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MINIMUM AVIATION SYSTEM PERFORMANCE STANDARD ON ATN-IPS END-TO-END INTEROPERABILITY AND CERTIFICATION

RTCA DO-404
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Prepared by: SC-223
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FOREWORD

This document was prepared by Special Committee 223 (SC-223) and approved by the RTCA Program Management Committee (PMC) on September 21, 2023. The work was joint with EUROCAE Working Group 108 (WG-108) and was approved by the EUROCA Council on the same date.

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

- developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of minimum operational performance standards for electronic systems and equipment that support aviation; and

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

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1 PURPOSE AND SCOPE

1.1 PURPOSE AND SCOPE OF THE MASPS

This document contains Minimum Aviation System Performance Standards (MASPS) for Aeronautical Telecommunications Network, Internet Protocol Suite (ATN/IPS). ATN/IPS is fully defined operationally in the Operational Services and Environment Definition (OSED) which is included as Annex A.

This IPS MASPS specifies system characteristics, IPS is composed of several individual components, which are implemented in the aircraft as well as part of the ground infrastructure. This MASPS **should** be useful to designers, manufacturers, installers, service providers and users of systems.

Compliance with this standard is recommended as one means of ensuring that the IPS system and each of its subsystem will perform its intended function(s) satisfactorily under all conditions normally encountered in routine aeronautical operations for the environments intended. One potential use of this MASPS is to support early ATN/IPS development and prototyping. Additionally, the MASPS may be invoked by one or more regulatory documents and/or advisory documents (e.g., certifications, authorizations, approvals, commissioning, advisory circulars, notices, etc.) and may be implemented in part or in total. Any regulatory application of this document is the sole responsibility of appropriate governmental agencies.

1.2 SCOPE OF THE DOCUMENT

As Internet Protocol (IP) standards mature and current communication technologies are upgraded or new systems are developed, a move to IP-based communication becomes a more viable and attractive alternative to existing technologies. Enterprises can begin to leverage the benefits stemming from a unified IP based communications strategy including greater network flexibility due to better scalability, lower life-cycle costs and ultimately better performance.

The Aviation Industry’s planned end-state has recently been identified as one based on the ATN/IPS standards. ICAO has planned to adopt the IPS standards for future aeronautical datalink communications to enable seamless, broadband, end-to-end communications supporting all of the aviation ecosystem.

ICAO CP has directed that the ICAO Doc. 9896 Edition 2 (2015) be updated to complete the air-ground IPS requirements and RTCA requested to develop the corresponding A-G IPS Profiles and Minimum Aviation System Performance Specification (MASPS) documents in RTCA Special Committee 223. All future FAA Aviation systems, including System Wide Information Management (SWIM) and Unmanned Aircraft System (UAS) Command & Control (C2) Beyond Radio Line-of-sight (BRLOS) networks, can then be designed and developed leveraging these new communication standards to enable more effective and efficient sharing of data.

For a coordinated ATN/IPS deployment between US and Europe, EUROCAE also created WG-108 to provide a guidance document for ATN/IPS certification and deployment in Europe.

Following the two initiatives described above, RTCA SC-223 and EUROCAE WG-108 decided to work together on joint deliverables to ensure IPS consistency over US and EUROPE. The joint group has developed:

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- IPS MASPS on IPS end-to-end deployment and certification,
- IPS Profiles.

Based on the scope defined in the MASPS, the IPS profiles will leverage the IETF RFCs and their updates. However, aviation specific requirements will be addressed in the detailed profile.

The Scope and objectives of work undertaken by SC-223 and WG-108 for the IPS Profiles and MASPS include:

- SCOPE
  - Describe the IPS operational environment (OSED/CONOPS)
  - Safety assessment for IPS operations
  - Security assessment for IPS operations
  - Security operations (SecOps)
  - Allocate security requirements to IPS subsystems
  - Allocate safety requirements to IPS subsystems
  - Allocate performance requirements (QoS, availability, reliability) to IPS subsystems
  - Allocate functional requirements to IPS subsystems
  - Specify the validation mechanism
- OBJECTIVE
  - Enable FAA/EASA to approve IPS system implementations (both aircraft and ground)
  - Support continuous operational safety with a reliable network
  - MASPS and Profiles requirements validation and verification
  - Assure end-to-end interoperability
  - Provide guidance for transition of applications, services and legacy aviation networks to IPS
  - Provide guidance on regional implementation constraints.

1.2.1 Internet Protocol Suite Overview

The IPS system has adopted the same four-layer model as defined in Internet Society (ISOC) internet standard STD003. This standard consists of a combination of transport and network layer functionalities as described in the Internet Standards RFC 1122 and RFC 1123. The high-level IPS protocol architecture is shown in Figure 1-1.

The IPS scope includes the transport layer and network layers as well as supporting functional elements including dialogue service specification, application interfaces, mobility, multilink, security, firewall, monitoring, logging, and other aspects that are necessary for end-to-end operation. These aspects are specified in ICAO Doc. 9896 and ARINC 858 Part 1, Airborne IPS System Technical Requirements. The IPS scope also includes ground gateways for transition, which accommodate end systems that use different protocols (e.g. OSI and ACARS). This is described more in-depth in ARINC 858 Part 2, IPS Gateway Air-Ground Interoperability.

ARINC 858 Part 3, Common IPS Radio Interface protocol specification, then defines a protocol for conveying radio status information and for transferring digital data between the Airborne IPS System and Airborne Radios.

The IPS system is also intended to support the Command and Control (C2) Link system for Unmanned Aircraft System (UAS). The RTCA DO-377A contains the UAS C2 Link System specification. For the purposes of this MASPS, only the UAS classes that operate or intersect Controlled Air Space and are required to communicate with Air Traffic Control are addressed. UAS classes that only operate in uncontrolled airspace are not specifically addressed but are not precluded to use IPS for their C2 Link System communications.

Note: Using IPS in an uncontrolled airspace means using IPS protocols and standards in a custom operational environment different from controlled aviation networks.

Although the current version of this MASPS does not specifically address the operational use cases for air/ground System Wide Information Management (A/G SWIM), use of IPS to offer A/G SWIM is not precluded.

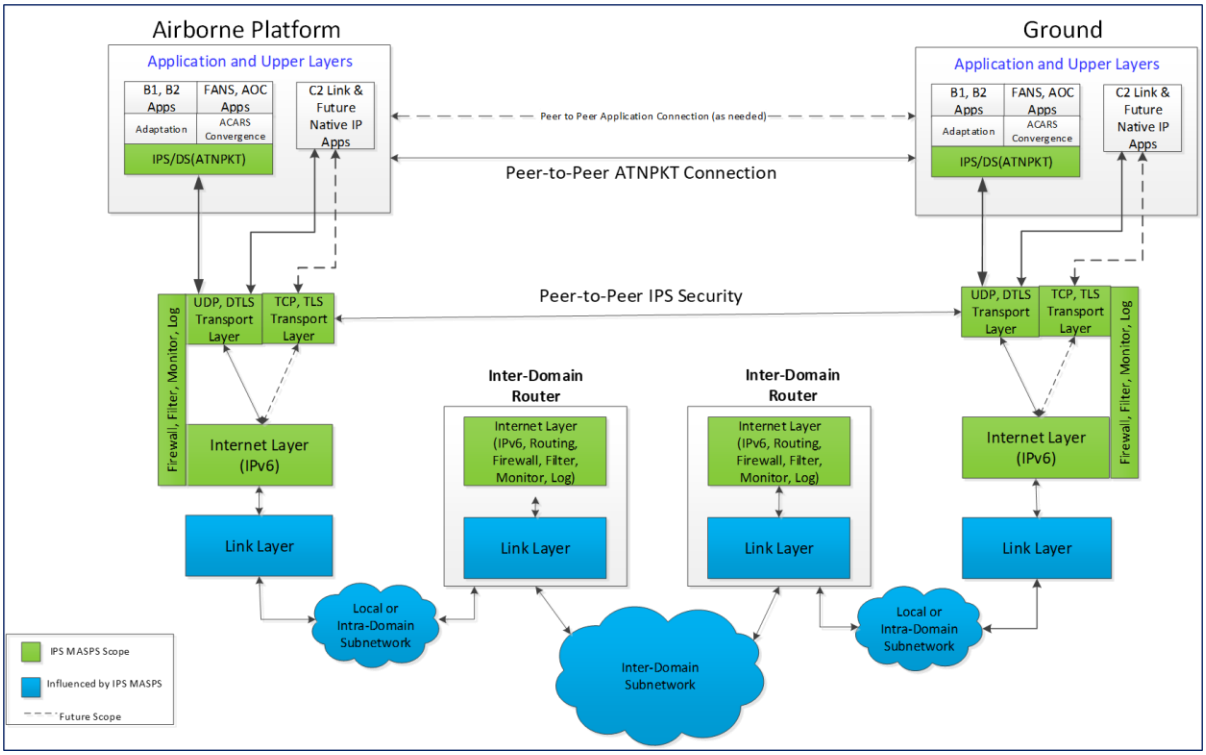


Figure 1-1: IPS Protocol Architecture

Note: "Airborne Platform" in the Figure is a generic representation, which could be a piloted or unmanned aircraft. The functions shown inside the 'Airborne Platform' or 'Ground' represent different configuration and transition options, which may not be implemented on the same aircraft. For example, an air transport (AT) aircraft will not implement the C2 link capabilities.

The IPS protocol architecture diagram with its major functions for the airborne and ground subsystems is shown in Figure 1-1. The items in the figure related to IPS are coloured green if they are within the IPS MASPS scope, blue if they are influenced by the IPS MASPS, or uncoloured if they are ancillary to the IPS system but make use of IPS.

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As implied in the paragraphs above, the IPS System encompasses both airborne and ground entities that provide the network, transport and upper layer communication protocols and supporting functional elements, except the underlying subnetworks. Therefore, when “IPS System” is mentioned in the remainder of this document, then the associated context applies to all systems that participate in the network, transport and upper layer information exchanges between one or more application entities. When it is necessary to differentiate the capabilities between airborne or ground, then either “Airborne IPS System” or “Ground IPS System” is used to specifically identify the target entity.

The IPS System provides two standardized interfaces to the upper layer protocols. The IPS Dialogue Services (DS) supports ATN, FANS and AOC applications as defined in ICAO Doc. 9896 and ARINC 858 Part 1. Future native IPS safety service applications can also be supported by IPS, which allows future growth and accommodation of UAS, SWIM and other services that will be able to take advantage of the IPS infrastructure and protocols. These future applications may make use of other transport mechanisms (e.g. TCP, UDP, etc) instead of the IPS DS.

Native AOC applications can also use alternative approaches to directly connect to IPS DTLS, UDP, TCP, etc.

This gives maximum flexibility and allows future applications to move beyond legacy dialogue service-type interfaces.

The subnetwork interface of the IPS system is not a full specification. Instead, it consists of a few requirements imposed on the subnetwork, or access network, tensure a minimum set of parameters and signaling are supported by the subnetworks to meet the IPS quality of service. Details of this interface are left open for implementation to accommodate current and future access networks. The supported IPS access networks include current and proposed aeronautical datalinks, specifically, Aeronautical Mobile Airport Communication System (AeroMACS), INMARSAT and IRIDIUM Class B and future Class A SATCOM, L-band Digital Aeronautical Communications System (LDACS) and Very High Frequency (VHF) Digital Link (VDL) Mode 2. In addition, other access networks may be supported assuming they are approved by regulators for safety communications. The IPS system interfaces are shown in Figure 1-2, which only depicts one side of the IPS protocol functions, that could be a representation of either the airborne or the ground IPS system.

The core IPS network layer functions include Internet Engineering Task Force (IETF) standard IPv6 network layer and support functions such as addressing, naming, routing and relaying. Mobility and multilink, which are aeronautical specific functions of the IPS network, are also supported.

It is anticipated that future aeronautical communication systems will implement multi-layer security, typically consisting of end-to-end security implemented at the transport layer and access network layer security to protect the air/ground subnetwork link. IPS includes an additional security function to protect the control flows.

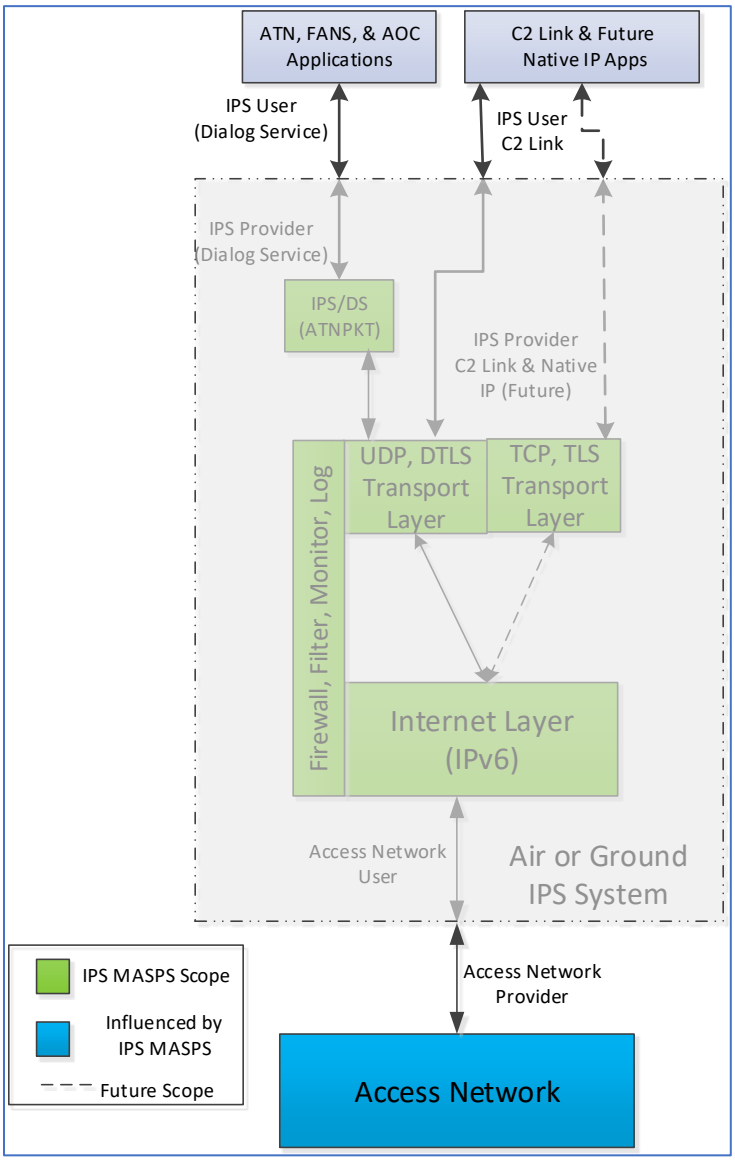


Figure 1-2: IPS System Interface Diagram

Note 1: *IPS System User is an application entity that invokes the services of the IPS System to exchange information with its corresponding peer application entity. An IPS System User could be an IPS Dialogue Service User that supports ATN, FANS or AOC applications as specified in the ICAO Doc. 9896. An IPS System User could also be a native Internet Protocol application.*

Note 2: *IPS System provider is the IPS functional entity that offers a set of IPS communication services to its corresponding IPS System User to facilitate the exchange of information. An IPS System provider could be an IPS Dialogue Service Provider supporting ATN, FANS or AOC applications as specified in the ICAO Doc. 9896. An IPS System Provider could also be a native Internet transport or session layer protocol.*

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Note 3: *The functional diagram in Figure 1-1 is for illustration purposes. Some IPS System protocols, such as transport, can be embedded in the Native IPS application to provide implementation flexibility.*

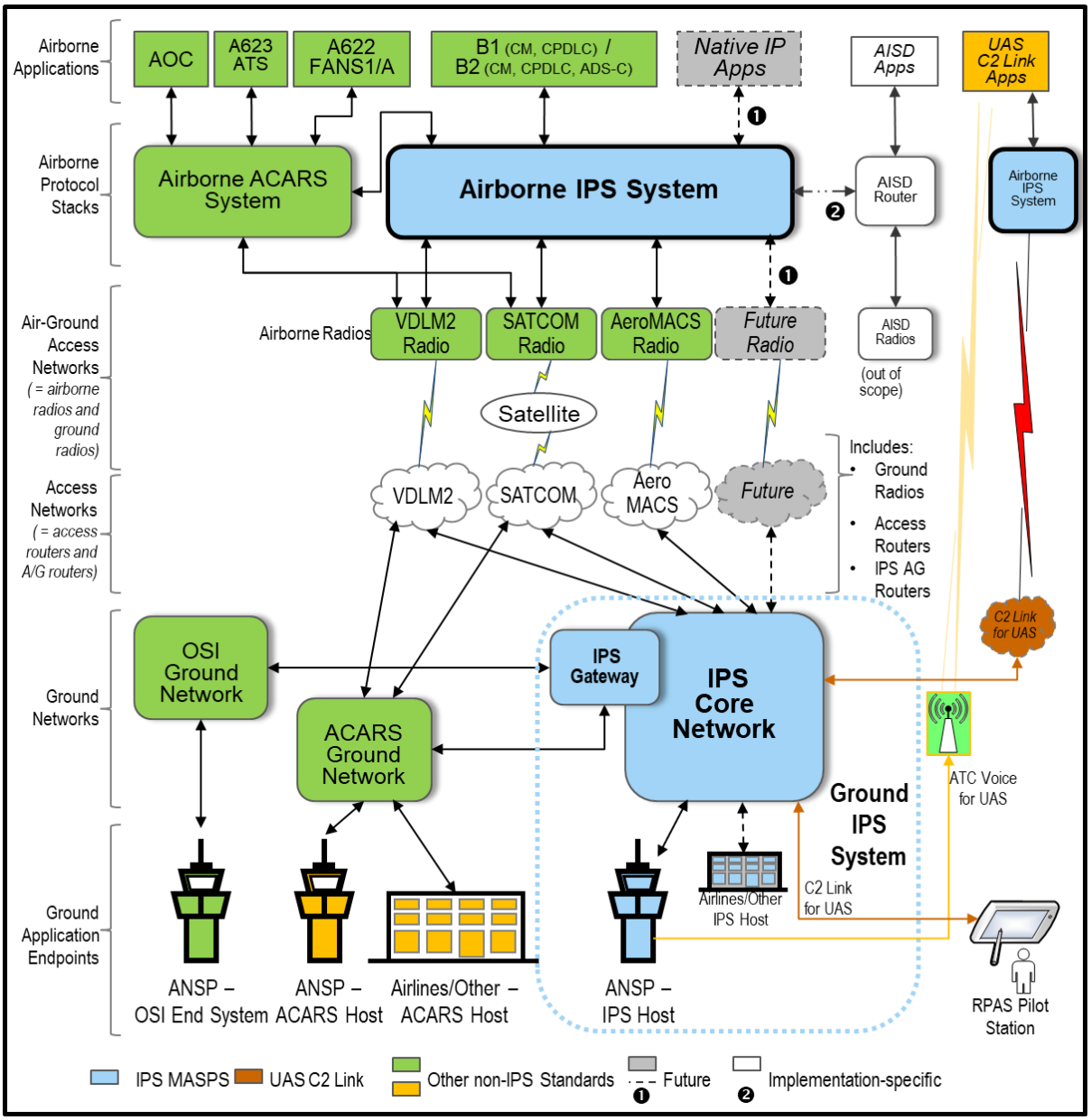


Figure 1-3: IPS Context Diagram

Note 1: *In the figure above, Only ACARS and IPS Systems are described as it is expected that the Aircraft will not implement the three stacks (ACARS, ATN/IPS and ATN/OSI). However, an OSI ground End System will be able to communicate with an IPS aircraft through the IPS Gateway as shown in the figure.*

Note 2: The figure above does not show how an OSI aircraft can operate in the IPS environment but this case will be covered by the transition/deployment section and is also described in ARINC 858 Part 2.

Note 3: In the figure above, it is assumed that a link between FANS 1/A and IPS host on ground is not likely to happen and the gateway will take care of the protocol translation between ACARS and ATN/IPS.

Note 4: The figure above is similar to a figure provided to AEEC and published in ARINC 858 Part 1. The figure has been updated for this MASPS.

1.3 STRUCTURE OF THE DOCUMENT

Section 1 (the current section) provides an explanation of the scope and purpose of this document and introduces ATN/IPS.

Section 2 describes the approach and methodology aspects applied for the development of ATN/IPS and outlines the performance and interoperability assessments made in this document.

Section 3 describes the system requirements including operational, performance, safety, and security requirements. for the ATN/IPS based upon the detailed specification of the OSED and related appendixes. Enhanced system performance requirements (those beyond the minimum requirements) may be included in a non-normative appendix for guidance. The Section also contains the minimum performance standards for each subsystem/function that is a required element of minimum system performance. These standards specify the required performance under the standard environmental conditions of the OSED. The Section also includes the key assumptions made for ATN/IPS.

Section 4 introduces the Interoperability Requirements applicable to ATN/IPS.

Section 5 describes the means to verify system/application performance (e.g., end-to-end performance verification) and the means to meeting the minimum performance requirements in Section 3 and Section 4. These means **should** be particularly helpful in prototyping and preoperational trials of the system/application. Section 5 also includes guidance on the methods and tools to validate IPS Systems.

Annex A is providing the Operational Services and Environment Definition (OSED) for ATN/IPS. This does not cover OSED for the applications and services that are already defined in other specification documents.

Annex B is RESERVED FOR FUTURE USE.

Annex C is providing the CONOPS for ATN/IPS.

Annex D is providing the key terms used in this document.

Annex E is providing the summary of requirements defined in this document.

1.4 RELATIONSHIP TO OTHER INDUSTRY DOCUMENTS

1.4.1 IPS Standards Guidance for Implementers

The avionics systems implementers must follow the Advisory Circulars (AC) published by the regulatory authorities to obtain system-level airworthiness certification. The AC typically references the RTCA/EUROCAE MASPS for functional, protocol and performance requirements as well as for specific verification methods defined in the

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MASPS to demonstrate requirements compliance. It is expected that the regulatory agencies will invoke the IPS MASPS for avionics certification. The IPS Profiles (DO-379/ED-262) document contains the IETF Request For Comment (RFC) specifications, profiled for aviation use. The objective of the aviation profile is to ensure consistent implementation of the IPS for global interoperability and uniform performance. The IPS Profiles are referenced by the IPS MASPS, thereby are also required for avionics certification.

The functional and interoperability requirements specified in the MASPS and the Profiles are derived from the high-level IPS requirements specified in the ICAO Annex 10, Standards and Recommended Practices (SARPs) and its subordinate Technical Manual, ICAO Doc.9896, Edition 3. The ICAO SARPs are the governing agreements at the national level, signed by the States to ensure uniform, interoperable air-traffic safety services around the World. Therefore, IPS implementers are expected to comply with the requirements specified in the ICAO IPS SARPs and the ICAO Doc. 9896, Edition 3. In addition, the implementers may also satisfy the IPS certificate policy and cyber security governance requirements specified in forthcoming ICAO Doc. 10090 and ICAO Doc. 10095.

Finally, the IPS avionics implementers also may follow the ARINC 858 Part 1, which specifies the avionics form, fit, interface and key management functional requirements.

In addition to the avionics specifications, the ICAO Doc. 9896 Edition 3, and this RTCA/EUROCAE MASPS provide requirements and guidance for the ground system implementers. Legacy system to IPS transition guidance is also provided in the ICAO Doc. 9896 Edition 3, RTCA/EUROCAE MASPS and the ARINC 858 documents. The hierarchy and inter-dependencies of the IPS industry standards and the flow of technical content across those documents are shown in Figure 1-4 while brief descriptions of the relevant industry standards are provided in the following sub-sections.

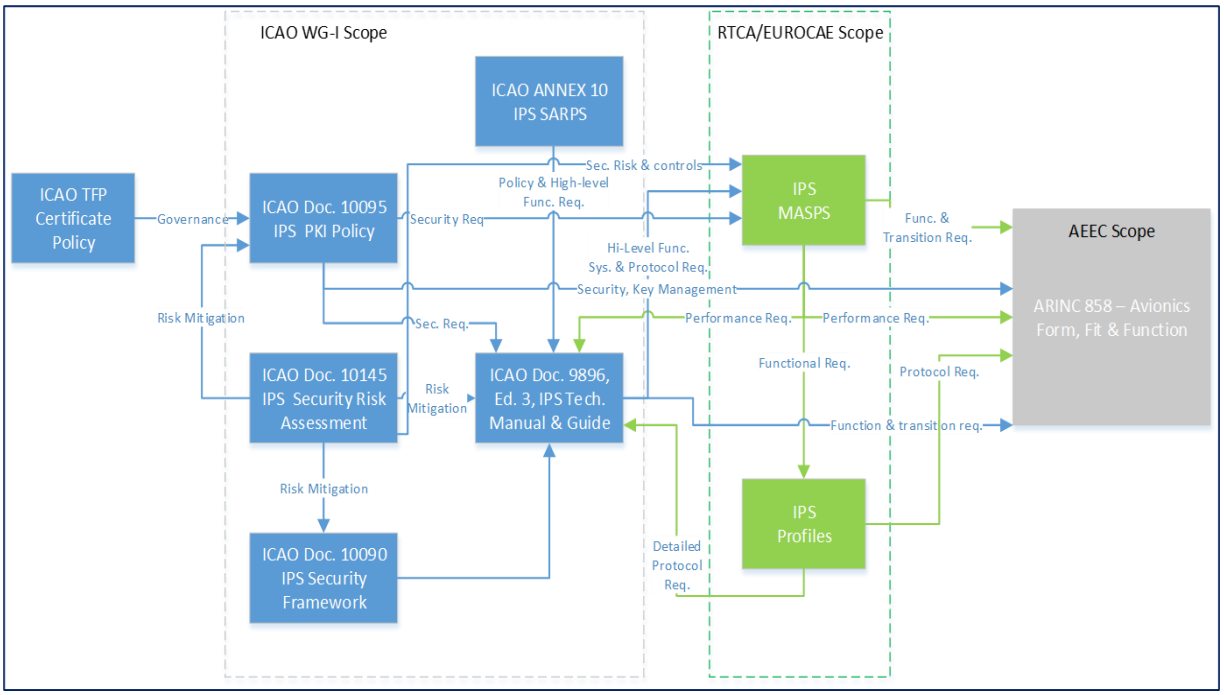


Figure 1-4: Relationship of IPS Industry Standards

1.4.1.1 ICAO Standards

1.4.1.1.1 ICAO Annex 10 Aeronautical Telecommunications, Volume III, Part I, Chapter 3 (ATN)

Standards and Recommended Practices (SARPs) that define the minimum required protocols and services that will enable the global implementation of the aeronautical telecommunication network (ATN). It contains the highest-level requirements referring to applicable policies and required functionality to achieve prescribed performance in a safe and secure manner.

1.4.1.1.2 ICAO DOC. 9896 - Manual on the Aeronautical Telecommunication Network (ATN) using Internet Protocol Suite (IPS) Standards and Protocol

Supplements ICAO Standards and Recommended Practices (SARPs) by defining the data communications protocols and services to be used for implementing the ATN/IPS. It provides functional requirements and contains technical specifications and guidance for ATN/IPS applications.

1.4.1.1.3 ICAO DOC 10090: Manual of Security Services for Aeronautical Communications

Defines the rules governing the protection of ATN data, services and resources associated with ATN applications and processes from both unintentional defects and deliberate attack.

1.4.1.1.4 ICAO DOC 10095: Manual of Public Key Infrastructure (PKI) Policy for Aeronautical Communication

Identifies a set of security controls and practices to support the secure issuance of certificates for ATN/IPS. It contains the ATN/IPS Certificate Profiles and applicable Certificate Policy.

1.4.1.1.5 ICAO DOC 10145: Manual of Security Risk Assessment for Aeronautical Communications.

It contains a high-level security risk assessment for ATN/IPS. Identifies security controls and security requirements to be addressed by other documents.

1.4.1.2 RTCA / EUROCAE Standards

1.4.1.2.1 DO-379 / ED-262: Internet Protocol Suite Profiles

The IPS Profiles document specifies the unique adaptations required to enable use of the current IETF RFC documents as technical requirements for aeronautical data communications. The Profiles document only covers RFCs that are mandatory for IPS.

IPS may also interoperate with other public communication systems that are specified in IEEE 802 series of standards, or the Internet RFCs or cellular specifications developed by the 3rd Generation Partnership Project (3GPP). As IPS system deployments span over the next few decades, it is possible that additional communication system specifications will be introduced over the lifetime of IPS. This section is not intended to provide an exhaustive list of all possible standards and specifications that will be relevant for the deployment and operation of the IPS. Instead, this section is intended to alert the implementer and the regulatory approver of the IPS to identify and apply the standards necessary for its operational context.

1.4.1.2.2 Other RTCA/EUROCAE Standards

As shown in Figure 1-3, IPS Context Diagram, IPS interfaces with various applications and access subnetworks to provide the required end-to-end communication capabilities. Some

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of those applications are aviation specific, which are defined in aviation standards such as RTCA/EUROCAE DO-280A/ED-110, DO-324/ED-175, DO-350()/ED-228(), DO-351A/ED-229A, DO-352A/ED-230A, DO-353/ED-231 and DO-377A.

Similarly, the access subnetworks are specified in industry standards such as RTCA/EUROCAE DO-224, DO-231, DO-262/ED-243, DO-346/ED-223, etc. It may be Noted that the subnetwork standards may evolve over time to become compliant with the ATN/IPS requirements and later revisions of these standards may have to be applied.

1.4.1.3 AEEC Standards

1.4.1.3.1 ARINC Specification 858: IPS for Aeronautical Safety Services, Part 1, Airborne IPS System Technical Requirements

This document serves as an ARINC Standard to define the IPS avionics architecture, functions, and interfaces, and to describe implementation options and constraints as well as high level details regarding the accommodation of different applications utilizing IPS as the network transport mechanism.

1.4.1.3.2 ARINC Specification 858: IPS for Aeronautical Safety Services, Part 2, IPS Gateway Air-Ground Interoperability

This document serves as an ARINC Standard to define IPS Gateway functional requirements and provide an overview of its performance and safety considerations. It further describes the principles of operation for air-ground communication between IPS Hosts and ACARS or ATN/OSI End Systems via the IPS Gateway.

1.4.1.3.3 Other AEEC Standards

The primary IPS applications are aviation specific, these are defined in aviation standards such as ARINC Specifications such as 619, 620, 622, 623, etc.

This document uses shorthand references to other documents. The references and full identification of the applicable documents are as given below. The reference documents of the exact date and issue, including the indicated changes, apply unless otherwise Noted.

Table 1-1: Reference Documents

Identifier	Revision	Title
ICAO Doc. 9896	Forthcoming 3rd edition1	Manual for the Aeronautical Telecommunication Network (ATN) using Internet Protocol Suite (IPS) Standards and Protocols
ICAO Doc. 10095	Forthcoming	Manual of Public Key Infrastructure (PKI) Policy for Aeronautical Communications
ICAO Doc. 10090	Forthcoming	Security Services for Aeronautical Communications
ICAO Doc. 10145	Forthcoming	Security Risk Assessment for Aeronautical Communications
ICAO Doc. 9869	2nd Edition, 2017	Performance-based Communication and Surveillance (PBCS) Manual
ICAO Annex 10, Volume III	7th Edition, July 2018	Aeronautical Telecommunications – Communication Systems
ED-262/DO-379		Aviation Profiles for Internet Protocol Suite

[1] The authors of this MASPS are aware of the efforts to update the ICAO documents listed in Table 1-1 and discussed throughout this document. The information contained in the MASPS is consistent with material expected to be contained ifuturICAO publication.

Identifier	Revision	Title
ED-228B/DO-350B		Safety and Performance Requirements Standard for Baseline 2 ATS Data Communications (Baseline 2 SPR Standard)
ED-202A/DO-326A		Airworthiness Security Process Specification
ED-203A/DO-356A		Airworthiness Security Methods and Considerations.
ED-204A/DO-355A		Information Security Guidance for Continuing Airworthiness
ED-205A/ DO-393		Process Standard for Security Certification and Declaration of ATM ANS Ground Systems
ARINC 858 Part 1()		Internet Protocol Suite (IPS) for Aeronautical Safety Services, Part 1, Airborne IPS System Technical Requirements
ARINC 858 Part 2()		Internet Protocol Suite (IPS) for Aeronautical Safety Services, Part 2, IPS Gateway Air-Ground Interoperability
ARINC 620()		Datalink Ground System Standard and Interface Specification (DGSS/IS)
DO-377A		Minimum Aviation System Performance Standards for C2 Link Systems Supporting Operations of Unmanned Aircraft Systems in U.S. Airspace
ED-201A/DO-391		Aeronautical Information System Security (AISS) Framework Guidance
ED-85A		Data-Link Application System Document (DLASD) for the "Departure Clearance" data-link service
ED-89A		Data-Link Application System Document (DLASD) for the "ATIS" data-link service
ED-106A		Data-Link Application System Document (DLASD) for the "Oceanic Clearance" data-link service
ED-175/DO-324		AISMET SPR

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