROCAE DO-317B/ED-194A.*

3.4 CONSIDERATIONS FOR PARTIAL EQUIPAGE ENVIRONMENT

3.4.1 When implementing CAVS, the impact of partial equipage of ADS-B OUT will have to be considered to ensure that the benefits and safety objectives are achieved.

Note 1.— CAVS is not allowed to use TIS-B information. This may limit the operational utility and benefits of CAVS unless ADS-B OUT is mandated in the airspace where CAVS is used.

Note 2.— See also sections 2.5.1.4 and 2.5.1.5 for relevant considerations related to partial equipage of ADS-B OUT.

3.4.2 Delivering efficiency benefit to early users has been proven as an effective way to encourage an increase in voluntary equipage. However, a balanced transition strategy through a collaborative decision-making process with all stakeholders needs to be developed to avoid unacceptable increase of workload for air traffic controllers.

3.5 STAKEHOLDERS CONSIDERATIONS

3.5.1 Air navigation services provider (ANSP)

3.5.1.1 *ANSP considerations for CAVS*

3.5.1.1.1 By design, CAVS has no direct impact on ANSP infrastructure or on the ATC procedures. These capabilities can be used in the same environments as current operations from the communication, navigation and surveillance perspectives and from ATM system perspectives. However, ANSPs should consider the merits of training air traffic controllers on these capabilities and the possible resulting pilot behaviour, such as pilot use of other aircraft's ADS-B identification in voice communications.

3.5.1.1.2 ANSPs may want to provide the information to the air traffic controller (i.e. whether the aircraft is ADS-B OUT and/or IN equipped) using the ADS-B capability field of the ICAO FPL format (item 10b (B1 and B2)), augmented by supplementary information contained in Field 18 after the "SUR/" indicator. The data may be used as an awareness of the aircraft equipage in the area of responsibility to allow ATC to better assess the capabilities of the traffic in the sector.

3.5.2 Regulator and aircraft operators

3.5.2.1 *General considerations*

3.5.2.1.1 In States where air traffic services are provided based on CAVS capabilities, the requirements to receive those services should be clearly defined for operators. The States of the Operators and the States of the Registry should ensure that operators meet these requirements before operating such capabilities.

3.5.2.1.2 The States of the Operators and the States of the Registry should publish any necessary requirements for granting operational approval to operate the CAVS capability. It is also useful to make available a State-level guidance document on how the approval can be obtained.

3.5.2.1.3 To ensure safety via consistent implementations of CAVS, civil aviation authorities are highly encouraged to harmonize their conditions and requirements for approving operations of CAVS capabilities. The process and conditions for issuing such approval should be harmonized between States so that an approval issued by one State is automatically accepted by all other States, unless explicitly forbidden.

3.5.2.1.4 Before conducting CAVS operations, operators should obtain appropriate operational approvals from their respective civil aviation authorities in accordance with the conditions and requirements issued by the States of the Operators.

3.5.2.2 The following sections provide guidelines for operators on training and documentation.

3.5.2.2.1 For effective and safe employment of CAVS during a critical phase of flight, operators are required to produce SOPs for their pilots. During the development of these SOPs, care needs to be given to properly mitigate any potential information overload and increase to the pilot's workload.

3.5.2.2.2 Operator's training programme for CAVS

3.5.2.2.2.1 Operators are expected to ensure that their pilots are trained to operate CAVS in conformance with applicable regulations and guidance from State regulators. The training materials may be developed by the operator or suggested by the aircraft or avionics OEM.

3.5.2.2.2.2 Recommended items for a pilot training programme include:

a) avoidance of excessive head-down time;

b) awareness of why the traffic display may not include all aircraft and vehicles;

c) recognition of expected performance characteristics and limitations of the system;

d) operational concepts (see section 3.1);

e) pilot procedures, including appropriate responses to any alerts provided by CAVS (see section 3.3);

f) avoidance of radio communication using other aircraft identification; and

g) flight plan implications (refer to section 3.5.1).

3.5.2.2.2.3 Furthermore, additional training should be developed and given for the system functions, indications and interactions for CAVS.

3.5.2.2.3 Documentation for CAVS

Operators are required to update their documentation with regard to flight operations (e.g. Operations Manuals – Parts A, B, C and D) and maintenance. This documentation may be provided by the aircraft or avionics OEM.

3.6 VALIDATION OF CAPABILITIES / APPLICATIONS

FAA validation activities were conducted for CAVS. Per a trial by US Airways at the Philadelphia International Airport, the additional information and alerting functionality provided by CAVS contributes to better management by the pilot of the aircraft's flight path, relative to the preceding traffic on visual arrival and approach.

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Chapter 4

INTERVAL MANAGEMENT

*Note 1.— This chapter provides initial information regarding IM capabilities as defined in RTCA DO-328B/EUROCAE ED-195B (*Safety, Performance and Interoperability Requirements*) and RTCA DO-361A/EUROCAE ED-236A (*Minimum Operational Performance Standards (MOPS) for flight-deck interval management (FIM)*). These interval management capabilities are designed for use in an arrival flow onto the same runway and where PANS-ATM, Chapter 8 separation is in use. These capabilities are not widely used; however, an operational trial is planned. An implementation timeline for the capabilities described in this chapter are given in the* Global Air Navigation Plan (GANP) *(Doc 9750).*

Note 2.— ICAO guidance for implementation and operational approval will also be made available.

4.1 DESCRIPTION OF INTERVAL MANAGEMENT (IM)

4.1.1 IM is defined as the overall system that enables improved means for managing traffic flows and aircraft spacing.

4.1.2 This includes both the use of ground and airborne capabilities as follows:

a) ground capabilities that assist the air traffic controller in issuing clearances to merge and space aircraft safely and efficiently by allowing the use of IM clearances; and

b) airborne capabilities that allow the pilot to conform to the IM clearance. These airborne capabilities are referred to as the airborne spacing or FIM avionics.

4.1.3 The objective of the IM application is to achieve and/or maintain an assigned spacing goal between the IM aircraft and the designated aircraft (referred as the target aircraft), using the guidance of the FIM avionics on the flight deck that enables the pilot to actively manage the spacing relative to the target aircraft. The assigned spacing goal (ASG) is a time or distance interval between the IM aircraft and a target aircraft assigned by the controller as part of the IM operation. The ASG is determined by the controller issuing the IM clearance and the type and value(s) of the ASG are selected to achieve the controller's goal of establishing an efficient flow while maintaining separation from all traffic.

4.1.4 Air traffic controllers and pilots are provided with new procedures and a new phraseology for IM operations.

4.1.5 During IM operations, the air traffic controller retains responsibility for separation. The pilot is responsible for complying with the speeds generated by the FIM avionics and other ATC instructions to achieve and/or maintain the spacing assigned by the air traffic controller.

Note.— Additional descriptive information related to IM may be found in the Safety, Performance and Interoperability Requirements Document for Airborne Spacing – Flight-deck Interval Management (ASPA-FIM) *(DO-328B/ED-195B).*

4.2 OPERATIONAL ENVIRONMENTS FOR IM

4.2.1 IM operations can occur in a variety of environments and situations. Furthermore, IM can be used during most phases of flight (i.e., en-route, arrival and approach phases).

4.2.2 IM operations may only be performed relative to aircraft equipped with ADS-B OUT. TIS-B may not be used. As a consequence, the IM procedure is only possible for aircraft within ADS-B range.

4.2.3 IM clearances are communicated via direct controller-pilot voice communication, e.g. VHF or via data communication, e.g, CPDLC.

Note.— refer to Safety and Performance Standard for Baseline 2 ATS Data Communications, Initial Release (Baseline 2 SPR Standard), *RTCA/EUROCAE DO-350A/ED-228A Volume I and II and* Interoperability Requirements Standard for Baseline 2 ATS Data Communications, Initial Release (Baseline 2 Interop Standard) *(DO-351A/ED-229A, Volume I and II).*

4.3 BENEFITS FOR IM

Potential benefits of IM operations include:

a) timely speed advisories removing later requirement for path-lengthening;

b) increased capacity in arrival and approach environments using fixed routes where vectoring for spacing is avoided due to noise abatement procedures or other operational reasons;

c) continuous descent profile in high density environments;

d) reduced ATC instructions due to the reduced number of speed instructions; and

e) more efficient aircraft operations for FIM-equipped aircraft, when aircraft are pre-sequenced, e.g., with the use of arrivals management (AMAN).

Note.— These benefits are obtained via the combined use of IM and other enablers. There are other alternative enablers supporting these operations (e.g. point merge).

4.4 AIR TRAFFIC CONTROL (ATC) ROLE

4.4.1 As in today's operations, the controller is responsible for:

a) ensuring separation; and

b) expediting and maintaining the orderly flow of traffic, for example by:

   1) building a sequence of traffic; and

   2) anticipating and delivering required spacing based on altitude, aircraft performance and environmental conditions.

4.4.2 The controller uses IM to manage the spacing between aircraft when the aircraft in sequence need to be spaced closely together. The controller, considering the eventual information provided by supporting ground-based automation (if available), determines the appropriate target aircraft, ASG, the location of the achieve-by point (ABP) and the planned cancellation point (PCP). It is important to note that ASG is understood as the time or distance assigned by the controller for spacing, ABP is the waypoint by which the ASG must be met and PCP is the waypoint where the IM operation is planned to end. This consists of:

a) identification of the sequence of aircraft;

b) identification of the desired spacing between aircraft, i.e., assigned spacing goal; and

c) ensuring that the IM applicability conditions are met as follows:

1) IM aircraft is capable of performing IM;

2) target aircraft is ADS-B Out equipped and the surveillance information is available to the IM aircraft;

3) both IM and target aircraft speed performances are compatible (or compatible characteristics with respect to aircraft performance);

4) both IM and target trajectories are compatible; and

5) IM and target aircraft relative positions are compatible.

4.4.3 The controller provides the appropriate IM clearance to the IM aircraft:

a) achieve by and maintain: used when the controllers want the IM aircraft to achieve the assigned spacing goal at the ABP and then maintain the assigned spacing goal until the planned cancellation point;

b) capture then maintain: used when the controllers want the IM aircraft to achieve the assigned spacing goal quickly and then maintain it until the planned cancellation point;

c) maintain current spacing: used when the controller wants the IM aircraft to maintain the current spacing interval, as determined by the FIM equipment, until the planned cancellation point; and

d) IM turn: used when the controller wants the IM aircraft to adjust its horizontal path to help achieve the assigned spacing goal at the achieve-by point.

4.4.4 The controller determines the assigned spacing goal type that meets the operational need. The assigned spacing goal can be given in either distance or time. If during the IM operations the controller needs to issue a new clearance to either the IM or target aircraft that would result in a modification to their Intended flight path information, the controller instructs the IM aircraft to either:

a) cancel IM; or

b) suspend IM

Note.— See SPR DO328B/ED-195B.

4.4.5 Throughout the entire duration of the IM operation, the controller remains responsible for ensuring the separation between the IM and the target aircraft as well as from all other traffic.

4.5 PILOT ROLE

4.5.1 The pilot is responsible for identifying the target aircraft (provided by the controller) and complying with the IM clearance if accepted. While most IM clearances will keep the IM aircraft on its current route and result only in speed management, other clearances may include a controller-defined turn for path lengthening.

4.5.2 The pilot is required first to acknowledge the reception of the IM clearance and, in particular, to confirm the target identification, the assigned spacing goal, the location of the achieve-by point and the planned cancellation point.

4.5.3 The identification of the target aircraft is achieved via the CDTI. The pilot is required to confirm that the target aircraft is selected and tracked by the FIM avionics. The pilot/controller communication will contain the messages and/or the phraseology for the identification.

4.5.4 Once the target is selected, the pilot is required to enter the clearance parameters in the FIM avionics. The FIM avionics checks the feasibility of the clearance (eg. own aircraft speed and route). If the FIM avionics validates the feasibility, the pilot will confirm the acceptance of the clearance. The pilot/controller communication will contain the messages and/or the phraseology for the clearance.

4.5.5 The pilot will execute the clearance and in particular promptly react to the speed advisories. Some clearances may include an IM turn (controller-defined) which should be executed in an order to comply with the clearance.

4.5.6 During the execution of the clearance, the pilot follows the FIM speed advisories. In case of conditions which affect the ability to comply with the clearance, the pilot is required to notify the controller who can cancel the IM procedure or issue a new clearance.

4.6 CONSIDERATIONS FOR PARTIAL EQUIPAGE ENVIRONMENT

4.6.1 When implementing IM, the impact of partial equipage of ADS-B OUT will have to be considered to ensure that the benefits and safety objectives are achieved.

Note 1.— IM is not allowed to use TIS-B information. This may limit the operational utility and benefits of IM unless ADS-B OUT is mandated in the airspace where IM is used.

Note 2.— See also sections 2.5.1.4 and 2.5.1.5 for relevant considerations related to partial equipage of ADS-B OUT.

4.6.2 Delivering efficiency benefit to early adopters has been proven as an effective way to encourage an increase in voluntary equipage. However, a balanced transitional strategy through a collaborative decision-making process with all stakeholders needs to be developed to avoid unacceptable increase of workload for air traffic controllers.

4.7 STAKEHOLDER CONSIDERATIONS

4.7.1 Air navigation services provider (ANSP)

4.7.1.1 *General considerations*

4.7.1.1.1 ANSPs are required to train air traffic controllers on these capabilities and interactions with pilots, such as use of other aircraft's ADS-B identification in voice communications.

4.7.1.1.2 ANSPs may want to provide FIM operational approval status (from the ICAO flight plan) to the air traffic controller. The data may be used as an awareness of the operational approval status in the area of responsibility to allow ATC to assess the capabilities of the traffic in the sector.

4.7.1.2 ANSP considerations for IM implementation.

4.7.1.2.1 IM operations require the air traffic controller to provide a clearance to the eligible IM aircraft which includes the assigned spacing goal. An ANSP implementation may require ATC automation support to the air traffic controller in determining which aircraft are eligible to receive an IM clearance, and the appropriate assigned spacing goal to provide in the IM clearance.

4.7.1.2.2 It is up to the States, CAAs and service providers, who are responsible for implementing IM, to determine in which part of its airspace, if any, IM is authorized. The IM application defines some new procedures for air traffic controllers. Therefore, specific training is required. This training should include conditions to be met for the initiation, execution and termination of the procedure, communications with the pilots, and management and/or identification of abnormal situations.

4.7.2 Regulatory considerations

4.7.2.1 *General considerations*

4.7.2.1.1 In States where air traffic services are provided based on IM capabilities, the requirements to receive those services should be clearly defined for operators. The States of the Operators and the States of the Registry should ensure that operators meet these requirements before operating such capabilities.

4.7.2.1.2 The States should publish any necessary requirements for granting operational approval to operate the IM capabilities. It is also useful to make available a State-level guidance document on how the approval can be obtained.

4.7.2.1.3 To ensure safety via consistent implementations of IM, State CAAs are highly encouraged to harmonize their conditions and requirements for approving operations of IM capabilities. The process and conditions for issuing such approval should be harmonized between States so that an approval issued by one State is automatically accepted by all other States unless explicitly forbidden.

4.7.2.1.4 Before conducting IM operations, operators should fulfill appropriate conditions and requirements published by relevant CAAs.

4.7.2.2 The following sections provide guidelines for operators on training and documentation.

4.7.2.2.1 Operator's training programme

4.7.2.2.1.1 Operators are expected to ensure that their pilots are trained to operate IM in conformance with the provisions of the *Procedures for Air Navigation Services – Aircraft Operations (PANS OPS)* (Doc 8168) and the *Procedures for Air Navigation Services – Air Traffic Management (PANS ATM)* (Doc 4444). The training materials may be developed by the operator or suggested by the OEM.

4.7.2.2.1.2 Recommended items for a pilot training programme include:

a) the nature of the displayed information;

b) appropriate use of the traffic display;

c) avoidance of excessive head-down time;

d) recognition of expected performance characteristics and limitations of the system;

e) operational concept and pilot-controller phraseology and/or messages;

f) pilot procedure, including energy management and appropriate responses to any alerts provided by IM avionics;

g) use of other aircraft identification in radio communication; and

h) flight plan implications.

4.7.2.2.2 Documentation

4.7.2.2.2.1 Operators are required to update their documentation with regard to flight operations (e.g., Operations Manuals – Parts A, B, C and D) and maintenance. This documentation may be provided by the aircraft or avionics OEM.

4.7.2.2.2.2 Operational approval is required for the pilots and the aircraft to perform IM. An operation manual or other appropriate material, as required by State regulations, is needed to permit the use of the IM.

4.8 FLIGHT PLANNING

4.8.1 All operators with ADS-B capability are expected to provide corresponding information on ADS-B OUT capability in the flight plan form (item 10), as defined in *PANS ATM* (Doc 4444).

4.8.2 Operators are expected to use the ADS-B IN descriptor (ICAO flight plan field 10b) and ADS-B-IN descriptive information (inserted after the ICAO flight plan field 18's "SUR/" indicator) to provide information on IM capability in anticipation of the dissemination of the information to the ATS units as shown below. The IM capability denoted in the flight plan means that the aircraft has the necessary equipment, the pilots have received the necessary training and the State of the operator has approved the operators for IM operation.

Table 4-1. Flight Plan Information related to IM Capability

Capability	*Supported application*	*Item 18 SUR/ descriptor*	*Comments*
Interval Management	Initial Interval Management	I0	ACSS SafeRoute Merging & Spacing, 2020 version
	Flight Deck based Interval Management for Spacing (FIM-S)[1]	I1	RTCA DO-361/EUROCAE ED-236
	Interval Management (IM)	I2	RTCA DO-361A/EUROCAE ED-236A
Spacing for paired approaches	Paired Approach (PA)	P1	RTCA DO-361A/EUROCAE ED-236A

1. FAA does not anticipate supporting this version of Interval Management, as there is no [E]TSO which invokes DO-361/ED-236.

4.8.3 It is noted that the aircraft identification (item 7) is important for the consistency of the data on the traffic display. Operators are required to take appropriate steps to ensure that aircraft identification in the flight plan is identical to the one in the on-board systems for ADS-B for each flight. The format also needs to be identical to the filed flight plan. For example, there should be no leading zeros or spaces, or any embedded spaces, per ICAO guidance on aircraft designators (refer to *Designators for Aircraft Operating Agencies Aeronautical Authorities and Services* (Doc 8585)).

4.9 ARCHITECTURE

4.9.1 Functional architecture

4.9.1.1 The functional architecture described in this section provides information on airborne surveillance systems enabling the IM capability. They can be grouped into three components as follows:

a) subsystems for ASA transmit participant;

b) subsystems for ASA receive participant; and

c) ground automation systems supporting arrival management.

Note 1.— Two of them, a) and b), are addressed in section 2.9: Data flows, the elements essential to implement air-to-air surveillance function, are in Figure 2-2.

Note 2.— The third element, c), enhances the availability of air-to-air surveillance in the IM. Further details can be found in sections 4.9.1.6 and 4.9.3.

4.9.1.2 Descriptions on the subsystems for the ASA transmit participant can be found in section 2.9.1.2.

4.9.1.3 On-board equipment to implement subsystems for transmit participant are listed in Table 2-1 and data flows are shown in Figure 2-2.

4.9.1.4 Descriptions on the subsystems for ASA receive participant can be found in section 2.9.1.4.

4.9.1.5 On-board equipment to implement subsystems for the receive participant are listed in Table 2-2. The following ASSAP functions feature IM application/capability:

a) speed command for IM aircraft is generated using data/information via ADS-B IN, pilot’s input, FMS and/or other suitable options; and

b) the status of the IM application/capability is distinguished in the processing.

Note.— Other suitable processing will be added for enhancing IM applications/capability.

4.9.1.6 Ground automation systems are expected to enhance the IM application/capability as follows:

a) strategic sequencing and scheduling of the IM and non-IM aircraft in the air traffic could be automated for supporting the IM application/capability on the ground; and

b) other suitable functions could be added for air-ground collaboration (further details can be found in section 4.9.3).

Note 1.— In the current operation, ground automation systems has been implemented for supporting aircraft arrival management. The functional enhancement will be added for achieving even better IM solutions.

Note 2.— Essential to implement the ground automation systems and interactions between the IM aircraft are shown in Figure 4-1.

4.9.2 Description of cockpit solutions

4.9.2.1 The implementation of the IM capability in the cockpit requires display solutions as described in section 2.9.2.

4.9.2.2 The implementation of the IM capability requires HMI solutions in the cockpit. They can be grouped into two components as follows:

a) input devices, which allow the pilot to input data/information required for ASSAP processing; and

b) display units, which show required data/information to the pilot.

Note 1.— a) and b) provide mutual interactions between the pilot and ASSAP while executing IM application.

Note 2.— Input devices allow the pilot to input data/information of target aircraft, assigned spacing goal, time/distance spacing and any others required in the ASSAP processing.

Note 3.— Display units provide speed command, IM status and any other data/information required for enhancing IM application/capability.

4.9.3 Description of ground solutions

4.9.3.1 Ground automation systems are expected to enhance the IM operation. Their components can be listed as follows:

a) ground processing, which assists in sequencing and spacing the IM and non-IM aircraft in the traffic flow; and

b) HMI, which are designed to support air traffic controllers in the IM execution/termination.

4.9.3.2 The ground automation is expected to support air traffic controllers to select IM spacing time/distance, target aircraft, sequencing the IM aircraft in the traffic flow and any other tasks enhancing the IM application/capability.

4.10 VALIDATION

4.10.1 Methodologies for IM validation are enumerated as follows:

a) fast-time simulation, which estimates operational benefits and impacts based on computer simulation models; so called model-based simulation in other words;

b) real-time simulation, in which human operators (pilots and air traffic controllers) evaluate performance and feasibility following operational procedures in the simulation loop under higher-fidelity experimental environment than fast-time simulation; so called human-in-the-loop simulation in other words; and

c) flight tests and field demonstrations, which confirms safety, performance and benefits in operations under real environments.

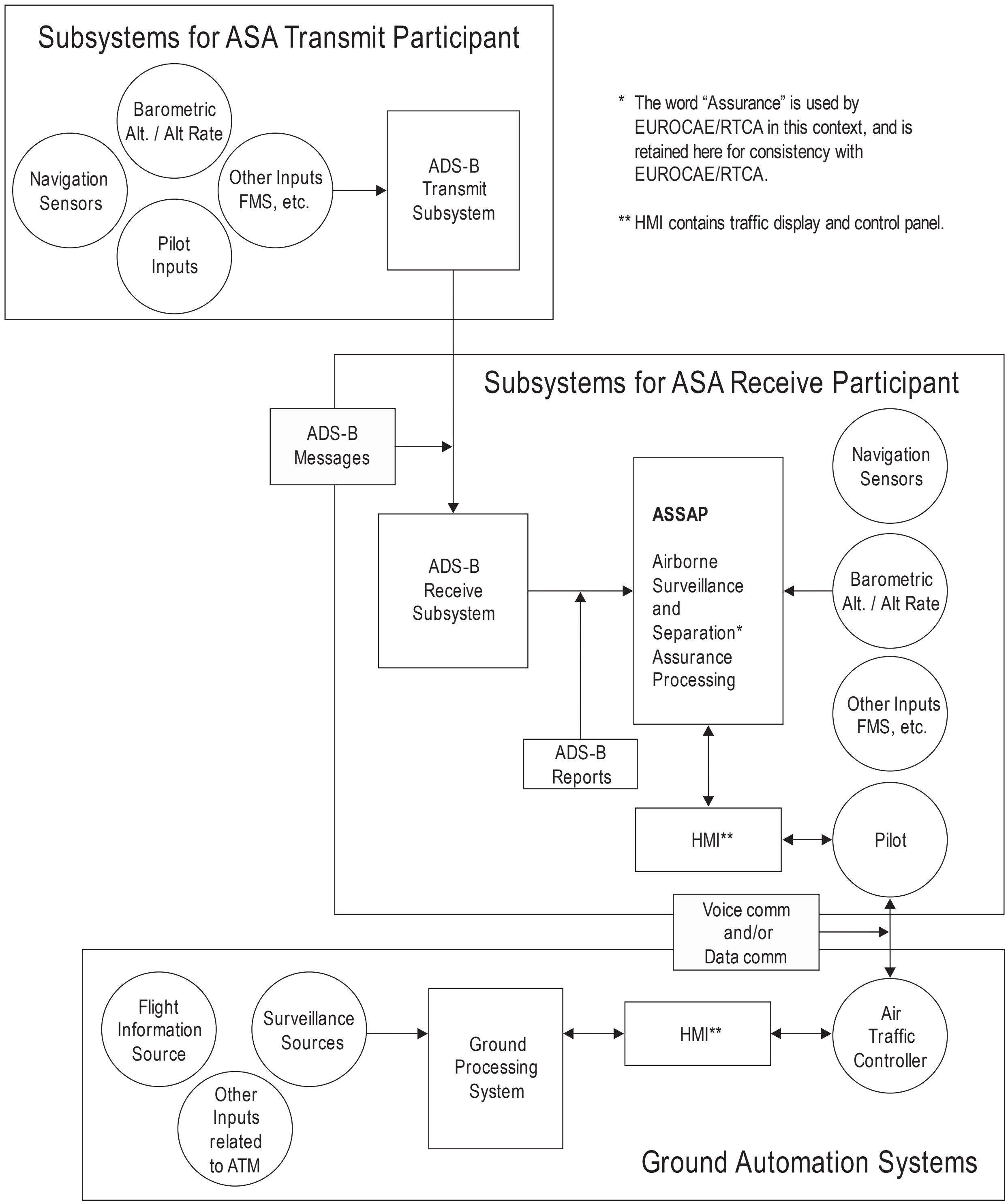

Figure 4-1.   IM functional diagram

4.10.2 According to validation outcomes reported by the European Union, Japan and United States research groups, IM operation appear to:

a) improve time-spacing performance between IM and its target aircraft, which contribute to increased runway throughputs;

b) be feasible for flight crew and air traffic controllers using automated support tools;

c) deliver safe operation under experimental environments in real operations; and

d) contribute ecologically-friendly airline operation by reducing fuel consumption.

4.10.3 Toward IM implementation, validation outcomes suggest further work on the:

a) ground automation tools, which support appropriate traffic pre-conditioning and sharing on-board IM status (e.g. with the use of extended arrival managers); and

b) operational procedures, which simplify air-ground communication under high-density and non-nominal operations for air traffic controllers and pilots.

Chapter 5

ADVANCED APPLICATIONS

5.1 DESCRIPTION OF ADVANCED AIRBORNE SURVEILLANCE APPLICATIONS (ASA)

Note.— This section provides descriptive material on ASA for which some development work has been done and one or more of these applications may be included in future ADS-B IN avionics standards.

5.1.1 Enhanced traffic situational awareness on the airport surface with indications and alerts (SURF-IA)

5.1.1.1 The SURF-IA application is intended to decrease the likelihood of runway incursions and collisions on or near the airport surface by:

a) increasing pilot awareness of runway traffic information; and

b) increasing the number of timely and correct responses by the pilot.

5.1.1.2 The SURF-IA application adds two distinct components to the SURF application:

a) SURF-IA indications, which are provided for normal operational situations where potential collision hazard exists; and

b) SURF-IA alerts, which are provided for non-normal operational situations where collision hazard exists.

5.1.1.3 Under normal operational conditions, in order to improve situational awareness beyond the traffic information on display, SURF-IA indications identify the runway traffic status and traffic as relevant to own aircraft operations. There are two types of indications triggered as follows:

a) runway status indications (RSIs) are provided if the pilot should verify runway status prior to proceeding. A collision hazard could result if own aircraft were to enter a runway with an RSI, takeoff when own aircraft is in position and hold on a runway with an RSI, or land when own aircraft is lined up on approach for a runway with an RSI. The reasons for the RSI are required to be evident for the information shown on the display. The absence of an RSI does not alleviate pilots from verifying the runway status prior to proceeding; and

b) traffic indications are provided if there could be a collision hazard in the immediate future. Traffic indications increase the pilot's situational awareness about traffic of interest that could affect runway safety.

5.1.1.4 SURF-IA indications are expected to have the greatest benefits in the proximity of a runway while approaching, entering, crossing or holding on a runway.

5.1.1.5 SURF-IA alerts are intended to draw the pilot's attention to the traffic situation depicted on the traffic display and by doing so help prevent collisions between two aircraft or an aircraft and a vehicle. SURF-IA includes two alert levels:

a) cautions which require immediate pilot awareness and require subsequent pilot response. The pilot may not respond to the caution by a compensatory action; they may, for example, search for additional information; and

b) warnings which require immediate pilot awareness and immediate pilot response.

5.1.1.6 SURF-IA alerts are also expected to have benefits in the early stages of a take-off or late in the approach or landing when pilot attention is focused more out the window and therefore are less likely to observe the traffic display or any indications.

Note.— Runway incursions would be detected with SURF-IA and provide essential safety benefits in such hazardous situations.

5.1.1.7 Current phraseology is expected to be used for the SURF-IA operations.

5.1.1.8 Air traffic controller procedures and responsibilities will not change with the SURF-IA application. Furthermore, no changes in the basic responsibilities for pilots are required.

5.1.1.9 The pilot may scan their display for SURF-IA indications or alerts at any time during surface operations as deemed safe by the pilot (e.g. crossing a runway, prior to initiating the take-off roll, etc.).

5.1.1.10 SURF-IA indications are supplemental information to visual information which is the primary means of navigation. After a caution alert occurs, the pilot uses all available information including radio communication, visual contact and the SURF-IA display to quickly assess the situation, determine the safety risk and appropriate action, and if necessary, initiate the appropriate response. After a warning alert, the pilot responds immediately to the warning as specified by their approved procedures or flight manual while still considering the overall safety of the situation.

Note.— These alerts are not directive.

5.1.1.11 SURF-IA Safety, Performance and Interoperability Requirements document (RTCA DO-323) was published by RTCA in 2010. Before progressing further towards implementation, a few issues to be resolved have been identified, including quality of ADS-B OUT position reports for the SURF-IA application in some airport configurations.

— END —

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