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# Introduction (BOEING)

## Purpose

It is generally agreed by aviation stakeholders that the future aviation network communication infrastructure will be based on selected commercial Internet Protocol (IP) standards. This future aviation communication network has been referred to in ICAO as ATN/IPS[[1]](#footnote-1) (Aeronautical Telecommunication Network/Internet Protocol Suite) and is considered as the successor in the long term of the previously defined ICAO network infrastructure based on the Open Systems Interconnection (OSI) model and referred to as ATN/OSI. The ATN/IPS network will be implemented onboard an aircraft and the ground infrastructure to support safety related services, including Air Traffic Services (ATS) and Aeronautical Operational Control (AOC) that often operate over the Airline Communication and Reporting System (ACARS).

Therefore, the Airlines Electronic Engineering Committee (AEEC) has initiated the development of the required avionics standards to support ATN/IPS. AEEC has acknowledged that ATN/IPS standards development is complex and it needs to be coordinated with other organizations such as ICAO, EUROCAE and RTCA. Furthermore, the exact scope and the potential impact on aircraft communication functions, such as applications and communication media, need to be understood. In addition, there may be interdependencies with related industry standards and those that need to be developed by other organizations.

Therefore, the AEEC has agreed to proceed in two steps for the development of the ATN/IPS avionics standards.

The first step was the analysis and capture of the high-level user requirements for ATN/IPS focusing on the airline, but also considering when possible the ground users (ANSPs), requirements, investigating what is needed for ATN/IPS standardization for aviation, considering the current and/or expected plans of the other standardization organizations, and focusing in identifying what exactly needs to be developed by AEEC for ATN/IPS. The outcome of this first step was a detailed plan for the work to be carried out by AEEC in the second step defining also the perimeter of the necessary ARINC Standards for ATN/IPS, as well as general recommendations for the general ATN/IPS standardization work that is required in aviation. The recommendations will be a valuable input/feedback to the ATN/IPS standardization groups in ICAO, EUROCAE, and RTCA.

## This document represents the second step of the aforementioned process, which is the execution of the recommendations coming out of the Step 1 work in relation to the effort to develop ARINC Standards for ATN/IPS.Scope

This document serves as an ARINC Standard to define the avionics architecture, functions, and an IPS profile that describes implementation options and constraints as well as higher level details regarding the accommodation of different applications. The scope of this standard will correspond to the Communications Management Unit (CMU) (or equivalent avionics). This will include, as necessary, other systems that interface and interoperate with the CMU or equivalent function.

This document also covers the necessary end-to-end context of ATN/IPS, as it is recognized that some of the requirements that are levied on the aircraft will also require similar requirements on the peer ground side. This needs to take different aspects of the potential ground side into account, including deployment options and architectures, transition phases, security, and other aspects. Therefore, ground requirements and considerations are also captured in this document.

The intent of this document, in coordination with other related industry standards, is to provide the level of detail necessary to achieve ATN/IPS standardization.

## Relationships to other Standards Activities and Documents

It is recognized that the ATN/IPS as whole represents a broad range of functions and components. These necessarily span many different standards development organizations. Phase 1 of the ATN/IPS standardization activity produced the ARINC Report 658: Internet Protocol Suite (IPS) for Aeronautical Safety Services – Roadmap Document (A658). Within this document is a discussion of other related standards organizations that impact or are impacted by ATN/IPS. These groups will need to have a continued dialog to ensure that work scopes are adjusted as appropriate to accommodate ATN/IPS-related items. This coordination will be an on-going activity, and will include other AEEC, RTCA and ICAO groups. The A658 document sections will updated to reflect the latest work divisions, gap analysis, and other related coordination information.

This document as well as relevant documents from other SDOs are expected to be based upon and coordinated with updated versions of the ICAO Document 9896, which defines the agreements in ICAO for ATN/IPS, and on prevalent commercial IP network technology (e.g., IETF RFC 2460 for IPv6) with the modifications necessary to support aeronautical safety services.

## Document Organization

This document is generally organized in six sections as follows:

* Section 1 – Introduction

This section ….

* Section 2 – ATN/IPS Overall Architecture

This section ….

* Section 3 – ATN/IPS Airborne Architecture

This section ….

* Section 4 – Security

This section ….

* Section 5 – ATN/IPS Airborne Implementation Options

This section ….

* Section 6 – Airborne Application Data Considerations

This section ….

* Attachment 1 – List of Acronyms

This attachment provides a list of acronyms used in the report.

* Attachment 2 – Glossary

This attachment explains the precise meaning of terms used in this report to avoid ambiguity and confusions.

* Appendix A – ATN/IPS Ground Architecture Considerations

This appendix ….

* Appendix B – Airbus Profiles

This appendix ….

* Appendix C – Boeing Profiles

This appendix ….

# ATN/IPS OVERALL ARCHITECTURE (TH)

Overall E2E Architecture diagram / description

## Assumptions and Constraints

Including the ground segment, more details in Appendix.

# ATN/IPS AIRBORNE ARCHITECTURE (HONEYWELL)

## Architecture Overview (TH)

This section provides an overview of the ATN/IPS system architecture. It considers the boundary of the system, its relationship to applications and equipment external to the system, and the protocols and interfaces presented by the system to other parts of the aircraft avionics.

This section also considers and defines the core functions that define the behavior of the system in relation to existing and future applications’ data. Some of these core functions are standardized by other bodies and are described here in relation to those standards. Other core functions are described and standardized within this document.

Functions that are part of the IPS system but are not core to its operation are also described here. The realization of these functions may be implementation specific however their behavior is described here and some of this functionality shall be subject to standardization within this document.

Key issues / questions:

* The context diagram used in ARINC 658 will need to be modified probably in order to be aligned with the following list of the core functions
* Some of the core functions need to be defined accurately in order to agree on their scope (e,g, QoS / priority, Compression, Segregation) and they will have to be inserted in the glossary (not present in ARINC 658)
* The redundancy aspects should be first discussed at this level and impact on the architecture (interfaces, comm management, …)

### Airborne Architecture Overview

(Context diagram – to be updated)



Figure 3- – ATN/IPS System Context Diagram – Avionics Perspective

### **ATN**/IPS System Functions

#### Application Adaptation

* ATN application adaptation
	+ Instance of the ATN/IPS DS provider (as specified in Doc 9896 Ed.2)
		- Assembly of the ATNPKT
		- UDP reliability mechanism
	+ Instance of the Secure Dialogue Service (SDS)
	+ Application-level compression
* FANS1/A application adaptation
	+ ??? (Possible reuse of ATNPKT, still evolving)
	+ ??? (Possible reuse of DS and SDS, still evolving)
	+ Application-level compression
* AOC application adaptation?
	+ ??? (Possible reuse of ATNPKT, still evolving)
	+ ??? (Possible reuse of DS and SDS, still evolving)
	+ Application-level compression

#### Core IPS Functions

##### UDP

Support for the existing, non-IPS applications requires the provision of a transport layer instance. ICAO 9896 specifies that nodes requiring a connectionless transport mechanism shall use UDP as defined in RFC 768. This function represents the transport layer in IPS. It should be noted that, although supported under ICAO 9896, TCP implementation is optional for nodes, and then only when they require a connection oriented transport service.

Transport layer port numbering for IPS services is defined under ICAO 9896.

*Author Note: If the application adaptation exists in the application space equipment, will the UDP/IP function also exist there? If it exists in the IPS System then what is the protocol between the application equipment and the IPS system?*

##### IPv6

The IPv6 function implements the IPv6 protocol defined by RFC 2460 and required by ICAO 9896. This function implements all the features of IPv6 required by ICAO 9896 and further defined by the profiles developed by RTCA SC-223.

##### ICMPv6

The ICMPv6 function defined in RFC4443 provides a network layer error reporting function which is required to support IPv6 features such as Path MTU Discovery. It also allows reachability of nodes to be determined by a sending node using the ICMP Echo (ping) command.

* + NS/NA, RS/RA,

##### Address acquisition

Although ICAO 9896 specifies the implementation methodology of the IPS addressing of equipment on the aircraft, the mechanisms whereby the aircraft obtains one or more addresses related to its current point of attachment to the ground network are still evolving and may depend on services provided by the local service provider. The method of address acquisition is discussed in detail in Section 3.2.5.

##### Policy based routing

The Policy Based Routing function exercises control over the main routing function and ensures predictable routing behavior based on configured policy. Policy may be based on one or more factors including traffic prioritization (indicated by the DSCP field of the IP header), source and/or destination address, transport layer port numbers, or other identifiable features of the traffic. This is covered in Section 3.2.5.3.

##### Routing

The routing function enacts the routing of data packets between the internal network and the external interfaces provided by the attached radios. The routing action is driven by the output of the Policy Based Routing function described above.

##### Prioritization

The queuing mechanism used to achieve this prioritization is discussed in detail in Section 3.2.3.

##### QoS

* + Traffic shaping mechanisms (in order not to overflow a given datalink)
	+ Definition of queuing mechanisms
	+ Flow control mechanisms (in case of a congested datalink)

##### Packet filter firewall

* + Filtering packets in an uplink direction (based on black/white lists provided by the configuration function)

##### VPN (TBD)

* + Network (IPSec) or transport (D/TLS) layer tunnel to a ground entity

##### Mobility signaling (TBD)

* + A signaling mechanism related to the ground based mobility solution – typically a mechanism providing: location announcement information; preferred priority of links in an uplink direction

##### A/G route monitoring (TBD)

* + A signaling mechanism monitoring the path from the router to a selected ground entity (TBD). The mechanism would provide a trustable information to the Airborne ATN/IPS system about the whole path (TBD), complementing the status information from the Airborne radios.

##### Compression (TBD)

* + Compression at the network layer (e.g. ROHC) or at the transport layer

#### Non-Core IPS Functions

* Comm Manager
	+ The “brain” performing the link selection decision based on the status of the datalinks (reported by airborne radios, and possibly the A/G route monitoring mechanism) and the state of the aircraft (e.g. flight phase, geographical position, etc.). It instantiates the decisions via the Policy based routing function.
	+ Synchronization/coordination with an External Comm Manager (TBD)
* Radio management
	+ A function monitoring the state of all datalinks (via status reports from the airborne radios) and monitoring the health of the airborne radios (i.e. it verifies that no reception of status changes of the datalinks is not caused by a non-operative radio).
* Airborne IPS system management
	+ Health monitoring of the Airborne IPS system and reporting to aircraft systems
	+ Security event secure storage, monitoring and reporting to aircraft systems (e.g. packet firewall blocking events, SDS data integrity mismatch, etc.)
* Airborne IPS configuration management
	+ Link selection policy configuration (e.g. priorities of links for given conditions)
	+ Packet filter firewall configuration (e.g. white lists/black lists)
	+ IP address related configuration (e.g. any static address assignments)
	+ Routing table configuration (possible static aspects of the routing/policy based routing)
* Redundancy support
	+ Functions supporting redundant implementations, like state date distribution (for hot redundancy) or master/slave decisions (cold/warm redundancy)
* Security management
	+ PKI functions
		- Management of keys used by the security-related functions, like SDS, security events secure storage or VPNs (TBD)
	+ Certificate management
		- Loading of the certificates used by the security-related functions, like SDS or VPNs(TBD), certificate revocation functions, …

#### Internal Interfaces

* Core ATN/IPS function ⬄ ATN application adaptation
	+ ATNPKT?/UDP datagram?/IPv6 packet?
	+ To be standardized elsewhere (TBD)
* Core ATN/IPS function ⬄ FANS 1/A application adaptation
	+ ATNPKT?/UDP datagram?/IPv6 packet?
	+ To be standardized elsewhere (TBD)
* Core ATN/IPS function ⬄ AOC application adaptation
	+ ATNPKT?/UDP datagram?/IPv6 packet?
* Other(?)
	+ Implementation specific(?)

### Interfaces to External Systems

* ATN applications ⬄ ATN application adaptation
	+ IPS DS
	+ To be standardized elsewhere
* FANS 1/A applications ⬄ FANS 1/A application adaptation
	+ TBD
	+ To be standardized elsewhere
* AOC applications ⬄ AOC application adaptation
	+ TBD
	+ To be standardized elsewhere
* Native IPS applications ⬄ Core ATN/IPS function
	+ ATNPKT?/UDP datagram?/IPv6 packet?
* Airborne radios ⬄ Core ATM/IPS function
	+ To be standardized elsewhere
* External Comm Manager ⬄ Comm Manager
	+ TBD
* Other(?)
	+ Implementation specific(?)

### Redundancy Considerations

## ATN/IPS Core Functions (HW)

### Applications Adaptation (BOEING)

DS and application layer interface; generic interface. Additional details in Section 6 for the data and Section 3.4.1 for the interface.

* B1/B2
* ACARS / FANS
* DS-based and non-DS based interfaces

### Transport (RC)

* End-to-end communication details. The transport section can provide details on how the avionics system and the ground center (ATC or Airline host) will manage the link: link initiated by the ground, link initiated by the air.
* Transport Protocols: presentation of the transport layers selected by ICAO (TCP, UDP, MP-TCP, RTCP...). This can be connection-oriented and/or connectionless transport protocols. This section should clearly define how these protocols will be used depending on the application type. Ideally, the same protocol should be used for all air-ground link to simplify the avionics system.
	+ Note: RTCA is recommending that UDP is required and TCP is an option
	+ Need to consider constraints imposed by some of the communication links
* Ports: ports being used as defined by ICAO. In the frame of the ARINC standard, some details can be added about the fact that these ports can be part of the configuration of the system.
	+ Consider addressing in the application section of the document (e.g., ports for FANS, AOC, etc.)
	+ Handling of ephemeral port numbers (e.g., SBB)
* Link with profiles that will need to be applied by the transport layers to be compliant with the ATS performance requirements.
	+ Profiles will be defined in RTCA

### QoS/Priority (TH)

Objective:

* Define the QoS aspects supported by the communication manager
* Describe the different level of prioritization in the ATN/IPS router

Key issues / questions:

* The main aspect related to prioritization is related to the segregation between ACD and AISD
* Do we want to insert additional levels of prioritization?
	+ Prioritization between ATS and AOC in the ACD domain
	+ Different ATS applications (ATN B3 over FANS)
* At the network layer, the QoS is managed by the communication manager -> interaction with the radios and the applications
* Resource reservation is specific to the radios
* Need to ensure that the IPS router does not prevent the Communication Manager to get QoS information from the traffic (e.g. IPSec)
	+ - 1. **Prioritization within the ATN/IPS System**
* For different application types

The ATN/IPS system shall support data traffic associated with the AC Domain, which currently carries application traffic including ATS and AOC. Furthermore, it is anticipated that further applications will be hosted on this system in future.

It is thus necessary that the system be able to prioritize traffic such that safety critical communications do not suffer delay or loss through the presence of lower priority data. While the handling of data outside of the ATN/IPS System is out of the control of the system, prioritization shall be effected at all points within the system where a conflict of priority may exist.

It is assumed that control of prioritization rests with the ATN/IPS system and is not driven by any characteristic of the data traffic that cannot be verified by that system. This would imply that the DS field of packets could only be used for prioritization if it were to be set by the ATN/IPS system or if the application was trusted by the system.

* + - 1. **QoS Management**
* Interaction with application and radio bearers (protocols used to talk to external systems)
* Availability of the QoS information

The ATN/IPS System, whilst not having control over the quality of service offered by any particular bearer, may use whatever means available to determine the communications performance of attached bearers. The information obtained may be used to allow selection of the most appropriate bearer or bearers at any given location or phase of flight.

By monitoring the Bit Error Rate of a transmission link it is possible to make a comparison with the performance of other links or to apply a threshold below which performance is no longer deemed acceptable.

The ability to determine the performance of each radio gives the ATN/IPS system the ability to intelligently switch bearers or to add/subtract bearers in a multilink environment thereby making best use of the communications environment.

This model of operation may be extended to use other metrics, such as link cost, to choose how to route data. This has particular relevance when the aircraft is on the ground where ground based communications such as AeroMACS or WiFi offer significantly better performance (delay, bandwidth, etc. at a lower cost.

### Compression (RC IMS)

With the ever-increasing population of aircraft traveling the skies, IPS employs compression to increase bandwidth efficiency and to use available radio spectrum as efficiently as possible.

#### Lossless Compression Methods

Compression algorithms are reversible but not necessarily lossless procedures that help to increase bandwidth efficiency. Since communication between aircraft and ground IPS systems is defined to support safety-related services, all compression methods used must be lossless.

The following list summarizes the lossless compression methods considered for IPS:

1. Run-length encoding (RLE) – works best on repeating data
2. Huffman coding – Unix Pack, pairs well with other algorithms
3. Prediction by partial matching (PPM) – works best on plain text
4. Bzip2 – Burrows-Wheeler transform with RLE and Huffman coding
5. Byte Pair encoding – simple byte replacement aaa 🡪 X with lookup table.
6. Snappy (Zippy) – medium compression based upon LZ77 algorithm
7. Lampel-Ziv compression (LZ77 and LZ78) – dictionary-based algorithm basis for modern compression, examples of which
	1. DEFLATE – LZ77 and Huffman coding used by ZIP, gzip, PNG images
	2. Lempel-Ziv-Markov chain (LZMA) – very high compression Ratio 7zip and xz
	3. Lempel-Ziv-Oberhumer (LZO) – optimized for speed over compression
	4. Lempel-Ziv-Storer-Szymanski (LZSS) – LZ77 with textual substitution used by WinRAR with Huffman coding
	5. Lempel-Ziv-Welch (LZW) -- used by GIF images and compress.
	6. Lempel-Ziv-Stac (LZS) – LZ77 with Huffman coding (Sliding Window of fixed 2k size)
	7. Lempel-Ziv-Ross-Williams (LZRW) – LZ77 with Hash Tables
	8. LZWL – Character Based LZW Compression
	9. LZX – File Archiver, Microsoft cabinet files.
	10. Others that have similar capabilities or are licensed products.

From this list, both DEFLATE and LZO were considered as candidates for IPS. Both algorithms are supported by TLS/DTLS via initial handshaking and both are supported commonly by resource limited computers like avionics. DEFLATE is the optimal choice since it is designed to achieve a higher level of compression then LZO and since it is specified in existing avionics standards (e.g., ARINC 823 and ARINC 841).

#### Minimum Supported Compression Methods for IPS

At a minimum, IPS avionics systems, IPS gateways, and IPS ground end systems **shall** support the following compression methods:

* ROHC – Robust Header Compression
* DEFLATE – LZ77 and Huffman coding

Additional compression methods may be added in the future.

The following sections describe how compression is applied to application data and to the protocol headers at transport, network, and link layers.

##### Application Data Compression

Application data (e.g., ACARS, FANS, AOC, B1/B2, or Native IP), which may be compressed, is encapsulated in the ATNPKT format specified in ICAO Doc. 9896. As shown in Figure x.x, the User Data field is prefaced by a two-byte length parameter and a one-byte compression parameter. The length parameter specifies the length of the compressed payload, and the compression parameter indicates either none or the data compression method/algorithm used to compress the payload data.

**COMMENTARY**

Some ASN.1 encoded messages have been found to increase in size when compressed. Defining a compression field allows the ground and/or aircraft to determine compressibility and choose the most efficient method of conveying the data.



**Figure x.x Compression Indication in ATNPKT**

Table x.x summarizes the compression parameter values. A value of 0x00 in the compression field indicates that no compression is applied to the data. A value of 0x01 indicates that DEFLATE compression is used. As compression technology improves, additional compression methods may be defined.

**Table x.x Compression Parameter Values**

|  |  |
| --- | --- |
| **Compression Parameter (Hex)** | **Payload Compression Algorithm** |
| 0x00 | None |
| 0x01 | DEFLATE |

If necessary, the resulting compressed payload data is then fragmented to fit the maximum transfer unit (MTU) size for the connectivity service. If the payload requires more than one ATNPKT, then the ‘More’ bit indicates that an additional fragment is following this ATNPKT. In a fragmented payload, only the first ATNPKT contains the length and compression parameters.

##### Network and Transport Layer Compression

The Network IP layer and UDP/TCP transport layer headers are compressed together using Robust Header Compression (ROHC) as defined in RFC 5795, plus profiles for IP per RFC 3843 (as amended), UDP per RFC 3095 (as amended), and TCP per RFC 6816. Reducing the header size will allow for smaller packet sizes over the RF spectrum.

**Figure x.x Example of RHOC Compression**

##### Datalink or Link Layer Compression

The Layer 2 framing of IPS data is not compressed so that each frame can be routed without the use of costly decompression methods (i.e., performance cost at each hop). The Message Integrity Check (MIC) is used at layer 2 between the aircraft and service provider for authenticating each message. The MIC is an HMAC derived from mutual authentication established at the beginning of the session with the service provider.



**Figure x.x General Example showing non-Compressed Link Layer Fields**

**Figure x.x VHF-specific Example showing non-Compressed Link Layer Fields**

### Addressing and Routing (HW)

#### Aircraft Addressing

* Sub-netting – e.g. how to assign proposed addressing scheme (per ICAO/RTCA discussions) onboard the aircraft (apportionment of the /56 prefix) – e.g. having a dedicated subnet for ACD, AISD (safety), towards each airborne radio. This would/could also link to traffic segregation (based on subnetwork).
* The role of airborne radios in the addressing scheme
* IP address acquisition – stateless autoconfiguration / DHCPv6 server / static configuration

#### Access Subnetwork Addressing

* Impact on the onboard Layer3 devices (Airborne Router, Airborne radios (if L3))
* Multiple points of attachment (e.g., SATCOM, LDACS, AeroMACS)

#### Routing

* Air-to-ground (outbound from airborne apps) routing – should the destination address of the packet be taken into account for selection of the A-G link, or not (i.e. default route over each A-G link, selection only based on CoS (DSCP), aircraft/link state, etc.)?
* Ground-to-Air (inbound toward airborne apps) routing – how to apply prioritization in this direction?
* IPV6 signaling (like RS/RA, NS/NA, other ICMPv6 signaling) – the role of the airborne router in generation/reception of these
* Use of the DSCP tags – how the router will evaluate the DSCP tags in the IPv6 header
	+ Only A🡪G, or also G🡪A?
	+ Policy based routing – use of the DSCP tags as a class of service (CoS) identifier (inserted in the packets by the airborne end system) to apply policy based routing (i.e. select the A-G link based on the combination of DSCP tag and aircraft/link state, etc.)
	+ QoS – use a DSCP tag in a standard way to apply per-hop-behavior (PHB) in the whole infrastructure (or at least access networks) and/or to do traffic shaping on the outbound interface of the router
* Static vs. dynamic routing – shall the airborne router implement a routing protocol and keep a routing table reflecting the state of routes on the ground?
* Routing engine performance – what is the required throughput, allowed latency, etc. of the routing engine?

### Multi-link (RC)

Description of the objectives/assumptions of the multi-link:

* No simultaneous transmission of the same message on different links
* Set-up several links in parallel with available communication means,
	+ I.e., when the aircraft detects link availability, it should setup the link so that it is “ready” (need to define what we mean by “ready”, e.g., ready to transfer data, implications of security on link establishment, implications of route selection and default route selection, etc.)
* Evaluate the priority between links when a downlink needs to be sent based on various criteria such as, the airline preference, the link availability & quality, the aircraft geographical location

Multi-link mechanisms selected for ATN/IPS:

* Various options to be evaluated during the standardization phase (Vertical handover): MIH, ATN/IPS specific simple solution... This should have some links with the mobility solution described in §3.2.8.
* Link selection algorithm based on link quality, airline customization (cost), security, load, bandwidth...
	+ Framework that can support the provision and constraints. But some aspects may not need to be specified precisely from an interop perspective – need to find the dividing line.

Need for a link supervisor to evaluate the link quality and modify dynamically the link preference order? (Network reputation, game theory based, specific ATN/IPS solution...)

### Mobility Considerations (BOEING)

Likely just a reference to the relevant documents defining mobility.

* Background on solutions, including explanation of mobility solutions chosen and descriptions of representative architectures
* Interop guidance

Specific requirements for the implementation

### Segregation (HW)

Including discussion of safety/non-safety usage, AOC/ATC traffic

* Access network segregation (may be able to rely on that)
* Message traffic segregation (is this really needed?)
* Link to the different on-aircraft architectures
* VPN tunnels (initiated in the IPS core; intersects with the Security section)
* Firewalling (intersects with Security section)

Need to clarify the scope/intent of this section:

* Segregation of safety and non-safety application traffic in one airborne router?
* Airborne router access to safety and non-safety A-G links?
* Mixing safety traffic and non-safety links? Or non-safety traffic and safety links?
* Segregation of ATC and safety AOC traffic? Is prioritization not enough in this case?

## ATN/IPS Supplementary (Non-Core) Functions (BOEING)

Identify any necessary interactions or functional interfaces; may not be necessary to define, but should capture assumptions / constraints

\*\*Need architecture and scope to be first identified before specifying non-core functions.\*\*

* IPS Configuration Management (e.g., customer-defined link selection policy)
* IPS System Management (e.g., security event monitoring and reporting)
* Comm Management
* Radio Management
* Security Management

## ATN/IPS Core Interfaces (AIRBUS)

### External

\*\*Need architecture and scope to be first identified before specifying all necessary external interfaces.\*\*

The objective of this section is to provide the detailed **functional definition** of all ATN/IPS airborne function external interfaces, which could be identified as services:

* Name of the interface/service
* Parameters
* Protocol if necessary

The section will be organized per type of interface:

* Interface with applications or external adaptation layers (FANS 1/A, AOC/MIAM over IP, B2 application dialog service based)
* Interface with management functions (monitoring, security, external com manager, displays TBC,…)
* Interface with communication links (VDL2, SATCOM, AeroMACS,…)
* …

Some examples:

* Application: Dialog service based primitives, management primitives (purge, link status, addresses management…)
* Links: Link status, Link establishment, Send packet, receive packets…
	+ Take a look at the concepts in A839 (MAGIC), e.g., media-independent interface definition and media-dependent adaptation
* Management: Configuration primitives/interfaces (addresses, users, routing policies…) Reporting/monitoring primitives/interfaces…

### Internal

Local implementation dependent – Need architecture first before identifying and assessing it is necessary to describe internal interfaces. Need to assess what needs to be defined vs. what can be local implementation.

## ATN/IPS Core Performance Requirements (AIRBUS)

Any requirements that we need to apply to the core to meet the required service needs (e.g. number of independent connections, time to establish a secure connection, volume of traffic, etc)

This section will detail the following aspects/requirements:

* The ATN/IPS router shall allow meeting the ATS performances requirements per RCP240/RSP180. How these requirements could be apportioned among the different sub-functions of the CORE ATN/IPS should be explained.
* The ATN/IPS router shall allow meeting the ATS performances requirements per RCP130/RSP160 as per ED228 SPR. How these requirements could be apportioned among the different sub-functions of the CORE ATN/IPS should be explained.
* The ATN/IPS router shall allow meeting the ATS performances requirements per RCP60/RSP60 predicted by SESAR 15.2.4. How these requirements could be apportioned among the different sub-functions of the CORE ATN/IPS should be explained.

Note: To meet these objectives: the ATN/IPS functions shall minimize the protocol overhead.

This section will be further detailed and will define (list not exhaustive):

* How many simultaneous “connexions” need to be supported
* How many IP packets (per time unit) can be routed
* How many “messages” (application level) can be managed (per time unit)
* Duration for secured “connexion” establishment/release
* Duration for secured “connexion” handover between links (depending on multilink concept)
* Duration for link handovers (anticipation?)
* ATC performance versus AOC performance
* Expected throughput at application level (considering protocol/link maintenance, security) versus links physical throughput
* …

Reminder from A658:

|  |  |  |  |
| --- | --- | --- | --- |
| **Performance Parameter** | **ATN B1**ED-120 SPR standard published Based on Eurocontrol generic ACSP requirements document | **B2**ED-228 SPR standard published Based on most stringent RCP130/RSP160 | **B3**SESAR 15.2.4 predicted (no standard yet) Based on most stringent RCP60/RSP60 |
| Transaction Time One way (sec) | 4sec - 95% of messages12sec – 99.9% of messages | 5sec - 95% of messages12sec – 99.9% of messages | 2sec - 95% of messages5sec – 99.9% of messages |
| Transaction Time Two way (sec) |  | 10sec - 95% of messages18sec – 99.9% of messages | 4sec - 95% of messages8sec – 99.9% of messages |
| Availability – CSP | 0.999 | 0.9995 | 0.999995(maybe reduced by multi-link) |
| Availability – Aircraft |  | 0.99 | 0.999 |
| Integrity | 1-10-5 | Not specifiedMust be good enough to meet RCP/RSP | Not specifiedMust be good enough to meet RCP/RSP |
| Security | Physical protectionUnauthorized access | Not specified but Unauthorized access protection needed, ICAO requirements | Technical security requirement likely |

# SECURITY (RC)

## TBD

# ATN/IPS AIRBORNE IMPLEMENTAION OPTIONS (RC)

## Overview and Assumptions

## ARINC 429

## ARINC 664

## Ethernet

## Etc.

## Redundancy Considerations

Not sure if this should be included, but multiple ports may be needed depending on functional requirements that are trying to be met

# AIRBORNE APPLICATION DATA CONSIDERATIONS (BOEING)

Potentially separate document? Describe assumptions instead of specifics?

## B1/B2

## FANS1/A

## ACARS

## Non-DSI Encapsulation

## Etc.

1. List of Acronyms *🡨 FROM 658*

4DT Four Dimensional Trajectory

4DTRAD Four Dimensional Trajectory Datalink

A-G or A/G Air-to-Ground

A-ISAC Aviation Information Sharing and Analysis Center

AC Advisory Circular

ACARS Aircraft Communications Addressing and Reporting System

ACD Aircraft Control Domain

ACL ATC Clearance

ACM Aircraft Communications Message

ACMS Aircraft Condition Monitoring System

ACR Avionics Communications Router

ACSP Air/Ground Communications Service Provider

ADS-C Automatic Dependent Surveillance-Contract

ADS-C EPP ADS-C Extended Projected Profile

AEEC Airlines Electronic Engineering Committee

AeroMACS Aeronautical Mobile Airport Communications System

AFN ATS Facilities Notification

AIM Aeronautical Information Management

AIREP Aircraft Report

AIS/MET Aeronautical Information Services/Meteorological

AISD Aircraft Information Services Domain

ALGA Active Low Gain Antenna

AMC ATC Microphone Check

AMET Airborne Meteorological

ANSP Air Navigation Service Provider

AOA ACARS Over AVLC

AOC Airline Operational Control

ARAC Aviation Rulemaking Advisory Committee

ARU AeroMACS Radio Unit

ASBU Aviation System Block Upgrade

ASN Access Service Network

ASN-GW Access Service Network Gateway

ATA Air Transport Association

ATC Air Traffic Control

ATM Air Traffic Management

ATN Aeronautical Telecommunication Network

ATS Air Traffic Services

ATSP Air Traffic Service Provider

ATSU Air Traffic Services Unit

AUTOMET Automatic Meteorological (report)

AVLC Aviation VHF Link Control

BLOS Beyond Line Of Sight

BS Base Station

CA Certificate Authority

CAA Civil Aviation Authority

CARATS Collaborative Actions for Renovation of Air Traffic Systems (Japan)

CDU Control Display Unit

CDM Collaborative Decision Making

CLNP Connectionless Network Protocol

CM Context Management

CMF Communications Management Function

CMU Communications Management Unit

CNS/ATM Communications Navigation Surveillance/Air Traffic Management

CoS Class of Service

COTP Connection Oriented Transport Protocol

COTS Commercial Off The Shelf

CP Communications Panel (ICAO)

CP Certificate Profile (PKI)

CPDLC Controller Pilot Data Link Communications

CPU Central Processing Unit

CRL Certificate Revocation List

CSN Connectivity Network Service

CSP Communication Service Provider

CSR Certificate Signing Request

D8PSK Differential 8-Phase Shift Keying

D-ATIS Digital Automatic Terminal Information Service

D-OTIS Datalink Operational Terminal Information Service

D-TAXI Digital TAXI

DAL Design Assurance Level

DCL Departure Clearance

DCNS Data Communications Network Service

DDoS Distributed Denial of Service

DLIC Data Link Initiation Capability

DLS-IR Data Link Services Implementing Rule

DME Distance Measuring Equipment

DoD Department of Defense

DoS Denial of Service

D-RNP Dynamic Required Navigation Performance

DS Dialog Service

DSI Dialog Service Interface

DSP Data Link Service Provider

EASA European Aviation Safety Agency

ECAC European Civil Aviation Conference

EFB Electronic Flight Bag

EIPI Extended Initial Protocol Identifier

EIRP Equivalent Isotropically Radiated Power

ESA European Space Agency

EU European Union

FAA Federal Aviation Administration

FANS Future Air Navigation System

FCI Future Communications Infrastructure

FDD Frequency Division Duplex

FEP Front End Processor

FF/ICE Flight and Flow Information for a Collaborative Environment

FIR Flight Information Region

FIS Flight Information Service

FMF Flight Management Function

FMS Flight Management System

FY Fiscal Year

G-G or G/G Ground-to-Ground

GANP Global Air Navigation Plan

GATM Global Air Traffic Management

GES Ground Earth Station

GHz Gigahertz

GNSS Global Navigation Satellite System

HDLC High-level Data Link Control

HF High Frequency

HFDL High Frequency Data Link

HGA High Gain Antenna

ICAO International Civil Aviation Organization

ICS Internet Communication Service

IER Information Exchange and Reporting

IETF Internet Engineering Task Force

IM Information Management

IMA Integrated Modular Avionics

IMS Information Management Services

IOC Initial Operational Capability

IP Internet Protocol

IPI Initial Protocol Identifier

IPS Internet Protocol Suite

IPsec Internet Protocol Security

IPv4 / IPv6 Internet Protocol Version 4 or Version 6

IS Information Services

ISO International Standards Organization

ISWG Infrastructure Specific Working Group

ITP In-Trail Procedure

ITU International Telecommunication Union

LDACS L Band Digital Aviation Communication System

LEO Low Earth Orbit

LGA Low Gain Antenna

LOS Line of Sight

MAS Message Assurance

MASPS Minimum Aviation System Performance Standards

MCDU Multi-purpose Control and Display Unit

MET Meteorological

MHz Megahertz

MIAM Media Independent Aircraft Messaging

MOPS Minimum Operational Performance Standards

MP-TCP Multi-Path Transmission Control Protocol

MRO Maintenance Repair and Overhaul

NAS National Airspace System

NextGen Next Generation Air Transportation System

NM Nautical Miles

NOTAM Notice to Airmen

OCL Oceanic Clearance

OEM Original Equipment Manufacturer

OFDM Orthogonal Frequency Division Multiplexing

OSWG Operational Specific Working Group

OTIS Operations Terminal Information System

PFIS Passenger Flight Information Systems

PGW Protocol Gateway

PIESD Passenger Information Services Domain

PKI Public Key Infrastructure

PLP Packet Layer Protocol

PMC Program Management Committee

POA Plain Old ACARS

PPPoE Point to Point Protocol over Ethernet

PR Position Reporting

PS Policy Statement

PT Project Team

QAR Quick Access Recorder

QoS Quality of Service

RCP Required Communication Performance

RCTP Required Communication Technical Performance

RF Radio Frequency

RFC Request For Comment

RNP Required Navigation Performance

RSP Required Surveillance Performance

RSTP Required Surveillance Technical Performance

SAL Security Assurance Level

SARPS Standards and Recommended Practices

Satcom Satellite Communications

SBB Swift Broadband

SBD Short Burst Data

SCTP Stream Control Transmission Protocol

SDO Standards Development Organization

SDR Software Defined Radio

sDS Secure Dialog Service

SDU Satellite Data Unit

SESAR Single European Sky Air Traffic Management (ATM) Research

SIGMET Significant Meteorological Information

SNAcP Subnetwork Access Protocol

SPR Safety and Performance Requirement

SWaP Size Weight and Power

SWIM System Wide Information Management

TAC Technical Advisory Committee

TACAN Tactical Air Navigation

TBD To Be Determined

TBO Trajectory Based Operations

TCP Transmission Control Protocol

TDLS Terminal Data Link System

ToR Terms of Reference

TSO Technical Standard Order

UDP User Datagram Protocol

UI Unnumbered Information

ULCS Upper Layer Communication Services

US United States

USB Universal Serial Bus

V&V Verification and Validation

VDL VHF Data Link

VDLM2 VHF Data Link Mode 2

VHF Very High Frequency

VOLMET Vol (flight) Meteo (weather)

VPN Virtual Private Network

WG Working Group

WiMAX Worldwide Interoperability for Microwave Access

WoW Weight on Wheels

XID eXchange Identification

1. GLOSSARY *🡨 FROM 658*

AAC – Aeronautical Administrative Communications

Communication used by aeronautical operating agencies related to the business aspects of operating their flights and transport services. This communication is used for a variety of purposes, such as flight and ground transportation, bookings, deployment of crew and aircraft or any other logistical purposes that maintain or enhance the efficiency of over-all flight operation.

ACARS – Aircraft Communications Addressing and Reporting System

A digital datalink network providing connectivity between aircraft and ground end systems (command and control, air traffic control).

ACD – Aircraft Control Domain

It consists of systems and networks whose primary functions are to support the safe operation of the aircraft. This domain connects to high-priority Air Traffic Services (ATS) and some Airline Operational Control (AOC) communications.

ADS-C – Automatic Dependent Surveillance-Contract

ADS-C is the same as ADS-A. Automatic Dependent Surveillance-Addressedis a datalink application that provides for contracted services between ground systems and aircraft. Contracts are established such that the aircraft will automatically provide information obtained from its own on-board sensors, and pass this information to the ground system under specific circumstances dictated by the ground system (except in emergencies).

Airborne ATN/IPS System

An airborne component that supports main ATN/IPS functions.

AISD – Aircraft Information Services Domain

This domain provides general purpose routing, computing, data storage and communications services for non-essential applications. The AISD domain can be subdivided into two sub-domains;

* Administrative sub-domain, which provides operational and airline administrative information to both the flight deck and cabin,
* Passenger support sub-domain, which provides information to support the Passengers

AOA – ACARS Over Aviation VHF Link Control

AOA is an attempt at gaining some early benefits of digital technology without the full risk of ATN. It is a step between full ACARS and full ATN. The most significant near-term benefit is the reduction of VHF congestion problems by transitioning traffic to the VDLM2 air/ground network. AOA allows airborne and airline host applications to remain unchanged (character format). The airborne AOA process packages the data so that it can be routed over the digital VDLM2 network. At some point on the ground, the data is restored to its original format for processing by legacy airline host applications. VDLM2 operates at 31.5 kbps versus ACARS at 2.4 kbps.

AOC – Airline Operational Control (Aeronautical Operational Control)

Operational messages used between aircraft and airline dispatch centers or, by extension, the DoD to support flight operations. This includes, but is not limited to, flight planning, flight following, and the distribution of information to flights and affected personnel.

APC – Aeronautical Passenger Communications

Communication relating to the non-safety voice and data services to passengers and crew members for personal communication.

Application

Functions that provide the services needed by the users. Applications are grouped into Application sets that are associated to specific network protocols. In the ACD domain the Applications sets are providing air traffic and operational control services.

ATN – Aeronautical Telecommunications Network

An internetwork architecture that allows ground/ground, air/ground, and avionic data subnetworks to interoperate by using common interface services and protocols based on the ISO OSI Reference Model.

ATN/IPS Node

An ATN/IPS node is a device that implements IPv6. There are two types of ATN/IPS nodes; 1) the ATN/IPS system that forwards Internet Protocol (IP) packets not explicitly addressed to itself and 2) ATN/IPS host, which does not have the capability to route traffic flows.

ATN/IPS

Internetwork consisting of ATN/IPS nodes and networks operating in a multinational environment in support of Air Traffic Services (ATS) as well as aeronautical industry service communication such as Aeronautical Operational Control (AOC) and Aeronautical Administrative Communications (AAC).

ATS – Air Traffic Services

A generic term meaning variously, flight information service, alerting service, air traffic advisory service, air traffic control service. The latter is a service provided for the purpose of preventing collisions, expediting and maintaining an orderly flow of traffic.

ATSU – Air Traffic Services Unit

A unit established for the purpose of receiving reports concerning air traffic services and flight plans submitted before departure. It is a generic term meaning air traffic control unit, flight information center, or air traffic service reporting office.

CM – Communication Manager

This function manages the connectivity of the aircraft with the ground system. It is decomposed into two sub-functions:

* ATN/IPS Communication Manager, which manages in the ATN/IPS system the selection of the radio bearer for a dedicated traffic flow and the associated mode of communication.
* External Communication Manager, which performs router selection and associated vertical handover decisions. This entity may be extended to include the management of multi-domain link selections.

CMU – Communication Management Unit

The CMU performs two important functions: it manages access to the various datalink sub-networks and services available to the aircraft and hosts various applications related to datalink. It also interfaces to the flight management system (FMS) and to the crew displays.

CNS/ATM – Communication, Navigation, Surveillance/Air Traffic Management

CNS/ATM is a system based on digital technologies, satellite systems, and enhanced automation to achieve a seamless global Air Traffic Management. Modern CNS systems will eliminate or reduce a variety of constraints imposed on ATM operations today.

CPDLC – Controller-Pilot Data Link Communications

The CPDLC application provides for the exchange of flight planning, clearance, and informational data between a flight crew and air traffic control. This application supplements voice communications and, in some areas, data may supersede voice.

DS – Dialog Service

The Dialog Service serves as an interface between the ATN applications and the ATN/OSI or ATN/IPS upper layer protocols via the control function.

FANS-1/A – Future Aircraft Navigation System 1/A

A set of operational capabilities centered around direct datalink communications between the flight crew and air traffic control. Operators benefit from FANS-1/A in oceanic and remote airspace around the world.

FMF – Flight Management Function

A collection of processes or applications that facilitates area navigation (RNAV) and related functions to be executed during all phases of flight. The FMF is resident in an avionics computer and automates navigational functions reducing flight crew workload particularly during instrument meteorological conditions. The Flight Management System encompasses the FMF.

FMS – Flight Management System

A computer system that uses a large database to allow routes to be preprogrammed and fed into the system by a means of a data loader. The system is constantly updated with respect to position by reference to designated sensors. The sophisticated program and its associated database insure that the most appropriate aids are automatically selected during the information update cycle. The flight management system is interfaced/coupled to cockpit displays to provide the flight crew situational awareness and/or an autopilot.

Ground ATN/IPS Router

A ground device that is used to support ATN/IPS packet forwarding in both air/ground and ground/ground environments.

Infrastructure

This is a general term corresponding to the communication systems that support the application sets. It consists of the Network and Sub-networks functions.

LINK 2000+ – The EUROCONTROL LINK 2000+ Program

The European validation program that demonstrated controller-pilot data-link-communication (CPDLC) services into a set for implementation in the European Airspace using the ATN and VDLM2 (Aeronautical Telecommunication Network and VHF Digital Link).

MASPS – Minimum Aviation System Performance Standards

High-level documents produced by RTCA that establish minimum system performance characteristics.

MOPS – Minimum Operational Performance Standards

Standards produced by RTCA that describe typical equipment applications and operational goals and establish the basis for required performance. Definitions and assumptions essential to proper understanding are included as well as installed equipment tests and operational performance characteristics for equipment installations. MOPS are often used by the FAA as a basis for certification.

Multilink

Concept that defines the use of concurrent, existing and future communication links between air and ground (e.g., AeroMACS, LDACS and Satcom), depending on the defined criteria (performance needs).

NAS – National Airspace System

One of the most complex aviation systems in the world that enables safe and expeditious air travel in the United States and over large portions of the world’s oceans.

Network

The Network function is decomposed into two main sub-functions; a router that routes data packets from a source to a destination and the communication manager, which is responsible for the network and link selections.

Network Layer

The Network Layer is based on Internet Protocol (IP) ensuring global routing over interconnected packet-switched communication networks.

Physical and Link Layers

They are associated with the Sub-networks and handle the physical interface with the transmission medium (i.e., radio links).

PIESD – Passenger Information and Entertainment Services Domain

It is characterized by the need to provide passenger entertainment and network services. Beyond traditional IFE systems, it may also include passenger device connectivity systems, Passenger Flight Information Systems (PFIS), broadband television or connectivity systems.

SARPS – Standards and Recommended Practices

Produced by ICAO, they become the international standards for member states. As the name implies, they are only “recommended” practices. It is up to each member states to decide how/if to implement them.

Satcom – Satellite Communications

Communication service providing data, voice, and fax transmission via satellite. Allows aircraft to communicate in BLOS areas.

SESAR – Single European Sky ATM Research

European air traffic control infrastructure modernization program. SESAR aims at developing the new generation ATM system capable of ensuring the safety and fluidity of air transport worldwide over the next 30 years.

Sub-network

The sub-networks correspond to all radio systems that are used to communicate between the aircraft and the ground.

Transport Layer

The transport layer protocols are used to provide reliable or unreliable communication services over the ATN/IPS system. Those include TCP for reliable transport services and UDP that is used to provide best effort service.

VDL – VHF Data Link

Also known as VHF Digital Link, VDL is the LOS sub-network supporting data communications that are sent over VHF frequencies. The traditional VHF voice radio can be used in conjunction with a data modem to send data messages over VHF frequencies.

VDLM2 – VHF Data Link Mode 2

A datalink-only service designed to digitize VHF and improve the speed of the VHF link. VDLM2 is intended for use within the US and Europe as an interim datalink solution for enroute ATC functions. VDLM2 provides a 31.5 kbps channel rate.

Vertical Handover

[AI - Arnaud TH]

1. ATN/IPS GROUND ARCHITECTURE CONSIDERATIONS (RC IMS)
	1. Potential Ground Architectures
		1. Full End-to-End
		2. Multiple “Segment Correlations”
	2. Gateway Architectures
		1. Dual-Stack (OSI / IPS)
		2. Dual-Stack (ACARS / IPS)
		3. Triple-Stack (ACARS / OSI / IPS)
	3. Gateway Functional Requirements (BOEING)

1. AIRBUS PROFILES (AIRBUS)
	1. Federated
	2. Modular
2. BOEING PROFILES (BOEING)
	1. Federated
	2. Modular
1. In this document the term “ATN” is used to refer generically to the Aeronautical Telecommunications Network and could be either ATN/IPS or ATN/OSI. Furthermore, if only “IPS” is used, this is considered equivalent to referring to “ATN/IPS”. [↑](#footnote-ref-1)